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Analysis of TIMSS results (II): A trend analysis on the International Science Achievement for Korea Elementary Students

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***Abstract*— The purpose of this study is to examine a trend of Korean elementary students' science achievement in TIMSS surveys. In TIMSS studies, Korean elementary students have managed to retain high response rates compared to the international average and to place highly in sciences internationally. Korean elementary students have also been recognized for advanced-level deduction skills, especially with female students taking lead over male students in science achievement for both TIMSS 2003 and 2007 studies.**

Index terms – TIMSS survey, Science achievement, Elementary student, Trend analysis.

I. INTRODUCTION

Many efforts are being made to meet the needs of concerns over the international reports of comparatively low educational standards of Korean students and the need to effectively revise the science curriculum. In the context, the international scientific achievement assessments PISA and TIMSS are widely known and respected [1, 2, 3, 4]. Introduced in 2000 and managed by OECD, PISA targets 15-year-old students from all over the world and looks at their abilities in science, mathematics, and reading literacy every 3 years. It has most recently been launched in 2012 and the results of this latest launch announced in late 2013.

TIMSS, however, stands out with its range of international science curriculum by looking at the trends of 4th to 8th graders' achievements in science and mathematics [5, 6, 7, 8]. Started in 1964, TIMMS has continued its research in 1995, 1999, 2003, 2007, and most recently in 2011 which was followed by the announcement of its results in December, 2012. TIMSS research does not only aim to compare different nation's education systems, but it also determines achievement rates in different subjects using as basis its curriculum formed from international standards and analyzes a variety of factors from students' backgrounds that might affect their achievement scores in order to provide data for potential education reforms and policies. TIMSS research takes place in many countries and works with a concept that data from a plethora of nations must be taken to fully grasp the concept of student learning.

Much research analyzing various aspects of TIMSS 2003 and 2007 studies target almost exclusively middle school students, while almost no study that relates the TIMSS results to primary school students' science achievement rates exists [9,10,11,12,13,14,15,16,17,18]. This study looks at the results of TIMSS 1995, 2003, 2007, and 2011 regarding Korean primary school students to look at how Korean students' science achievement rates has transitioned over the years.

This study looks at how Korean students' science achievement rates have transitioned over the years. For this, we looked at the average correct response rates and the development of science achievement rates by domain and student's sex from the results of TIMSS 1999, 2003, 2007, and 2011 studies [19, 20, 22, 23, 24].

This study also looks at the degree of agreement between TIMSS open-ended questions and Korean science curriculum and how that affects Korean students' correct response rates.

II. METHODOLOGY

A. Participants and materials

TIMSS 2003 recruited 300 4th-graders from 13 primary schools in southern Kyungsang province and commenced in February 2005 [13]. For assessment, we used 75 of 152 items used for assessing science in primary education. The items, after they were translated, were revised by 1 expert in science education and 2 primary school instructors [24].

For TIMSS 2007, we recruited 3000 4th-graders from 23 schools in Ulsan Metropolitan City and the southern Kyungsang province and commenced in February 2009 [12]. We used 71 of 174 open-ended items from TIMSS 2007, the translated versions of which were revised by 1 expert in science education and 3 primary school instructors. As for TIMSS 1995 and 2011 research, we referred to the domestic result report from KICE (Korean Institute for Curriculum and Evaluation) [18, 19, 20].

B. Data analysis

In order to minimize the intervention of subjectivity of the scorers for the scoring of released science items, we followed the TIMSS scoring criteria and allotted the score types,

"correct response", "partially correct response", and "incorrect response". This was in order to more effectively grasp how students approach problems and to categorize responses to different response types [24, 25].

Each item was scored in terms of percentage with a correct response receiving 100%. The standard score was determined from the method of analysis used by TIMSS with the scale average of 500 points and standard deviation to 100. The statistical analyses were performed with the SPSS 18.0 software [18, 19, 20].

The data from TIMSS 1995 that was used in this study was recalculated with the Korean domestic report and the international report. The data from TIMSS 2011 was also recalculated with the Korean report and the international report [25].

C. Limitations

Because the scale average is directly from the data in this study, it is hard to compare to the data from TIMSS 2003 and 2007 studies, in which Korean primary school students did not participate.

III. RESULTS AND DISCUSSIONS

A. Analysis of changes in science achievement results

Analysis of changes in average correct response rate

We looked at the correct response rate of Korean students' response rate for each item in the last four TIMSS studies to examine the changes in their science achievement. Table 1 displays the Korean students' average correct response rates to primary-level science items from the last four TIMSS studies.

