The Fourth Grade Students' Science Cognitive Performance and Influential Factors of Six Countries in TIMSS 2003

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Abstract

The fourth grade students' science cognitive performance and influential factors of the six best achievement countries, Singapore, Chinese Taipei, Japan, Hong Kong, England, and the United States, in TIMSS 2003 are discussed. The cognitive performances are studied in three domains, factual knowledge, conceptual understanding, and reasoning and analysis. T-test and one-way ANOVA are applied to examine the influential factors. The results showed that the fourth graders from Taiwan and Singapore have the best performance in factual knowledge and conceptual understanding domains among six countries. Japanese fourth graders performed best in reasoning and analysis domain. The variables of gender, family's book collection, whether a PC in one's family, interest in science, and confidence in science, are positively correlated to students' performances in factual knowledge and in conceptual understanding. Confidence in science is positive correlated to performance in reasoning and analysis.

Keywords: *cognitive domain, factual knowledge, conceptual understanding, reasoning and analysis*

Introduction

The status of a nation's educational performance shows its power in many ways, such as student achievements of mathematic and science, which seems to become a future competitive indicators of a nation. Therefore, the government of a nation always pays a lot of attention on its educational policies and also thinks that the education is a great enterprise. Some following up improvement of policy on the educations might be brought up according to international education researches or investigated consequences. Trends in International Mathematics and Science Study 2003 (TIMSS 2003) is held by the International Association for the Evaluation of Educational Achievement (IEA) for investigating students' mathematics and science performance as well as some variables periodically. According to TIMSS 2003 Assessment Framework, there are two organizing dimensions, a content dimension and a cognitive

dimension. For a more detailed description, please see TIMSS Assessment Framework (Mullis, Martin, Smith, Garden, Gregory, Gonzales, Chrostowski, and O'Connor, 2001). However, there is not much information about science achievement along with cognitive domains of fourth grade students in TIMSS 2003. The purpose of this study is to examine relationships of TIMSS 2003 fourth grade student science performances among six countries, cognitive domains, and background variables. That Singapore, Chinese Taipei, Japan, Hong Kong, England, and the United States are selected for this study is because they are the best six performed countries in fourth grade science of TIMSS 2003 (Martin, Mullis, Gonzalez, Gregory, Smith, Chrostowski, Garden, and O'Connor, 2004).

This study focused on fourth grade science cognitive dimension and tried to compare and analyze the influential factors on students' performance among Singapore, Chinese Taipei, Japan, Hong Kong, England, and the United States. Consequences of this study can provide us a better understanding about student learning factors from cognitive dimension. Information along with teacher character from individual country may serve as a valuable reference for policy deciders, educators, and educational workers in teaching and improving education.

Methodology and Data Sources

1. Research Design

The data of Singapore, Chinese Taipei, Japan, Hong Kong, England, and the United States was selected from TIMSS 2003 fourth grade student science achievement database for analysis in cognitive dimension, including factual knowledge, conceptual understanding, and reasoning and analysis. Variables in student's background, interest in learning science, and confidence in learning science were processed to discuss the factors that have impact on performances in cognitive domains. The structure of this study is shown as Figure 1. Variables corresponding to items of questionnaire are listed on Table 1.

[Take in Figure 1 about here]

[Take in Table 1 about here]

2. Subject and Data Sources

The best six performed countries in fourth grade science of TIMSS 2003 are selected for this study. Numbers of participated students in each country are shown on Table 2. Raw data of students' answers on CD-ROM attached with TIMSS 2003 User Guide for the International Database (Martin, 2005) were used for this study. There were some important information

used from TIMSS 2003 International Science Reports, International Technical Reports, and questionnaires.

[Take in Table 2 about here]

3. Statistic Methods

Correct percentage of items in each country was applied to analyze the relationships between variables and cognitive domain. Items were classified by their cognitive domain–scaling, and country averages of items' correct percentage in three domains were compared. T-test and one-way ANOVA along with aftermath comparison were applied to examine which county performed the best in cognitive dimension.

Finding and Discussion

1. Correct Percentage of Items in Each Cognitive Domain

The item correct percentages of each country in three cognitive domains were shown on Table 3. It showed clearly that students performed best in factual knowledge, less in reasoning and analysis in each country. Along with the results of one-way ANOVA and Post Hoc comparison in cognitive domains among six countries, student performances of Singapore and Chinese Taipei are prior to other countries' in factual knowledge and conceptual understanding. Japanese students performed the best in reasoning and analysis, shown on Table 4.

