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THE MIMIC MODEL APPROACH TO INVESTIGATE MATHEMATIC ACHIEVEMENT OF TURKISH STUDENTS

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ABSTRACT
The mathematical performance of the students is an essential factor in the field of mathematics education, because the mathematics performance symbolizes the success in the mathematics education. After investigated the effects of student characteristics of Turkish students participating PISA 2009 survey on mathematic achievement through MIMIC model approach, boys outperform girls. The higher education level of parents, higher socio-economic statue, and higher home possessions and higher home educational resources get improve mathematic achievement. Mathematic achievement is affected from learning strategies, positively with control and elaboration, and negatively with memorization.

Keywords: *Mathematic Achievement, PISA 2009, MIMIC Model*

INTRODUCTION

The OECD ‘Program for International Student Assessment’ (PISA) assesses and compares student achievement across the OECD and non-OECD countries. PISA assesses the student achievement based on three-years-period in 2000, in 2003, in 2006 and in 2009. Major domains are reading literacy in 2000 and 2009, mathematical literacy in 2003, and scientific literacy in 2006. Turkey participated in PISA in 2003 testing with mathematic, science, and reading to compare its education system with other OECD countries. PISA tests were applied to 15-year-olds students in schools. PISA aims at measuring how well students perform beyond the school curriculum rather than in terms of their school knowledge. PISA results show student performance as knowledge and skills. In addition, it displays relationship between student and school characteristics (PISA, 2004).

The results from the 2009 PISA assessment reveal wide differences in educational outcomes, both within and across countries. Korea, with a country mean of 546 score points in mathematics, is the highest performing OECD country. Three partner countries and economies, Shanghai-China, Singapore and Hong Kong-China, have a mean score that is around one proficiency level or more above the average of 496 score points in PISA 2009.

Other OECD countries with mean performances above the average include Finland (541), Switzerland (534), Japan (529), Canada (527), the Netherlands (526), New Zealand (519), Belgium (515), Australia (514), Germany (513), Estonia (512), Iceland (507), Denmark (503) and Slovenia (501). Three partner countries and economies perform above the average: Chinese Taipei (543), Liechtenstein (536) and Macao-China (525). Nine OE CD countries perform around the average: Norway, France, the Slovak Republic, Austria, Poland, Sweden, the Czech Republic, the United Kingdom and Hungary. The education systems that have been able to secure strong and equitable learning outcomes, and to mobilise rapid improvements, show others what is possible to achieve. Naturally, GDP per capita influences educational success, but this only explains 6% of the differences in average student performance. The other 94% reflect the potential for public policy to make a difference. The stunning success of Shanghai-China, which tops every league table in this assessment by a clear margin, shows what can be achieved with moderate economic resources and in a diverse social context. In mathematics, more than a quarter of Shanghai-China's 15-year-olds can conceptualise, generalise, and creatively use information based on their own investigations and modelling of complex problem situations. They can apply insight and understanding and develop new approaches and strategies when addressing novel situations. In the OECD area, just 3% of students reach that level of performance (PISA,2009). According to PISA 2009 results, Turkey (with mean of 445 score points) was below the OECD average (496 score points) in terms of both the mean point and rank in mathematics performance (OECD, 2010).

When looked at the previous studies, inconsistent findings are found about the relationship between the school resources and student performance. Some researchers suggested that more resources do not yield performance gains for the students (Hanushek, 1989; Okpala, Okpala and Smith, 2001; Papanastasiou, 2002). In contrast, some studies indicated that educational resources such as computers, library and teaching materials including textbooks and multimedia resources for learning are closely related to performance. Indeed, resources do have an influence on student achievement (Greenwald, Hedges and Laine, 1996; Oaker, 1989; D'Agostino, 2000; Schreiber, 2002).

2009 results of the program implemented once in three years were published in December 7, 2010. Comparison of the quality of education in Turkey with other participant countries in the light of the data reveals the following (OECD, 2010):

• Among the 40 countries which were included in the progamme in 2003, Turkey's rank in science and mathematics rose from 35th to 22rd place. In 2009 Turkey outscored Uruguay and Serbia with which it had similar mean scores in the test in 2003. Considering mean score in reading, Turkey outperformed Russia and advanced from 33rd to 32nd place.

• Among 65 countries evaluated in 2009's test, Turkey ranks the 43rd in science and mathematics and the 41st in reading proficiency.

• PISA 2009 results indicate that Turkey made an advance in both overall ranking and in mean reading, science and mathematics scores compared to 2003. Turkey's score in mathematics rose from 423 in 2003 to 445 in 2009. Similarly science mean score increased from 434 to 454 and reading mean score from 441 to 464 between 2003 and 2009. Despite the improvement in mean scores and ranking, Turkey could not make it to an upper level in reading proficiency, mathematics and science compared to 2003.2 Turkey's level was 2 in all three categories in 2003. Yet, 2009 results indicate that Turkey remains at the same level.

