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Original Research Article

Science Achievement in Finland, Slovenia, Kazakhstan and Turkey with Respect to TIMSS 2011 Results

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In order to obtain an adequate amount of information on what the students have achieved and how students can improve their learning, it is necessary to understand the educational contexts where the learning takes place. In this study, the structural relation between students' science achievement and educational context variables were examined among four countries, including Finland, Slovenia, Kazakhstan and Turkey using TIMSS 2011 data. The educational contextual variables were selected from the questionnaires for teachers and students to analyse the intended curriculum of each country. Having science achievement score as an indicator of attained curriculum, this study tries to model the school effectiveness and examine which factors mostly affect science achievement. A 2-level model of student and teacher were analysed. In result, this study found out the educational contextual characteristics of high performance and reasons why these countries outperformed other countries well in spite of many involved factors, and the social and cultural differences between countries.

Keywords: Context variables, TIMSS 2011, Science achievement, Student characteristics, Teacher characteristics.

INTRODUCTION

Purpose and educational Significance of the study

Many countries in the world are making efforts to improve their students' achievements as well as their educational systems by establishing quality control systems that monitor educational outcomes: at the national level by implementing national level achievement tests, and at the international level by participating in international studies of student assessment. TIMSS is one of the most important international qualities monitoring opportunity for Turkey as it indicates the placement of Turkish students with respect to other countries.

Understanding reasons of failure or success in science achievement is also important as much as knowing the rank of the country. TIMSS collects data from students, teachers, schools and countries. Since they are fundamental elements of education, evaluation of teachers and students' data allows finding out reasons behind the TIMSS results. In this study, the effect of some teacher' and student' characteristics on science achievement were determined and compared with three other countries. Finland, Slovenia and Kazakhstan have been selected for comparison because two of these countries have higher (Finland and Slovenia) and one of them has similar (Kazakhstan) eight grade science achievement scores related to Turkey. Determination of effect of selected factors on success would provide opportunity to conceive real factors behind the success and failure in science education.

Theoretical framework

Determination of teacher, student and school characters effecting academic achievement is one of the main traditional research areas. Especially large data sets like TIMSS or PISA datasets have been widely used to find out the link between these characters and academic achievement (Drent, Meelissen and Van Der Kleij, 2013; Glynn, 2012).

Many of the these studies have also been conducted to compare science achievement and factors affecting science achievement in different countries (Shen and Tam, 2008; Marsh and others, 2013; Roth, 2006). In these studies, researchers generally focused on how to determine the effect of selected students, teachers or school characters in different countries and try to deduce what factors, what kind of effects in

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different context. This study would attempt to obtain implications for effect of some students' and their science teachers' characteristics on science achievement. Eighth grades TIMSS 2011 data of these 4 countries will be analysed for these implications.

RESEARCH METHOD

Data sources

To analyse the effects of students' and teachers' characteristics, we used the results of the TIMSS 2011 for Finland, Slovenia, Kazakhstan and Turkey. Two of these countries (Finland and Slovenia) have a good rank in science score (respectively 5 and 6), other two countries (Kazakhstan and Turkey) are mid-rank countries (respectively 20 and 21). The target students of this study are those in eighth grades.

The sampled students took the mathematics and science tests for two hours after being allocated to one of fourteen test booklets by matrix sampling. The educational contextual variables were selected from the questionnaire for science teachers, and students in order to analyse the intended curriculum of each country. Using the science achievement score as an indicator of an attained curriculum, this study attempts to model teacher effectiveness and examines which factors affect science achievement the most.

Data

The TIMSS 2011 data were used for the HLM analysis. The numbers of students and science teachers in each country are summarized in Table 1 for the eight grades.

Analysis method and procedure

With respect to the analytical method applied to the structural and hierarchical characteristics of the data, a 2-level hierarchical linear model for students and teachers was constructed and analyses carried out by utilizing the statistics program HLM (Hierarchical Linear Modeling) 7.0 (Raudenbush and al., 2006). In the model, students' data was assigned to first level and science teacher data was assigned to second level. Since the lower-level units as individuals and the higher-level units as Groups and students are nested into teachers of them. This hierarchical linear model allows for the simultaneous investigation of the relationship within teachers and students, as well as the relationships across teachers and students.

