A STUDY OF VARIABLES AFFECTING ON A QUALITY ASSESSMENT OF MATHEMATICS SUBJECT BY USING VALUE ADDED ANALYSIS ON TIMSS 2011

Ruangdech Sirikit[1]

Abstract: The purposes of this research were 1) to study results of characteristics variables of students and schools towards the quality assessment of mathematics subject in the countries with high test scores – Republic of Korea and Singapore; and 2) to compare the similarity and difference of characteristics variables of students and schools towards the quality assessment of mathematics subject between Republic of Korea, Singapore and Thailand. The secondary data from Trends in International Mathematics and Science Study (TIMSS 2011) was used in this research. The samples were students, mathematics teachers who taught the student samples and executives of schools where the student samples were studying by dividing into: 150 schools and 5,166 students in the Republic of Korea; 165 schools and 5,927 students in Singapore; and 172 schools and 6,124 students in Thailand. The research specifically focused on mathematics subject with 14 papers of knowledge evaluation test on mathematics. There were 4 steps of data analysis – 1) To Organizing data according to the study factor 2) To estimate competency of students from the assessment of their mathematics proficiency by using MULTILOG program analysis of data; and estimation on competency of students from assessment of their mathematics proficiency by using MULTILOG program in 3) analyzing the value added in the model of quality assessment by applying the Value-Added Model with Hierarchical Linear Modeling (HLM) with 2 levels of analysis; and 4) comparing the similarity and difference of characteristics variables of students and schools towards the quality assessment of mathematics subject.

Results

1. Analysis of all variances proportional to the explained dependent variables or coefficient of determination (R^2) showed that the coefficient of determination in student level and school level was at 0.3395 (33.95%) and 0.8207 (82.07%) in the Republic of Korea and at 0.1147 (11.47%) and 0.5271 (52.71%) in Singapore.
2. Multi-level analysis of student-level variables showed that there were a total of 8 variables affecting the quality of mathematics subject, divided into 5 variables in all three countries, 2 variables in two countries and 1 variable in one country. There were a total of 7 school-level variables affecting the quality of mathematics subject, divided into 1 variable in two countries and 6 variables in one country.

Keywords: Variables, Quality Assessment of Mathematics Subject, Value-Added Analysis

---

[1] Ph.D., Lecturer, Educational and Psychological Test Bureau, Srinakharinwirot University, Thailand.
ruangdech_s@hotmail.com

Introduction

The Value-Added Model is the method which helps report the results to reflect the information on education arrangement that how much the value added the schools are able to create in learning results by comparing actual scores or observed scores to predicted scores from variables on background of students, community contexts, societies or existing achievements (Sirichai Kanjanawasi, 2007). The Value-Added Model in the education is applied to compile statistic techniques from students' test scores in order to assess the effect size of school or teacher (MaCaffrey, Lockwood, Koretz, & Hamilton, 2003). The Value-Added Model is implemented in two ways – one is to estimate the school for its accountability and another is to assess the teacher who is the relative efficiency with other teachers. Some models would particularly take into account the existing knowledge of students or combine other variables such as gender, religion and economic status of students in the consideration.

According to the assessment results of TIMSS 2011, Republic of Korea has the highest average score at 613 and Singapore has the second highest average score at 611 while Thailand has the average score at 427 which is in the poor level.

Applying the concept of value added analysis to the quality assessment of education arrangement is therefore the guideline which enables the information to reflect the performance of school and to fairly compare the operating results of school because other factors with different bases which may have unequal inputs of educational system are controlled. The result of value added measure which is implemented is thus accurate, reliable and useful in some respects to related persons such as policy makers, executives, teachers as well as students and their parents.

Objectives

To study results of characteristics variables of students and schools towards the quality assessment of mathematics subject in Republic of Korea and Singapore in two following issues:

1. To study results of characteristics variables of students and schools towards the quality assessment of mathematics subject in the countries with high test scores – Republic of Korea and Singapore.
2. To compare the similarity and difference of characteristics variables of students and schools towards the quality assessment of mathematics subject between Republic of Korea, Singapore and Thailand.

Literature Review

Value added of arrangement for mathematics subject in the school means the differential between the average competency parameters of school that are actually measured and the average competency parameters of school that are obtained from estimation and prediction from factors or variables of such school.

Quality of arrangement for mathematics subject of basic school means the value added scores of school or residual value from value added analysis in each model of quality assessment of education arrangement. The quality of education arrangement in the school in this research indicates the execution of arrangement in each school in order for students to have their learning with control of student- and school-level variables which are beyond control of the school.

