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Examining the Effects of Students and School Variables on PISA 2012 Problem-Solving Achievement in Turkey

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Abstract

Problem-solving skills are very important in ensuring effective participation in public life regard and schools play an important role in helping students develop problem-solving skills. The purpose of this study is to determine the student and school level variables that effect students' problem solving skills using a two-level Hierarchical Linear Modeling (HLM). The data in this study is belongs to 4848 students in 170 schools who participated PISA 2012. Gender, school attendance, openness to problem-solving and perseverance to reach solution variables constituted the student level variables whereas school type, educational resources, dropout rates and student/math teacher ratio variables constituted the school level variables. The findings indicated that all the variables but openness and perseverance have statistically significant effect on students' PISA 2012 problem-solving achievement scores. The results of the analysis indicate that 54 percent of the variability in the problem-solving achievement scores is attributed to the differences between the mean achievement of the schools.

Keywords: PISA; Problem solving; School effect; Two-level Hierarchical Linear Model (HLM)

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1. Introduction

Problem-solving competence, the individuals in the event of a problem me with no obvious solution is to understand the situation and capacity to solve with the help of cognitive processes according to PISA 2012. Problem-solving competence requires already acquired basic cognitive and practical skills, abilities and other psychosocial resources is used reuse (MoNE, Ministery of National Education, 2011). Problem-solving skills are very important in ensuring effective participation in public life regard. Primarily for the development of problem-solving proficiency is expected to be open and persevering person to problem solving to achieve the result. In addition, in many countries, to gain the problem-solving ability is one of the main objectives of the training programme (Lesh, & Zawojewski, 2007). Therefore, schools play an important role in helping students develop problem-solving skills. When the students of the schools interrupt the course of the ongoing throughout the school year they lead to failing to fulfill functions of schools (Altınkurt, 2008; Sulu Cavumirza, 2012). Also the student/math teacher ratio (Demir, 2009; Kim, 2006; Teodorovic, 2011), the quality of educational resources (Hanushek & Luque, 2003; Savascı, 2010) and types of schools (Cunnington, 2012; D'agostıno, 1997; Kim, 2006; Yang, 2000) affect in fulfilling the functions of the schools.

When scanning the relevant literature, there is not any studies, which examine influence of students and school variables on the problem-solving achievement by two-level Hierarchical Linear Model (HLM) analysis in Turkey while there is very little (Stockdale, 1995; Yang, 2011;) that has been identified in abroad. This research aimed to remedy the deficiencies in the literature and determine the variables that affecting on the PISA 2012 problem-solving achievement in the school and student level in Turkey.

1.1. Purpose of the Study

1. Is there any difference between the problem-solving achievement of schools that participated in PISA 2012 in Turkey?
2. What are the student-level variables affecting problem-solving achievement of students that participated in PISA 2012, if there is, in Turkey?
3. What are the school-level variables that explain the difference between the means problem-solving achievement of schools that participated in PISA 2012, if there is, in Turkey?

2. Method

2.1. Programme for International Student Assessment (PISA) 2012

A survey is conducted every three years by the Organization for Economic Cooperation and Development (OECD). After the problem-solving test student questionnaire were applied to determine the factors affecting the achievement of the students. The school questionnaire was completed by school administrators.

2.2. Sample

The schools that participated in PISA 2012 was selected by a two-stage stratified sampling method in all of schools have 15 years old students. The data in this study is gathered from 4848 students in 170 schools who participated in PISA 2012.

2.3. Variables

Overall problem-solving plausible values were used as the outcome variable in the student-level model. The gender (GENDER) and attendance status (TRUANCY) variables were coded as dummy variable (girls=1 and boys=2; not attending school=1 and attending school=2) while openness to problem-solving (OPENPS), perseverance to reach a solution (PERSEV) variables of student level were included in the analysis as continuous variables. The school type (SCHTYP) variable was coded as dummy variable (public schools=1, private schools=2) while quality of school educational resources (SCMATEDU), dropout ratio (SLEAVE), student/math teacher ratio (SMRATIO) variables of school level were included in the analysis as continuous variables.

2.4. Hierarchical Linear Model Analysis

The assumptions of independence of observations and equality of variances are violating in large samples of work. When one or both of these two assumptions is violated multiple regression analysis gives biased results (Raudenbush & Bryk 2002). Hierarchical linear modelling is used to avoid biased results of multiple regression as an alternative method of analysis.