HLM can test the significance of the between-group variance (variance between teachers) (τ_{00}) but cannot test the significance of the within group variance (variance between students) (σ^2). Therefore, we can calculate the ratio of the between group variance to the total variance termed as intra-class correlation (ICC). ICC represents the percent of variance in science achievement of students that is between teachers. Null model in HLM accomplishes ANOVA and it provides;

- The amount of variance within groups (teachers)
- The amount of variance between groups (students)
- Calculation of ICC using the following equation;

$$ICC = \frac{\tau_{00}}{(\tau_{00} + \sigma^2)}$$

The first step in the analysis was estimation of the proportion of student-level variance ( ) and teacher-level variance ( ) among the variances of total science achievement by setting the base model without any explanatory variables. This makes it possible to identify variance size caused by gaps among teachers in students' science achievement. This model is fully unconditional model;

$$SCIACHij = \gamma_{00} + r_{ij} + u_{0j}$$

Where,

SCIACHij: Science achievement score measured for *i*th student nested within *j*th teacher.

γ_{00} = overall mean
r_{ij} = random error associated with the *i*th student nested within *j*th teacher

Within-Unit Model

In two level hierarchical models, tested factors added to the equation. The model is called within-unit model as it describes the effects in the context of single groups (Gill, 2003). The equation represents simple regression developed for each student *i*. Dependent variable in the equation is science achievement score *(SCIACH)* measured for *i*th student nested within the *j*th teacher. In the with-in unit model, selected 3 students' factors were added to equations to test how much these factors cause chance in total Level 1 variance. These student characters are mother education level (MOTEDU), father education level (FATEDU) and share of school experience with parents (FAMSHA).

[Level 1 model: Students]

$$SCIACHij = \beta_{0j} + \beta_{1j}*(MOTEDU_{ij}) + \beta_{2j}*(FATEDU_{ij}) + \beta_{3j}*(FAMSHA_{ij}) + r_{ij}$$

Where

$MOTEDU_{ij}$, $FATEDU_{ij}$ and $FAMSHA_{ij}$: value on selected items.

β_{0j}*:* intercept for *j*th teacher.

β_{1j}, β_{2j} and β_{3j}: regression coefficients associated with selected items score for the *j*th teacher

r_{ij}: random error associated with the *i*th student nested within *j*th teacher

u_{0j} = random effect of the *j*th teacher

Between-Units Model

Regression coefficients in Level-1 are used as outcome variables in Level-2 models. Since Level-2 model describes variability across teachers (groups), level-2 models can be named as between-units model (Gill, 2003). In Level-2 model, tested teachers factors are added to equation. 4 teacher characters evaluated in the study are experience (EXP), educational level (EDULEV), computer usage in course (COMUSE) and participation to in-service training about integration of information technologies into education (PARINS).

Table 1. Data for Grade 8

Country	Rank of countries in Science Achievement	Science achievement Score	N of Teachers sampled	N of Students sampled
Finland	5	552	145	4.266
Slovenia	6	543	186	4.415
Kazakhstan	20	490	147	4.390
Turkey	21	483	239	6.928

The equation for Level-2 is;

$\beta_{0j} = \gamma_{00} + \gamma_{01}*(EXP_j) + \gamma_{02}*(EDULEV_j) + \gamma_{03}*(COMUSE_j) + \gamma 04*(PARINS_j) + u_{0j}$

Where,

β_{0j} = intercept for the *j*th teacher

γ_{00} = overall mean intercept adjusted for scores of selected teacher variables

γ_{01}, γ_{02}, γ_{03} *and* γ_{04} = regression coefficient associated with scores of selected variables (EXP, EDULEV, COMUSE and PARINS) relative to Level-1 intercepts

u_{0j} = random effect of the *j*th teacher adjusted for scores of selected variables on the intercept.

Between unit model is also named as the Random Intercept Model (Bryk & Raudenbush, 1992; Kreft & de Leeuw, 1998). By putting the explanatory variables of each level into the model sequentially, the extent to which input variables explain variances at each level can be identified through the ratio of the additional explanatory variances. In addition, the variables that affect science achievement can be examined and compared across the four countries.

The HLM model of this research is explained in Table 2. According to the hypothesis, a baseline model (null model) without the explanatory variables was set up and the total variance of science variance was divided into teacher level and student level. The intra-class correlation coefficient (ICC) - that is, the teacher level variance among the total variance - was calculated. After testing the baseline model, in Within-Unit Model, the students' characteristics variables were included in the baseline model for Step1. Between Units Model was then set up by including the teachers' characteristics variables for Step 2. Using Within Unit Model and Between Units Model, the effects of each explanatory variable and its significance were reported.