Competency value of students from measurement of achievement in mathematics subject means the student's competency parameters from TIMSS 2011 test. The estimation of student's competency parameters came from the analysis results with MULTILOG program.

Methods

The methods of research were divided into 3 sections: 1) data for research; 2) collection of data; and 3) analysis of data with following details:

Section 1: Data for Research

1) Study Samples

The samples were students, mathematics teachers who taught the student samples, and executives of schools where the students' samples were studying as shown in the Table 1 below:

Table 1: Number of Samples to Collect Data for Assessment by Country

Samples	Number of Schools	Number of Teachers	Number of Students
Republic of Korea	150	376	5,166
Singapore	165	329	5,927
Thailand	172	172	6,124

2) Tools for collecting data included:

Test – TIMSS 2011 comprised examinations of mathematics subject. In collecting data for assessment, there were 14 papers of mini test each of which was in the range between 26 – 34 items. The arrangement of test for project students relied on the systematic random of test. Thus, the students with adjoining sequence of test would have no chance to receive the same test and each student must simultaneously start each part of the test which comprised multiple-choice item and constructed-response item. Creating test was originated from synthesizing contents and curricula from various participating countries.

Section 2: Variables for Research

Variables used in this research were the data which came from the database in the TIMSS 2011 results assessment project. I took into consideration the structure of data in the education arrangement system which was hierarchical type; that was to say, the student were inserted into the school. The variables in this research were thus divided into student level and school level and might have different name in the TIMSS 2011 database in order to be appropriate and in conformity with the study of related documents and research.

Section 3: Analysis of Data

This research entitled "A Study of Variables Affecting on a Quality Assessment of Mathematics Subject by Using Value Added Analysis on TIMSS 2011" had 4 steps of analysis as follows:

Step 1 Organizing data according to the study factor
The analysis of basic statistic value of data was conducted with analysis program SPSS 19 for windows for analyzing fundamental data by means of descriptive statistics i.e. frequency, percentage, mean, standard deviation, highest value and lowest value.

Step 2 Estimating students' competency
To estimate students' competency from the assessment of their mathematics proficiency by Trends in International Mathematics and Science Study (TIMSS) 2011, the MULTILOG program was utilized to analyze the competency of testees.

Step 3 Analyzing the value added in the model of quality assessment

3.1 Analyzing the value added

To analyze the value added in the model of quality assessment, the Hierarchical Linear Modeling (HLM) with 2 levels of analysis was applied for analyzing the value added in the model of quality assessment in 3 countries – Republic of Korea, Singapore and Thailand with HLM program for Windows Version 6.03 to analyze each level.

3.2 Coefficient of determination

Competency in describing variance of dependent variables with predictor variable or coefficient of determination (R^2) in each model had the following equation:

$$\frac{\text{Variance of residual value reduced when with predictor variable}}{\text{Variance of residual value reduced when without predictor variable}}$$

Step 4 Comparing the similarity and difference of characteristics variables of students and schools towards the quality assessment of mathematics subject
The multi-level analysis results were used in comparing the similarity and difference of characteristics variables of students and schools towards the quality assessment of mathematics subject by taking in account the student-level and school-level variables significantly affecting the quality of mathematics subject.

Results

1. *Results of characteristics variables of students and schools towards the quality assessment of mathematics subject*

Republic of Korea
Multi-level analysis results of the Republic of Korea from fixed effect tests showed that the mean of students' competency from the assessment of their mathematics proficiency in every school (G00) had statistically significant variation at the level .01 (G00 = 0.888, p = 0.00). The regression coefficient of school-level variables with highest positive value was the level of learning and teaching arrangement support from the parents (β = 0.048); that was to say, the school with high level of learning

and teaching arrangement support from the parents would increase the students' competency from the assessment of their mathematics proficiency, followed by the professional experience of teacher in the school (β = 0.004). The student-level variables with highest positive effect were the level of Self-confident in mathematics learning (β = 0.382), followed by the level of enjoyment in mathematics learning (β = 0.180).

The results of random effect tests showed that the school-level residual value of students' competency from the assessment of their mathematics proficiency with control of variables in the student and school level (U0) or value added of schools had statistically significant variation between schools at the level .01 (χ^2 = 208.163) with variance between schools at 0.010, which represented approximately 1.86%, and variance in the school at 0.527, which represented about 98.14%. The analysis of all variances proportional to the explained dependent variables or coefficient of determination (R^2) showed that the coefficient of determination in student level and school level was at 0.3395 (33.95%) and 0.8207 (82.07%)

Singapore

Multi-level analysis results of Singapore from fixed effect tests showed that the mean of students' competency from the assessment of their mathematics proficiency in every school (G00) had statistically significant variation at the level .01 (G00 = 0.504, p = 0.00). The regression coefficient of school-level variables with highest positive value was the extra-large school (β = 0.512); that was to say, the extra large-scale school would increase the students' competency from the assessment of their mathematics proficiency, followed by the large scale school (β = 0.439). The student-level variables with highest positive effect were the level of Self-confident in mathematics learning (β = 0.115), followed by the level of enjoyment in mathematics learning (β = 0.101).