2.4.1. One-way Analysis of Variance Random Effects Model

To answer the first research question, also known as a null model of random effects ANOVA model in HLM analysis was used.

Level 1: $Y_{ij}=\beta_{0j}+r_{ij}$ Level 2: $\beta_{0j}=\gamma_{00}+u_{0j}$ (1)

Y_{ij} is problem-solving achievement of student i in school j, β_{0j} is the mean problem-solving achievement for the j^{th} school, r_{ij} is the deviation of achievement of student i in school j from mean achievement of school j in here. r_{ij} has "0" mean and variance σ^2 is assumed to be normally distributed. γ_{00} is the grand-mean achievement fort the population of schools and u_{0j} is the deviation of mean achievement of school j from grand-mean achievement. u_{0j} has "0" mean and variance τ_{00} is assumed to be normally distributed.

2.4.2. Random-coefficients Regression Model

To answer the second research question HLM analysis is performed when the variables related to the students is assigning the first level in this model.

Level 1: $Y_{ij}=\beta_{0j}+\beta_{1j}$(TRUANCY)$+\beta_{2j}$(GENDER)$+\beta_{3j}$(OPENPS)$+\beta_{4j}$(PERSEV)$+r_{ij}$ (2)

β_{pj}: a unit change in the independent variables (p=1,2,3,4) of student level corresponding to the amount of expected changes in problem-solving scores (outcome variable) in j-school.

2.4.3. Means as Outcome Model

To answer the third research question HLM analysis is performed when the variables related to the schools is assigning the second level in this model.

Level 2: $\beta_{0j}=\gamma_{00}+\gamma_{01}$(SCHTYP)$+\gamma_{02}$(SLEAVE)$+\gamma_{03}$(SCMATEDU)$+\gamma_{04}$(SMRATIO)$+u_{0j}$ (3)

γ_{0k}: a unit change in the independent variables (k=1,2,3,4) of school level corresponding to the amount of changes in mean of problem-solving scores (outcome variable) of schools.

3. Results

3.1. Is there any difference between the problem-solving achievement of schools that participated in PISA 2012 in Turkey?

The results of the random effects ANOVA model analysis for determining differences between the mean problem-solving achievement of the schools which participated in PISA 2012 are given in Table 1. The grand-mean problem-solving achievement was estimated as 447.88 with a standard error of 4.71.

As seen in Table 1, the estimate of variability in student level (σ^2) and the estimate of variability in school level (τ_{00}) are 2976.31 and 3531.66, respectively (χ^2=5715.87, df=167). It also shows that statistically significant variability (p<.001) between the schools participated in the PISA 2012 that there is a difference between these mean schools' problem-solving achievement. It can be said that 54 percent of the total variance is between schools BY calculating the between classes correlation coefficient (ICC). In another expression, 54 percent of the variability in problem-solving scores stems from the differences between the mean scores of problem-solving of schools attended PISA 2012. Also 46 percent of the total variance is due to differences between students. It was seen that the rate of explained variance at school level supported the use of two-level HLM (.54>.01). Results of Random Effects ANOVA Model analysis that the reliability estimation of mean achievement of problem-solving (β_{0j}) was estimated as r = .95.

Table 1. Results of random effects ANOVA model analysis

Fixed Effects	**Coefficient**	**Standard error (SE)**		***p*-value**
Grand mean achievement, γ_{00}	447.88	4.71		<0.001
Random Effect	**Variance**	**df**	χ^2	***p*-value**
Level-2, u_0	3531.66	167	5715.87	<0.001
Level-1, r_{ij}	2976.31			

3.2. What are the student-level variables affecting problem-solving achievement of students that participated in PISA 2012, if there is, in Turkey?

The results of the random effects ANOVA model analysis for determining the effect of student level variables on problem-solving achievement of the students who participated PISA 2012 are given in Table 2.