<Table 1> Changes in Korean students' correct response rate from TIMSS

	TIMSS 1995	TIMSS 2003	TIMSS 2007	TIMSS 2011
Korea	69.9	68.7	69.8	65.0
Int'l Avg.	59.5	56.3	49.2	48.0

With the average correct response rate of 69.9% in TIMSS 1995, 68.7% in 2003, and 69.8% in 2007, Korean students have maintained a consistently high rate of correct responses. Compared to the international average, Korean students' rate was higher than the international average (59.5%) by 10 points in TIMSS 1995, higher than international average (56.3%) by 12 points in TIMSS 2003, and higher than international average (49.2%) by 21 points in TIMSS 2007, 65% in TIMSS 2011. This is especially evident in that the international average fell by 11 points in TIMSS 2007 compared to the average in 2003 while the Korean average rose by 1 point. TIMSS 2011, in which the Korean average was higher than the international average (48.0%) by 17 points, showed that Korean students had higher standards for science.

B. Analysis of changes in achievements across different domains

TIMSS framework of science assessment is divided into two domains, "content domain" and "cognitive domain". The content domain is divided into categories of "physical science", "life science", and "earth science", while cognitive domain is divided into categories of "knowing", "applying", and "reasoning".

Analysis of changes in achievements across different content domains

In TIMSS 1995, Korean students garnered the highest correct response rates in life science (76.0%), followed by physical science (75.0%) and earth science (72.0%) (see Table 2). Compared to their international counterparts, Korean students scored better in life science than international average (64.0%) by 12 points.

<Table 2> TIMSS results of changes in Korean students' achievements across different content domains (%)

	Country	Physical Science	Bio Science	Earth Science
TIMSS 1995	Korea	75.0	76.0	72.0
	Int'l Avg.	57.0	64.0	57.0
TIMSS 2003	Korea	71.4	65.1	71.8
	Int'l Avg.	54.8	57.0	57.3
TIMSS 2007	Korea	76.8	60.3	75.5
	Int'l Avg.	50.3	45.7	51.7
TIMSS 2011	Korea	69.0	61.0	68.0
	Int'l Avg.	49.0	48.0	46.0

In contrast, TIMSS 2003 displayed highest correct response rates of Korean students in earth science (71.8%), followed by physical science (71.4%) and life science (65.1%). Compared to the international average, Korean students had higher correct response rates in physical science (54.8% for international average) by 17 points, as well as in life science (57.0% for international average) by 8 points and earth science (45.7% for international average) by 14.1 points.

Meanwhile, in TIMSS 2007 research, Korean students scored the highest in physical science with correct response rate of 76.8%, which was higher than the international average of 50.3% by 17 points. On the other hand, they scored the lowest in life science with correct response rate of 60.3%, but this rate was still higher than the international average of 45.7% by 15 points.

In TIMSS 2011 research, Korean students had the highest correct response rate in physical science with 69.0%, which was 20 points higher than the international average (49.0%). Although they had their lowest rate in life science (61.0%), this rate was still higher than the international average (48.0%) by 13 points.

Korean students' scores in life science in TIMSS 2003, 2007, and 2011 compared to their results from TIMSS 1995, probably because the Korean science curriculum does not go over the concepts of cloning, food chain, neuroscience, and human anatomy, all of which are big topics in life science.

Analysis of changes in achievements across different cognitive domains

In TIMSS 2003, which was when cognitive domains were formulated, Korean students had the highest correct response rate in the domain of knowing with 76.6%, while they had the lowest rate in the domain of reasoning with 60.4%. But compared to the international average, Korean students had a higher correct response rate in reasoning by 20 points, higher rate in knowing by 4 points, and higher rate in applying by 9 points (see Table 3).

In TIMSS 2007, Korean students scored the highest in the domain of knowing with the average correct response rate of 71.1%, while they scored the lowest in reasoning with the average rate of 67.3% which was still higher than the international average (40.6%) by 28 points. Korean students also had a higher rate of correct responses in knowing and applying than the international average by respectively 16 and 21 points.

In TIMSS 2011, Korean students had the highest correct response rate in the domain of knowing with 67.0% and the lowest rate in the domain of reasoning with 64.0%. However, the Korean students scored higher than the international average (46.0%) by 18 points in reasoning, while they also scored higher in the domains of knowing and applying by 15 points each.

Following our examination of studies after TIMSS 2003, we found that Korean students have an above-average level of science achievement in cognitive domains. Korean students had an especially high score in reasoning compared to their international counterparts, as did Korean middle school students.