The results of random effect tests showed that the school-level residual value of students' competency from the assessment of their mathematics proficiency with control of variables in the student and school level (U0) or value added of schools had statistically significant variation between schools at the level .01 (χ^2 = 1,797.479) with variance between schools at 0.076, which represented approximately 23.68%, and variance in the school at 0.245, which represented about 76.32%. The analysis of all variances proportional to the explained dependent variables or coefficient of determination (R^2) showed that the coefficient of determination in student level and school level was at 0.1147 (11.47%) and 0.5271 (52.71%).

2. *Results of comparing the similarity and difference of characteristics variables students and schools towards the quality assessment of mathematics subject between Republic of Korea, Singapore and Thailand*

Multi-level analysis results of student-level variables showed that there were a total of 8 variables affecting the quality of mathematics subjects. 5 variables which affected the quality of mathematics subject in all three countries included the attention of parents, educational level of parents, resources at home, level of self-confidence in mathematics learning, and level of enjoyment of mathematics learning. The 2

student-level variables which affected the quality of mathematics subject in two countries included the level of time consumption for mathematics homework and extrinsic motivation of mathematics learning. One variable affecting the quality of mathematics subject in one country was the wealth of family.

Multi-level analysis results of school-level variables indicated that there were a total of 7 variables affecting the quality of mathematics subjects. One variable which affected the quality of mathematics subject in two countries was the extra large-scale school while other 6 variables affecting the quality of mathematics subjects in one country included large-scale school, medium-scale school, level of learning and teaching arrangement support from the parents, level of awareness to the good working atmosphere, professional experience of teacher in the school and the level of homework assignment from teacher in the classroom. As shown in the Table 2 below:

Table 2: Coefficient of Characteristics Variables Students and Schools towards The Quality Assessment (Republic of Korea, Singapore and Thailand)

variables	Coefficient		
	Korea	Singapore	Thailand
Competency of students	0.888**	0.504**	- 0.628**
Student level			
Sex	0.042	0.023	- 0.013
Attention of parents	- 0.028*	- 0.041**	0.029**
Educational level of parents	0.091**	0.029**	0.012*
Resources at home	0.142**	0.066**	0.038**
Family Wealth	0.088**	NA	0.011
The level of time consumption for mathematics homework	- 0.063**	0.098**	- 0.008
The level of Self-confident in mathematics learning	0.382**	0.115**	0.029*
The level of enjoyment in mathematics learning	0.180**	0.101**	0.061**
Extrinsic motivation in mathematics learning	0.144**	- 0.008	0.045**
Esteem in mathematics	- 0.026	0.006	0.024
School level			
Extra-large school	NA	0.512**	0.231**
Large school	0.138	0.439*	0.114
Medium school	0.025	0.093	0.138*
Location schools in large cities	0.365	NA	0.150
Location school in a big city	0.305	NA	0.010
Location schools in the city	0.347	NA	0.155
Location schools in the township	0.294	NA	- 0.015
Responsibilities of Teachers	- 0.021	- 0.082	0.060

Level of learning and teaching arrangement support from the parents	0.048**	0.058	0.038
The resources used to support teaching and learning of school	- 0.013	- 0.056	0.005
Activities that support learning in mathematics	0.017	0.040	- 0.039
level of awareness to the good working atmosphere	0.029	- 0.176**	- 0.0161
The development of the teachers in the schools	- 0.026	0.044	0.066
The professional experience of teacher in the school	0.004*	0.004	0.001
Satisfaction of teachers towards the institution	0.029	0.072	- 0.033
level of homework assignment in the classroom	0.008	0.077*	0.056
Class size	- 0.027	0.090	0.002
The collaboration of teachers in schools.	- 0.027	0.018	0.006
Satisfaction with the working teacher professional.	0.001	- 0.008	0.045
The level of teaching students to engage in learning.	0.026	0.069	- 0.012
The frequency of a math test in the classroom.	0.019	- 0.049	0.016
variance components			
Level 1 – Variance within educational institutions (R)	0.527	0.245	0.247
Level 2 – Variance between educational institutions (U0)	0.010	0.076	0.094
Variance level of students' competency from mathematics proficiency evaluation at			
within educational institution (Level 1)	98.14%	76.32%	72.43%
Between educational institution (Level 2)	1.86%	23.68%	27.57%
Proportion of all variance of explained dependent variables (R^2)			
Level 1	0.3395 (33.95%)	0.1147 (11.47%)	0.0245 (2.45%)
Level 2	0.8207 (82.07%)	0.5271 (52.71%)	0.2785 (27.85%)