Table 2. Results of random coefficients model analysis

Fixed Effect	**Coefficient**	**SE**	***p*-value**	**Effect size**
Grand mean achievement, γ_{00}	404.99	5.43	<0.001	…
Mean TRUANCY-achievement slope, γ_{10}	4.30	1.59	0.007*	0.08
Mean GENDER-achievement, γ_{20}	24.00	2.08	<0.001	0.44
Mean OPENPS-achievement slope, γ_{30}	0.75	1.21	0.54	…
Mean PERSEV-achievement slope, γ_{40}	-0.94	1.28	0.47	…
Random Effect	**Variance**	**df**	***χ2***	***p*-value**
Level 2, u_{0j}	3559.19	167	5991.88	<0.001
Level 1, r_{ij}	2856.32			

*$p<0.05$

It had been found that problem-solving achievement was affected statistically by truancy (γ_{10}=4.56, p=.005), gender (γ_{20}=22.69, p<.001) while openness to problem-solving (OPENPS) and perseverance to reach a solution (PERSEV) not. When the effect size is considered, the mean problem-solving achievement of the boys are 0.44 standard deviation higher compared to the achievement of girls. It is said that the students' school attendance was not very important in practice. The effects size of non-statistically significant variables were not calculated. The variables included in the model of the student level were found to explain 0.04 of the variance between achievement of the students, using the results of the Random Effects ANOVA Model and Random Coefficients Model el analyses.

3.3. What are the school-level variables that explain the difference between the means problem-solving-achievement of schools that participated in PISA 2012, if there is, in Turkey?

The results of means as outcome model analysis for determining school level variables that explain the differences between the means problem-solving achievement of the schools which participated PISA 2012 are given in Table 3.

The grand-mean problem-solving achievement was estimated as 415.13 with a standard error of 13.18. When Table 3 was taken into consideration, the findings showed that problem-solving achievement was affected statistically by school type (γ_{01}=32.21, p=.003), dropout ratio (γ_{02}=-1.54, p=.012), the quality of educational resources (γ_{03}=16.54, p<.001) and student-math teacher ratio (γ_{04}=-.10, p=.002). When the effect size is considered, the mean problem-solving achievement of the students studying in private schools is 0.54 standard deviation higher compared to the success of the students studying in public schools. The problem-solving achievement of the students in the schools with more educational resources is higher 0.28 standard deviation than those in other schools. The effects of the variables which are dropout rates in schools and the ratio of students /math teachers can be said to be practically not significant.

Table 3. Results of means as outcome model analysis

Fixed Effect	**Coefficient**	**SE**	***p*-value**	**Effect size**
School mean achievement, β_0				
Grand mean achievement, γ_{00}	415.13	13.18	<0.001	…
School type, γ_{01}	32.21	10.72	0.003*	0.54
Dropout ratio, γ_{02}	-1.54	0.60	0.012*	-0.03
Quality of school educational resources, γ_{03}	16.54	4.73	<0.001	0.28

Student -maths teacher ratio, γ_{04}	-0.10	0.03	0.002*	-0.002
Random Effect	**Variance**	**df**	χ^2	***p*-value**
Level -2, (u_0)	2815.27	163	4493.14	<0.001
Level -1, (r_{ij})	2975.59			

*$p<0.05$

The variables included in the model of the school level were found to explain 20 percent of the variance between mean achievement of the schools, using the results of the Random Effects ANOVA Model and Means as Outcome Model analyses.

4. Conclusions and Recommendations

The results of the analysis indicate that 54 percent of the variability in the problem-solving achievement scores is attributed to the differences between the mean problem-solving achievement of the schools which participated in PISA 2012. At the end of random-coefficients model analysis it has been found that the variables gender and attendance status had a statistically significant effect on problem-solving achievement. The results of means as outcome model analysis indicated that all of the school level variables had statistically significant effect on students' problem-solving achievement. Considering the effect size, the gender variable at the student level (PISA 2014; 2005), school type and educational resources variables at the school level (Savasci, 2010; PISA 2005) had significant effect on problem-solving achievement. According to PISA 2003 results, the majority of school administrators said that the shortage of teachers is a factor negatively affecting students' achievement. However, the present study has reached the conclusion that student/math teacher ratio was not significantly effective in practice. The openness to problem-solving, perseverance to reach a solution, student/teacher of mathematics and dropout rates variables' effect on the problem-solving achievement should be examined again with different analysis methods. In addition, increasing the number of private schools, encouraging private school education policies and the quality of educational resources in schools may improve students' problem-solving skills in Turkey.

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