<Table 3> TIMSS results of changes in Korean students' achievements across different cognitive domains (%)

Test	Country	Application	Knowing	Infer
TIMSS 2003	Korea	67.0	76.6	60.4
	Int'l Avg.	58.2	61.0	44.5
TIMSS 2007	Korea	71.1	69.3	68.3
	Int'l Avg.	50.3	53.7	40.6
TIMSS 2011	Korea	64.0	67.0	66.0
	Int'l Avg.	46.0	53.0	41.0

Changes in achievements across different item types

In TIMSS 1995 research, Korean students scored higher on 'multiple-choice' items with correct response rate of 76.0% than on 'constructed response' items with correct response rate of 66.0%. Meanwhile, the international average for the correct response rate for constructed response items (48.0%) and multiple-choice items (63.0%) was lower than the Korean average by 18 and 13 points respectively. Korean students again scored higher on multiple-choice items in TIMSS 2003 with correct response rate of 75.7% than on constructed response items with rate of 55.2%. Both of these rates were considerably higher than the international average rates by 15 points for constructed response items (40.4%) and by 10 points for multiple-choice items (65.8%).

<Table 4> TIMSS results of changes in Korean students' achievements across different item types (%)

Test	Country	Multiple choice	Constructed response
TIMSS 1995	Korea	76.0	66.0
	Int'l Avg.	63.0	48.0
TIMSS 2003	Korea	75.7	55.2
	Int'l Avg.	65.8	40.4
TIMSS 2007	Korea	72.8	66.8
	Int'l Avg.	56.3	42.6

Korean students also scored higher on multiple-choice items with correct response rate of 72.8% than on configuration items with rate of 66.8% in TIMSS 2007 data. Compared to the international average, Korean rates were higher on the constructed response items (42.6% for international average) by 24 points, and on the multiple-choice items (56.3% for international average) by 17 points.

With the last three TIMSS survelys, Korean students did significantly worse on constructed response items than on multiple-choice item, but they still managed to score higher than their international counterparts on both types of items.

C. Changes in sex differences in achievement

Table 5 displays scientific achievement scores categorized by students' sex from the last four TIMSS studies. In order to optimally compare the international reports of achievement scores by sex, this study used converted average scores from them.

<Table 5> Average scientific achievement scores by sex

Test	Female students	Male students	Results
TIMSS 1995	590.0(4.5)	604.0(4.7)	Statically significance
TIMSS 2003	506.9(6.2)	495.5(5.4)	Not Statically significance
TIMSS 2007	503.9(1.7)	496.4(1.8)	Statically significance
TIMSS 2011	583.0(2.4)	590.0(2.3)	Statically significance

TIMSS 1995 found that Korean male students' average score (604.0) was significant higher ($p<.05$) than female students' average score (590.0). In TIMSS 2003, however, female students garnered a higher score (506.9) than male students (495.5) by 11.4 points, although this difference was not statistically significant ($p>.05$). Then in TIMSS 2007, female students again had a higher average score (503.9) than the male students (496.4) and this difference of 7.5 points was

statistically significant (p<.01). A very dissimilar occurrence was seen in TIMSS 2011, however, where male students' average score (590.0) was still significantly higher than female students' score (583.0), with the difference between the two scores being 7.0 points. In summary, female students' scientific achievement scores started being higher than male students' in TIMSS 2003; this trend, however, ended when the 2011 results showed that male students garnered higher scores in scientific achievement than female students.

As for the international results, male students' average score (488) was lower than female students' (489) by 1 point in TIMSS 2003, but this difference was not statistically significant. In TIMSS 2007, however, female students had a significantly higher average score (477.0) than male students (474.0) by 3 points. In TIMSS 201, however, male students had a significantly higher average score (590.0) than male students (583.0) by 7 points. This shows that the Korean trend of transitions in sex differences in science achievement is consistent with the international trend.

VI. CONCLUSION

This study looked at the transitions in Korean youth's rate of scientific achievement. Although many TIMSS science assessment contained many items that were not covered by the Korean primary-level science curriculum, Korean students were able to maintain one of the higher correct response rates by international standards.

In TIMSS studies, Korean elementary students have managed to retain high response rates compared to the international average and to place highly in sciences internationally. Korean elementary students have also been recognized for advanced-level deduction skills, especially with female students taking lead over male students in science achievement for both TIMSS 2003 and 2007 studies.

Although TIMSS serve the important functions of tracking nations' development in scientific achievement and the relationship between students' perception of science learning and scientific achievement, it receives less attention that PISA because of its use of multiple-choice items and its bias in researching scientific concepts. With Korea's participation in TIMSS 2011, however, future research needs to scrutinize its results from various aspects in order to analyze the changes in Korean students' scientific achievement rates and their perception towards science learning.

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