Turning to the situation of one country, the results indicate that Turkish students are well below international averages on various subjects, which increased the level of discourse about elementary and high school education in the country. This study focuses on differences in student performance in Turkish students. How large are these differences and where do they come from? The relationships between Socio-economic background, underlying social and economic inequality and mathematic performance at the student level were investigated using a MIMIC (Multiple Input Multiple Cause) model.

DATA AND MEASURES

Data used in this study consisted of 15 years old Turkish students participating PISA 2009 survey. After pairwise deletion of missing values of related variables 4855 of out of 3943 were used in the descriptive analyses and MIMIC modeling. According to this data, 51% of sample is male, 49% of female;20.1% of them have mother who has high school or university degree, 37.5% % of them have father who has high school or university degree. The variables used in the MIMIC modeling are given below. Notice that some of them are latent constructs (i.e., MATH, MEMOR, CONTROL, ELAB) while the others are covariates.

Mathematic Achievement (MATH): This is a latent endogenous construct measured by five different indicators of plausible values in mathematics computed for PISA 2009 survey.
PISA 2009 assesses students' use of learning strategies as memorization, elaboration and control strategies. Student learning strategies refer to cognitive and meta-cognitive processes employed by students as they attempt to learn something new.

MEMORISATION STRATEGIES(MEMOR) is a latent construct that refer to the memorization of texts and contents in all their details and repeated reading. Indicators of the MEMOR are;

- When I study, I try to memorize everything that is covered in the text
- When I study, I try to memorize as many details as possible
- When I study, I read the text so many times that I can recite it
- When I study, I read the text over and over again

ELABORATION STRATEGIES (ELAB) is a latent construct that refer to the transfer of new information to prior knowledge, out-of-school context and personal experiences. Indicators of the ELAB are;

- When I study, I try to relate new information to prior knowledge acquired in other subjects
- When I study, I figure out how the information might be useful outside school
- When I study, I try to understand the material better by relating it to my own experiences
- When I study, I figure out how the text information fits in with what happens in real life

CONTROL STRATEGIES (CONTROL) is a latent construct that mean to formulate control questions about the purpose of a task or a text and its main concepts. It also means to self-supervise current study activities, particularly whether the reading material was understood. Indicators of the CONTROL are;

- When I study, I start by figuring out what exactly I need to learn
- When I study, I check if I understand what I have read
- When I study, I try to figure out which concepts I still haven't really understood
- When I study, I make sure that I remember the most important points in the text
- When I study and I don't understand something, I look for additional information to clarify this

GENDER: is a dummy variable (0 for female and 1 for male students).

FISCED is a dummy variable indicating father's high school or university degree (0 for high education, 0 for not high).

MISCED is a dummy variable indicating mother's high school or university degree (0 for high education, 0 for not high).

MMINS is learning time (minutes per week) for Mathematics. The PISA index of minutes of mathematics instruction (MMINS) is calculated by multiplying the average length of a class period by the number of class periods receiving mathematics instruction. This index is derived from students' responses to the items measuring average length of a class period and their instructional time in mathematics in class periods. In some countries the amount of instructional time in mathematics varies across the year. This index indicates current instruction minutes in mathematics received by each student.

ENTUSE: The PISA index of ICT internet/entertainment use is derived from students' responses to the six items measuring the frequency of different types ICT (information and communication technology) use as listed below.

• The Internet to look up information about people, things, or ideas?
• Games on a computer?
• The Internet to collaborate with a group or team?
• The Internet to download software?
• The Internet to download music?
• A computer for electronic communication (e.g. e-mail or “chat rooms”)?

HEDRES: The index of home educational resources (HEDRES) is based on the items measuring the existence of educational resources at home including a desk and a quiet place to study, a computer that students can use for schoolwork, educational software, books to help with students’ school work, technical reference books and a dictionary.

WEALTH: Family wealth, the index of family wealth (WEALTH) is based on the students’ responses on whether they had the following at home: a room of their own, a link to the Internet, a dishwasher (treated as a country-specific item), a DVD player, and three other country-specific items; and their responses on the number of cellular phones, televisions, computers, cars and the rooms with a bath or shower.

CULTPOSS: Cultural possessions, the index of cultural possessions (CULTPOSS) is based on the students’ responses to whether they had the following at home: classic literature, books of poetry and works of art.