[Take in Table 3 about here]

[Take in Table 4 about here]

2. Students' Cognitive Performances by Gender

As the student variables correlated to students' performances in cognitive domains, the gender showed significant difference in factual knowledge and conceptual understanding in all students of six countries. There was no significant difference between boys and girls in reasoning and analysis among six countries (shown on Table 5). Boys performed better than girls in cognitive dimension. For individual country, boys of Chinese Taipei performed better than girls significantly in factual knowledge and conceptual understanding; as well as boys of the United States performed better than girls significantly in conceptual understanding.

[Take in Table 5 about here]

3. Students' Cognitive Performances by Family Book Collection and Whether a PC in One's Family

As the variables of family book collection in one's family showed the positive influence in factual knowledge and conceptual understanding among six countries (shown on Table 6) and no significant difference in reasoning and analysis except Chinese Taipei. As the variables of whether a PC in one's family showed the same pattern as book collection (shown on Table 7) .

[Take in Table 6 about here]

[Take in Table 7 about here]

4. Students' Cognitive Performances by Interest in Science and Confidence

Interest in science and confidence showed the positive influence in factual knowledge and conceptual understanding among six countries. Interest in science did not show significant difference in reasoning and analysis, but confidence did. According to Piaget's cognitive developmental theory, fourth grade students may be not well developed in high level thinking skills; therefore, students would not show significant difference in reasoning and analysis.

Conclusions

All fourth grade students of six countries performed best in factual knowledge, and much less in reasoning and analysis. Boys performed better than girls in cognitive dimension. The variables of gender, family's book collection, whether a PC in one's family, interest in science, and confidence in science are positively correlated to students' performances in factual knowledge and in conceptual understanding. However, only confidence in science is positive correlated to performance in reasoning and analysis.

References

Martin, M. O., Mullis, I. V. S., Gonzalez, E. J., Gregory, K. D., Smith, T. A., Chrostowski, S. J., Garden, R. A., and O'Connor, K. M. (2004). *TIMSS 2003 International Science Report: Findings From IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades.* Chestnut Hill, MA: Boston College.

Martin, M.O. (2005). *TIMSS 2003User Guide for the International Database.* (Ed.) Chestnut Hill, MA: Boston College.

Mullis, I.V.S., Martin, M.O., Smith, T.A., Garden, R.A., Gregory, K.D., Gonzalez, E.J., Chrostowski,

S. J., and O'Connor, K. M. (2001). *TIMSS assessment frameworks and specifications 2003*. Chestnut Hill, MA: Boston College.

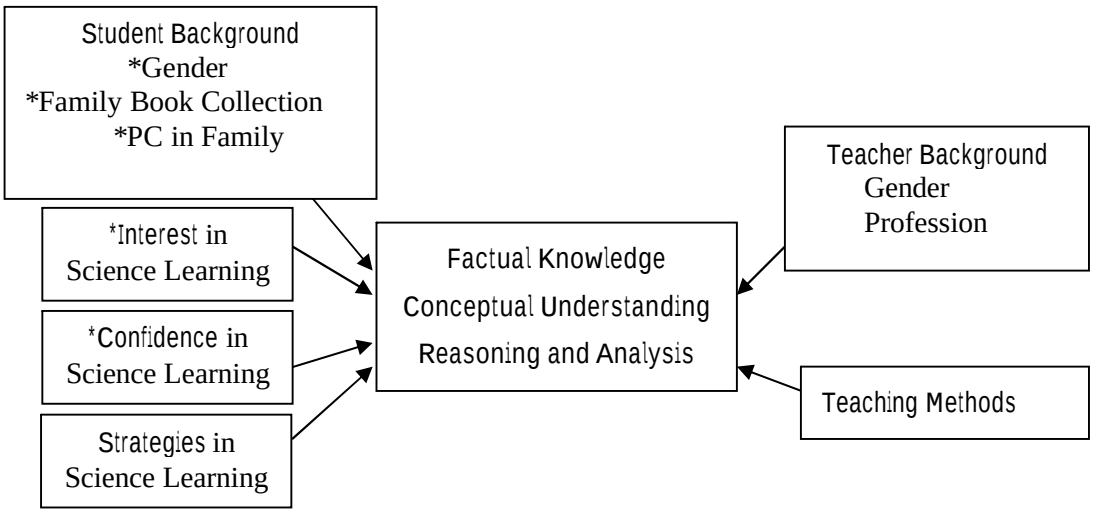

Figure 1. Structure of research: variables with * were studied.