RESULTS

Explained Variance

In Table 3, the intra-class correlation (ICC) attributable to schools and the proportion of variances explained by the HLM models are summarized together with the model which showed the best fit. In general, the ICC was various for four countries. Table 3 includes the variance of the baseline model of eighth grades science achievement.

The ICC of the four countries for Grade 8 also varied from 10,8 to 50,1. Slovenia has the least school variance with 10,8, and Kazakhstan has the greatest ICC with 50,1. Finland has an ICC of 12,8 and Turkey has an ICC of 28,8, as second and third lowest among the four countries. Since ICC represents variance depend upon group membership (Anderson, 2012), this values can be evaluated as indicator of teachers' effect on science achievement. According to ICC values (variance proportion among students level and teacher level), it was observed that science teachers in Slovenia and Finland have very low level of influence on science achievement and science teachers in Kazakhstan has a relatively high influence on science achievement.

In the next step in the model building process to add predictor variables at Level 1 (Student level). After all explanatory variables at student level are included in the model, changes in the percentage of explained variance compared to the baseline model is given in Table 4. Then, 4 teacher characteristics (participating in-service training, computer usage for science course, participating training about IT and experience training) added to the Model as predictors in teachers level. Change in the variance in teacher level also compared with with-in unit model.

After 3 variables at student level (Father education level, mother education level and sharing of school experience with parents) added, with-in school variance in all countries reduced slightly. However, addition of predictors at teacher level reduced explained variance 9,5% in Turkey, 3,8% in Kazakhstan, 2,4% in Slovenia and 0,8% in Finland. This values indicated that selected 3 students factors explained 2,5% of within school variability and selected 4 factors explained 9,5% of between teachers' variability in students' science scores in Turkey. Explanatory powers of selected factors in variances are less than these values in the other three countries.

HLM Analysis

After base-line model without any predictor conducted, three students' factor added to the Model as Level-1 predictors and within-group model generated in order to explain the individual variability among students' science achievement scores. Then, 4 teachers' factor added to the Model as Level-2 predictors and between-group model generated in order to explain the differences between science teachers. Result of HLM Analysis is given in Table 5.

Considering the students' characteristics, mother education level has 3,54 point positive influence on science achievement score in Slovenia and 5,15 points negative influence in Turkey. In Finland and Kazakhstan, there are no significant influences of mother education level on students' science achievement score. Another predictor, father education level has 3, 65 and 1, 66 point positive influence on science achievement scores in Turkey and Kazakhstan respectively and no significant effect in Finland and Slovenia. The last student factor included in the model is sharing of school experience with parents. This factor has 11,66 points negative effect on science achievement scores in Turkey and 2,79 points in Kazakhstan and no significant influence was determined in Finland and Slovenia.

Table 2. Analysis model and Input variables

Step	Model	Input variables
Baseline	Null model	NA
Step 1	Within Unit Model	Students characteristics
Step 2	Between Units Model	Students characteristics + Teachers characteristics

Table 3. Variance of Baseline Model of Science Achievement for Grade 8

		Finland		Slovenia		Kazakhstan		Turkey	
		Variance	(%)	Variance	(%)	Variance	(%)	Variance	(%)
Null Model	Student Level	3.708,59	(87,2)	5.165,39	(89,2)	3.180,20	(49,9)	6.986,04	(71,2)
	Teacher Level	544,82	(12,8)	622,75	(10,8)	3.124,08	(50,1)	2.830,43	(28,8)
	total	4.253,41	(100)	4.788,13	(100)	6.364,28	(100)	9.816,47	(100)
ICC		0,128	(12,8)	0,108	(10,8)	0,501	(50,1)	0,288	(28,8)

Table 4. Variance of each Model of Sciences Achievement for Grade 8

		Finland		Slovenia		Kazakhstan		Turkey	
		Variance	(% of change)	Variance	(% of change)	Variance	(% of change)	Variance	(% of change)
Between Students	Model 1	3.703,40	(0,1)	5.132,32	(0,6)	3.166,71	(0,4)	6.811,88	(2,5)
	Model 2	3.703,23	(0,1)	5.132,24	(0,6)	3.166,60	(0,4)	6.812,49	(2,5)
Between Teachers	Model 1	545,00	(-0,03)	624,56	(-0,3)	3.184,96	(-1,9)	2.837,54	(-0,3)
	Model 2	540,43	(0,8)	607,85	(2,4)	3.005,95	(3,8)	2.561,57	(9,5)