**p < .01, *p < .05

Discussion

The study of variables affecting the quality of mathematics subjects by applying the value added analysis through the project of Trends in International Mathematics and Science Study (TIMSS) of 2011 were concluded in two issues as follows:

1. *Results of characteristics variables of students and schools towards the quality assessment of mathematics subject in the countries with high test scores – Republic of Korea and Singapore*

The results showed that several variables affecting the change to assessment scores of mathematics in the Republic of Korea and Singapore included student-level variables, such as, attention of parents, educational level of parents, resources at home, level of time consumption for mathematics homework, level of self-confidence in mathematics learning, level of enjoyment of mathematics learning and extrinsic motivation of mathematics learning; and school-level variables, such as extra large-scale school, large-scale school, level of learning and teaching arrangement support from the parents, level of awareness to the good working atmosphere, professional experience of teacher in the school and the level of homework assignment from teacher in the classroom. It was indicated that the characteristics of variables in the level of student and school affected the quality assessment of mathematics subject which was in conformity with the reality; for example, the quality of school in many countries are relatively much different due to the difference of important resources i.e. money, personnel or size of school. Such difference is therefore like the different value added in each school.

2. *Comparing the similarity and difference of characteristics variables of students and schools towards the quality assessment of mathematics subject between Republic of Korea, Singapore and Thailand.*

From comparing the similarity and difference of characteristics variables of students and schools towards the quality assessment of mathematics subject between Republic of Korea, Singapore and Thailand, the quality assessment of mathematics subject by effectively analyzing the value added is required to take into account various details of variables in the student level and school level which can enhance the reliability of assessment results obtained.

References

Thai Language

Anong Intaprom (2009). *A Multilevel Analysis of Teacher-Level and Student-Level Factors Effecting on Students' Mathematics Achievement.* Doctoral Thesis, Department of Educational Research and Psychology, Faculty of Education, Chulalongkorn University.

Boonrueng Sriharun (2009). *A Study of Educational Factors Relating to and Influencing Student Outcomes and School Effectiveness Using Hierarchical Linear Models.* Doctoral Thesis (Curriculum Research and Development), Graduate School, Srinakharinwirot University. Prasarnmit Campus.

IPST (2009). *Trends in International Mathematics Study*. Bangkok: Institute for the Promotion of Teaching Science and Technology.

IPST (2011). *Sample Examination for Assessment of Mathematics Learning Results.* Bangkok: Institute for the Promotion of Teaching Science and Technology.

Ittirith Phongpiyaratana. (2008). *An Item Analysis and An Investigation of Differential Item Functioning: A Multilevel Analysis.* Doctoral Thesis, Department of Educational Research and Psychology, Faculty of Education, Chulalongkorn University.

Nittaya Muadthaisong (2000). *Casual Mediation of Student, Teacher and School Factors Affecting Mathematics Achievement: A Meta-Analysis of Research*. Master Thesis (Educational Research), Faculty of Education, Chulalongkorn University.

Pichit Dhammarak (2006). *Factors Affecting Mathematics Learning Achievement of Language Arts Program Students in Bangkok Metropolis*. Master Thesis, Department of Educational Research and Psychology, Faculty of Education, Chulalongkorn University.

Prakrittiya Tuksino. (2009). *A Quality Assessment of Science Instructional Management in Basic Education Schools: An Application of Differential Item Functioning and Value-Added Model.* Doctoral Thesis, Department of Educational Research and Psychology, Faculty of Education, Chulalongkorn University.

Rakchanok Yeesunesri. (2000). *An Analysis of Differential Functioning of Items and Tests based on DFIT Procedures in English and Mathematics for University Entrance Examination.* Master Thesis, Department of Educational Research and Psychology, Faculty of Education, Chulalongkorn University.

Ruangdech Sirikit (2011). *Comparative Analysis of the Model of a Quality Assessment of Mathematics Subject: An Application of Differential Item Functioning and Differential Distractor Functioning.* Doctoral Thesis, Department of Educational Research and Psychology, Faculty of Education, Chulalongkorn University.