HOMEPOS: the index of home possessions (HOMEPOS) comprises all items on the indices of WEALTH, CULTPOSS and HEDRES, as well as books in the home recoded into a four-level categorical variable (0-10 books, 11-25 or 26-100 books, 101-200 or 201-500 books, more than 500 books).

ESCS: the PISA index of economic, social and cultural status (ESCS) was derived from the following three indices: highest occupational status of parents, highest educational level of parents in years of education according to ISCED, and home possessions (HOMEPOS).

The PISA index of economic, social and cultural status (ESCS) was derived from a principal component analysis of standardised variables (each variable has an OECD mean of 0 and a standard deviation of 1), taking the factor scores for the first principal component as measures of the index of economic, social and cultural status.

HIGHCONF: Confidence in ICT high level tasks, the PISA index of confidence in ICT high level tasks (HIGHCONF) is derived from students' responses to the seven questions listed below. All items are inverted for IRT scaling and positive values on this index indicated high self-confidence in ICT high level tasks.

• Use software to find and get rid of computer viruses.
• Use a database to produce a list of addresses.
• Create a computer program (e.g. in <Logo, Pascal, Basic>).
• Use a spreadsheet to plot a graph.
• Create a presentation (e.g. using <Microsoft® PowerPoint®>).
• Create a multi-media presentation (with sound, pictures, video).
• Construct a web page.

HOMSCH: The PISA index of ICT (information and communication technology) for school related tasks.

LIBUSE: The PISA index of use of libraries.

PROPOSED MODEL AND RESULTS

The main goal of this study is to conduct MIMIC model research investigating the effects of learning strategies (MEMOR, CONTROL, and ELAB) used as latent exogenous variables, as well as other student characteristics consisted of student background variables (GENDER, MMINS, ENTUSE, HIGHCONF, HOMSCH, and LIBUSE) and parent related variables (FISCED, MISCED, ESCS, HEDRES, HOMEPOS, and WEALTH) used as covariates. So that, our proposed model includes the research questions given below.

1. Are there effects of learning strategies on mathematic achievement? If so, what are the directions and effect sizes of them?
2. What are the gender differences in mathematic achievement?
3. Is there effect of learning time (minutes per week) for Mathematics on mathematic achievement?
4. Is there effect of ICT (information and communication technology) internet/entertainment use on mathematic achievement?
5. Is there effect of Confidence in ICT high level tasks on mathematic achievement?
6. Is there effect of ICT for school related tasks on mathematic achievement?
7. Is there effect of use of libraries on mathematic achievement?
8. Is there a significant difference between the students who have high educated fathers and who do not have?
9. Is there a significant difference in mathematic achievement between the students who have high educated mothers and who do not have?
10. Is there effect of economic, social and cultural status on mathematic achievement?
11. Is there effect of home educational resources on mathematic achievement?
12. Are there effects of home possessions on mathematic achievement?
13. Is there effect of family wealth on mathematic achievement?

Our proposed MIMIC model provides an acceptable fit (χ^2 =2601.064, d.f.= 333; RMSEA= 0.042; P(RMSEA<0.05)=1.0; CFI=0.948; TLI=0.942; SRMR=0.048). The correlations between MEMOR and CONTROL, between MEMOR and ELAB, and between CONTROL and ELAB were 0.488, 0.310, and 0.811 respectively. The path coefficients to mathematic achievement with their corresponding standard errors and t values obtained from this MIMIC model are summarized in Table 1. To provide a remedy for the multicollinearity problem sourced from the high correlations between exogenous construct of MEMOR, CONTROL and ELAB, each of them modeled individually and separately rather than using all of them in same model.

The total variation in mathematic achievement explained by these factors (coefficient of determination) was 49.1%. The effects CONTROL, ELAB, GENDER, FISCED, MISCED, MMINS, ESCS, HEDRES, HIGHCONF, and HOMEPOS were positive while the effects of MEMOR, HOMSCH, LIBUSE, and WEALTH on mathematic achievement were found negative. There was no significant effect of ENTUSE on mathematic achievement.
The use of CONTROL and ELAB strategies get increase mathematic achievement, while us of MEMOR causes decrease on mathematic achievement.

A significant direct effect of covariate on latent factor represents population heterogeneity; that is, the factor means are different at different levels of covariate (Brown, 2006). Following this interpretation, the unstandardized direct effect of gender on latent factor mathematic achievement is 21.563, then the latent means of males and females differ by 21.563 units in favor of male student.

CONCLUSION

Mathematics achievement based on PISA has been discussed extensively elsewhere (eg., Chiu and Xihua, 2008, Chow et al., 2007). Some researches carried out comparative studies. As a comparative study between the United States and Hong Kong, Wang (2004) used The Third International Mathematics and Science Study (TIMSS) data compare students from the US on the mathematics achievement and on a series of family background factors such as mothers' expectations, parental education, living with family members and extracurricular time spent in various activities. Results indicate that Hong Kong students outperformed their US counterparts in mathematics scores and some of the factors influenced Hong Kong and US students differently. From this example and the other comparation studies in literature, factors effcting mathematic achievement may be different among countries as they may have different education system, different social, economical and cultural properties.