Table 5. HLM Analysis Summary for Grade 8

Variables		Finland		Slovenia		Kazakhstan		Turkey	
		Coefficient	S.d.	Coefficient	S.d.	Coefficient	S.d.	Coefficient	S.d.
Level- 1 Students									
Student Charakteristics	MATEDU	0.93	0.60	3.54***	0.72	-0.09	0.70	-5.15***	0.97
	FATEDU	-0.23	0.53	-0.68	0.74	1.66**	0.61	3.65***	0.81
	FAMSHA	-1.63	1.11	-0.65	1.08	-2.79*	1.21	-11.66***	1.20
Level- 2 Teachers									
Teacher Charakteristics	EXP	0.18	0.18	0.11	0.26	0.47	0.39	1.38**	0.45
	EDULEV	2.59	3.04	7.97	5.43	19.85	13.82	18.64*	8.42
	COMUSE	-2.66	4.67	4.98	8.09	-29.01	18.57	-19.18*	7.66
	PARINS	1.73	5.29	3.50	5.30	0.74	14.25	-12,98	8.16
Reliability									

*p<0,05 **p<0,01 ***p<0,001

There are 4 characteristics of science teachers added to Model as Level 2 predictor. Teacher experience has 1,38 points positive influence on students science scores only in Turkey. There were no significant determined for the other three countries. Similarly, educational level of teachers has significant positive influence on students' science scores only in Turkey. Although 19,85 points positive influence are calculated in Kazakhstan, it is not significant. Using of computer in their teaching practice is another teacher characteristic. Using computer has -19, 18 points significant negative influence on science achievement scores in Turkey.

In Kazakhstan, this predictor also has -29,01 points negative influence, but it is not significant. The last teacher' character added to the model is participation to in-service training related with integration of technology into science. There is no significant effect observed in 4 countries, but -12,98 points negative effect on science achievement score in Turkey is remarkable.

SUMMARY AND CONCLUSION

The 8th grade science achievement results of TIMSS 2011 in Finland, Slovenia, Kazakhstan and Turkey were analysed with forenamed method. This study attempted to compare the student related and teacher related factors affecting science achievement in high and mid-level achieving countries. Multilevel models have been conducted to explain cross-national differences and similarities effecting student science achievement scores. In the model, 3 students' characteristics and 4 teachers' characteristics have been used as predictors for science achievement. Since students are nested into teachers, students are first level and their science teachers are second level of the hierarchical model.

Comparison between countries indicated that influence of selected teacher factors on science achievement is more apparent in mid-level, achieving countries (Turkey and Kazakhstan) than high level achieving countries (Finland and Slovenia). This situation indicated that there is a bigger gap between teachers or schools in mid-level 2 countries.

There is more homogeneity among teachers or schools in high level achieving 2 countries. Similar to selected teachers' characteristics, selected student characteristics also have more influence on science achievement scores in mid-level achieving countries than high level achieving countries. In Finland, none of the selected students' factors have significant effect on science achievement score. In Slovenia, only mother education level has 3,54 points positive influence on science achievement score. While father education level has 1,66 points positive influence on science achievement in Kazakhstan and 3,65 points positive influences in Turkey.

These results can be evaluated as weakness of educational system because pupils, who have parents with high educational level, can possess more opportunity for education. Interestingly, mother education level has -5,15 points negative influence on science achievement score in Turkey. 3 of the teacher characteristics evaluated as predictors have significant influence on science achievement scores only in Turkey. The biggest influence is 19,14 points negative influence of computer usage on science achievement scores. This high effect indicated that teachers in Turkey don't have the necessary knowledge and skills to use computer in science education effectively. Even if insignificant, similar result is also obtained in Kazakhstan.

Educational level of teachers has also great positive impact (+18,64 points) on science achievement scores in Turkey. Teachers must complete 4 or 5 years undergraduate education in Turkey. While 86% of undergraduate education with 9% and 5% of associate teachers involved in the implementation of education at the graduate level in Turkey has. 95% of teachers participating in the implementation in Kazakhstan with a bachelor's degree, while 3% and 2% have undergraduate education at the graduate level. Almost all of the teachers in Finland and Slovenia are trained at the graduate level.

Participating in-service training about integration of technology don't have significant influence on science achievement in all of 4 countries. Despite it is not significant, participation to in-service training about integration of IT into education have nearly 13 points negative effect in Turkey. This results can be evaluated as failure of in-service training. Quality, cirruculum and implementation of in-service trainings have to be looked over.

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