Sirichai Kanjanawasi. (2007). *Multi-Analysis.* 4th Edition. Bangkok: Chulalongkorn University Press.

Sirichai Kanjanawasi. (2005). *Classical Test Theory*. 5th Edition. Bangkok: Chulalongkorn University Press.

Sirichai Kanjanawasi. (2007). *Modern Test Theories.* 3rd Edition. Bangkok: Chulalongkorn University Press.

Sucheera Mahimuang (2004). *Factors Influencing Academic Achievement and Improvement: A Value-Added Approach.* Doctoral Thesis (Educational Research), Faculty of Education, Chulalongkorn University.

English Language

Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist* 44: 1175 – 1184.

Camilli G., and Shepard L. A. (1994). *Method for identifying biased test items.* California: SAGE.

Cheong, Y. F. (2006). Analysis of school context effects on differential item functioning using hierarchical generalized linear models. *International Journal of Testing* 6(1): 57-79.

Chiu, M. M., Xihua, Z. (2008). Family and motivation effect on mathematics achievement: Analyses of students in 41 countries. *Learning and Instruction* 18: 321-336.

D'Agostino, J. V. (2000). Instructional and school effects on student' longitudinal reading and mathematics achievements. *School Effectiveness and School Improvement* 11: 197-235.

Green B. F., Crone C. R., and Folk V. G. (1989). A Method for studying differential distractor functioning. *Journal of Educational Measurement* 26(2): 147-160.

Hack, R. H. (2000). Examining the impact of school quality on school outcomes and improvement: A value-added approach. *Educational Administration Quarterly* 36(4): 513-552.

Hægeland, T., Kirkebøen, L. J. (2008). School performance and value added indicators what is the effect of controlling for socioeconomic background? *Research Department.* [Online]. Available from http://www.ssb.no/english/ subjects/04/90/doc_200808_ en/doc_200808_en.pdf [2008, March 3]

Hambleton K. R., Swaminathan H., and Rogers H. J. (1991). *Fundamentals of item response theory*. California: SAGE.

Koon S. (2010). *A Comparison of methods for detecting differential distractor functioning*. Doctoral dissertation, Florida State University.

Lord F. M. (1980). *Applications of item response theory to practical testing problems. Hillsdale.* New Jersey: Lawrence Erlbaum Association.

Mellenbergh G. J. (1994). Generalized linear item response theory. *Psychological Bulletin* 115(2): 300-307.

Middleton K., and Laitusis C. C. (2007). *Examining test items for differential distractor functioning among students with learning disabilities.* Princeton, NJ. Education Testing Service.

Monahan O. Patrick, and co. (2007). Odds Ratio, Delta, ETS classification, and standardization measures of DIF magnitude for binary logistic regression. *Journal of Educational and Behavioral Statistics.* 32(1): 92–109.

Narayanan P. and Swaminathan H. (1994). Performance of the Mantel-Haenzel and simultaneous Item bias proceders for detecting differential item functioning. *Applied Psychological Measurement* 18: 15-328.

Oshima, T. C., Raju, N. S., and Nanda, A. O. (2006). A new method for assessing the statistical significance in the differential functioning of items and tests (DFIT) framework. *Journal of Educational Measurement* 43: 1-17.

Palardy, G. J. (2008). Differential school effects among low, middle, and high social class composition schools: a multiple group, multilevel latent growth curve analysis. *School Effectiveness and School Improvement* 19(1).

Postlethwaite, T. N., (2004). *Monitoring educational achievement.* Paris, UNESCO. Institute for Educational Planning.

Potenza M. T., and Dorans N. J. (1995, March). DIF assessment for polytomously scored item: A framework for classification and evaluation. *Applied Psychological Measurement* 19(1): 23-37.

Raju N. S. (1990). Determining the significance of estimated signed and unsigned areas between two Item response functions. *Applied Psychological Measurement.* 19(4): 353-368.

Raju N. S., Fortmann-Johnson K. A., Kim W., Morris S. B., Nering M. L., and Oshima T.C. (2009). The item parameter replication method for detecting differential functioning in the polytomous DFIT framework. *Applied Psychological Measurement* 33: 133-147.

Shealy R., and Stout W. T. (1993). A Model-base standardization approach that separates true Bias/DIF as well as item Bias/DIF. *Psychometrika*, 58(2): 159-194.

TIMSS. (2011). *User guide for the International database*. Publisher: TIMSS & PIRLS International Study Center. Lynch School of Education, Boston College.

Trautwein, Ludtke, Schnyder and Niggli. (2006). Predicting homework effort: Support for a domain-specific, multilevel homework model. *Journal of Educational Psychology* 98: 438-456.