Our findings from PISA 2009 results have shown that after learning time of mathematics, students' socio-economic background variables are stronger predictor of achievement. The higher education level of parents, higher socio-economic statue, the higher home possessions, higher educational resources at home, and higher confidence in ICT get increase mathematic achievement. Uses of memorization strategy, ICT for school related tasks and library get decrease mathematics achievement. In addition, family wealth affects student's mathematic achievement negatively.

TABLE 1. RESULTS FROM THE PROPOSED MODEL OF MATHEMATIC ACHIEVEMENT

Factors: *Exogenous construct*	**Path Estimate**	**Standard error**	**t value**	**p value**
MEMOR	-36.431	2.183	-12.515	0.000***
CONTROL	33.239	3.481	9.845	0.000***
ELAB	41.772	3.357	11.924	0.000***
Covariates				
GENDER	21.563	2.183	9.878	0.000***
FISCED	19.019	3.481	5.464	0.000***
MISCED	18.657	3.357	5.558	0.000***
MMINS	0.296	0.014	21.935	0.000***
ENTUSE	0.001	0.001	0.672	0.508
ESCS	8.268	2.368	3.491	0.000***
HEDRES	2.561	1.776	2.123	0.034*
HIGHCONF	3.526	1.037	3.401	0.005**
HOMEPOS	27.934	3.872	7.215	0.000***
HOMSCH	-9.960	1.060	-9.397	0.000***
LIBUSE	-14.236	1.123	-12.679	0.000***
WEALTH	-18.653	3.078	-6.059	0.000***

*p<0.05, **p<0.01***p<0.001

Control strategies are essential for effective self-regulation of learning because they help students adapt their learning to the particular task at hand. Schools may need to focus on allowing students to manage and control their learning in order to help them develop effective strategies, not only to support their learning at school but also to provide them with the tools to manage their learning later in life (OECD, 2010).

Memorization strategies, such as reading material aloud several times and learning key terms, are important in many tasks, but they commonly lead only to verbatim repetitions of information. Students who rely heavily on memorization strategies tend to store information as it is, with little further processing. Memorization strategies are useful when all a learner is asked to do is store information and retrieve it as originally presented. Since research suggests that memorization strategies do not lead to deep understanding, they do not help develop students' skills to extrapolate the underlying meaning and message of stored information so that new material can be integrated with prior knowledge accumulated on/from diverse contexts elaboration strategies, such as exploring how the material relates to things one has learned in other contexts, or asking how the information might be applied in other situations, can be used to reach the goal of deep understanding. Some researchers have argued that memorization is an inefficient strategy for learning new material and memorization was negatively associated with achievement. (e.g., Czuchry and Dansereau, 1998). In this study, this situation was empricially supported.

Elaboration strategies reflect the extent to which students are prepared to use the knowledge acquired at school outside of school. Schools and education systems that ensure that students can use effective elaboration strategies can help equip them for the challenges of an ever-changing world by fostering their ability to become lifelong learners.

Earlier studies on science achievement found gender differences favoring males, recent ones proposed that the gap has narrowed substantially, if not disappeared (Lauzon, 2001; Ulkins, 2007; Brotman & Moore, 2008). Yet studies utilizing PISA data show that gender gap still exists. For example, Ma (2003) found that boys outperformed girls in scientific literacy among both immigrant and nonimmigrant groups on PISA 2000 in France. Examining 28 OECD countries' PISA 2000 data, Langen, Bosker, and Dekkers (2006) showed that boys did better than girls in all countries. In this study also, boys outperformed girls in terms of mathematic achievement. "Turkey is amongst the countries who achieved the largest score improvements; however we could not make it to the upper level. In the assessment where 1 denotes the worst and 6 denotes the best performance, Turkey's level is 2 in all three categories - science, mathematics and reading – both in 2003 and 2009. Although the recent steps in the right direction taken in the field of education proved fruitful, need for a comprehensive reform in education still prevails."

Among the many factors that influence scholastic proficiency, teaching and learning strategies are second only to home circumstances in their proximity to the day-to-day activities of students and hence in their potential to influence performance directly. Teaching strategies also change through educational policy initiatives and through teacher education and professional development. Determining which teaching and learning strategies are most effective in improving overall performance and reducing disparities in performance is one of the primary functions of educational research and one of the most direct ways in which policy decisions can influence learning.

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