Table 1: Variables corresponding to items of questionnaire

Variables	Items of questionnaire
Student Background	▪ Are you a girl or a boy? ▪ About how many books are there in your home? ▪ Do you have any of these items at your home? (b) Computer
Interest in Science Learning	▪ I would like to do more science in school ▪ I enjoy learning science
Confidence in Science Learning	▪ I usually do well in science ▪ Science is harder for me than for many of my classmates ▪ I am just not good at science ▪ I learn things quickly in science

Table 2: Numbers of participated students in each country (Data from Martin *et al.*, 2004, p.373 and p.375)

Rank of science achievement	Countries	Number of participated schools	Number of participated students
1	Singapore	182	6668
2	Chinese Taipei	150	4661
3	Japan	150	4535
4	Hong Kong	132	4608
5	England	123	3585
6	the United States	248	9829
Total		985	33886

Table 3: The item correct percentages of each country in three cognitive domains

Cognitive Domains	Chinese Taipei	Hong Kong	Japan	Singapore	the United States	England
Factual Knowledge	73	71	70	72	71	72
Conceptual Understanding	63	58	62	64	58	59
Reasoning and Analysis	58	55	62	57	54	57

Table 4: One-way ANOVA on item correct percentages by three cognitive domains

Cognitive Domains		Sum of Square	df	Mean Square	F	Post Hoc Comparison
Factual Knowledge	Between Groups	4.08	5	.82	17.07***	1,4> 2,3,5,6 2< 1,3,4,5,6
	Within Groups	1615.86	33827	.05		
	Total	1619.94	33832			
Conceptual Understanding	Between Groups	25.84	5	5.17	98.42***	3> 2,5,6 1,4> 2,3,5,6
	Within Groups	1776.02	33830	.05		
	Total	1801.86	33835			
Reasoning and Analysis	Between Groups	12.29	5	2.46	20.30***	3> 1,2,4,5,6 2,5< 1,3,4,6
	Within Groups	4089.93	33806	.12		
	Total	4102.21	33811			

1: Chinese Taipei 2: Hong Kong 3: Japan 4: Singapore 5: the United States 6: England

***: p<.001

Table 5: Students' cognitive performances by gender

	N	girls		boys		t-value	Difference
		Mean	Standard Deviation	Mean	Standard Deviation		
Factual Knowledge	33689	70.9	.21	71.1	22.5	-.57**	boys> girls
Conceptual Understanding	33693	63.3	.23	63.6	.24	-1.17**	boys> girls
Reasoning and Analysis	33388	56.4	.35	56.5	.35	-.42	

**: p<.01

Table 6: Students' cognitive performances by family book collection in one's family

Cognitive Domains		Sum of Square	df	Mean Square	F	Post Hoc Comparison
Factual Knowledge	Between Groups	63.18	4	15.79	347.80 ***	1< 2< 3< 4 1,2,3< 5
	Within Groups	1514.41	33343	.04		
Conceptual Understanding	Between Groups	78.23	4	19.56	387.67***	1< 2< 3< 4 1,2,3< 5
	Within Groups	1682.49	33347	.05		
Reasoning and Analysis	Between Groups	1.26	4	.31	2.60*	
	Within Groups	4015.31	33042	.12		

1: Chinese Taipei 2: Hong Kong 3: Japan 4: Singapore 5: the United States 6: England

***: p<.001 *: p<.05

Table 7: Students' cognitive performances by whether a PC in one's family

	N	With a PC		Without a PC		t-value	Difference
		Mean	Standard Deviation	Mean	Standard Deviation		
Factual Knowledge	33345	72	.21	65	.23	17.73***	With> Without
Conceptual Understanding	33349	64.3	.23	58.4	.23	15.17***	With> Without
Reasoning and Analysis	33046	56.6	.35	56.0	.35	.98	

***: p<.001