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Correlation of earth science curriculum and student cognitive level in earth science at the secondary level in the Philippines and Japan

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(Keywords : cognitive level, earth science education, secondary school, Philippines, Japan)

Introduction

Imperative to economic development is quality education. With the belief that science and technology is a twin vehicle towards the attainment of a country's economic development, science education has always been the object of reform.

Educational reform is not an easy task. Some developed countries like Japan identified three areas of concern with regard to the problems that they had faced at the time when a modern educational system was introduced, namely : (1) problems inherent in the relationship linking the community, family and children ; (2) problems related to educational infrastructure such as the inadequacy of school building or educational equipment ; and (3) problems in line with the content and quality of education (JICA 2004).

In the Philippines, the Presidential Commission on Education Reform Report (April 2000) that focused on educational reform identified science and mathematics as one of the major areas of concern. Furthermore, based on the assessment made by the Department of Science and Technology (DOST) on its past plans specifically the Science and Technology Master Plan (STMP), a 10-year (1991-2000) plan formulated as comprehensive and long–term planning in S & T, one of the problems that plague the Philippines is poor S & T education (DOST 2000).

Learning from the history of other countries like Japan and based on the assessments done, change in the curriculum has been introduced to attain the primary aim or objective of Science Education in the Philippines. This reform emphasizes the following thrusts : integration of science and health in the elementary level ; and integration of science and technology in the high school level ; focus on science process skills ; integration of values education and use of community resources for instruction.

This restructuring led to the existence of different science curricula, namely, the Basic Education Curriculum (BEC) and the enriched curricula of Science High Schools. This provides us with an opportunity to explore whether this has an effect on students' performance in one of the components of Science that is, Earth Science.

Theoretical framework

The theoretical framework of this study is based on the principle of curriculum effectiveness. Research studies along this area should be promoted as a critical aspect of the educational process since the student learning is the ultimate goal of education. Discovering whether what we do is helping to achieve that goal is fundamental to an educator's role. One of the questions that highlight the findings of this study is : 'What are the strengths and weaknesses of the existing curriculum in relation to the state of art or best practices in education?' (Little and VanTassel–Baska 2002). In this light, the science curriculum implemented in two countries, Philippines and Japan, was correlated with the cognitive level of students in Earth Science. The

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concept on curriculum is hardly new —but the way we understand and theorize it has altered over the years — and there remains considerable dispute as to meaning. But for consistency, let us look at Kerr's definition where he described it as, 'All the learning which is planned and guided by the school, whether it is carried on in groups or individually, inside or outside the school, for closing (Kelly 1983 : 10 ; see also, Kelly 1999).

Background of the Study

Educational system

The public educational system in Japan is centrally governed by the Ministry of Education, Science, Sports and Culture (Monbukagakusho or Monbusho). The system was established in 1871, and has since undergone several reforms and changes. The organization of the present school system is divided into five basic divisions defined by age and grade as presented in table1.

Kindergarten admits children aged3, 4 or 5 and provides them with one–to–three–year courses. Children must attend 9 years of compulsory education from age 6 to age 15. Attendance is mandatory for elementary and lower secondary schools (or the lower division of secondary education school) and in the case of special education, for the elementary and lower secondary departments. In principle, to enter any school beyond the compulsory school level, one is required to pass an entrance examination.

Universities require the completion of 3—year upper secondary schooling or its equivalent for admission, and offer four–year courses (six–year courses for medicine, dentistry and veterinary medicine) leading to a bachelor's degree. A university may set up a graduate school offering advanced study in a variety of fields leading to masters and doctorate degrees. The standard duration of a master course is two years and that of a doctorate course is five years (four years for medicine, dentistry and veterinary medicine). Some doctoral courses are divided into two stages : the first stage of two years can be treated equal to a master course ; and the second stage of three years can be treated as a doctoral course. (Ministry of Education, Science, Sports and Culture–Japan 2000).

The Japanese school year begins on April 1st and ends on March 31st of the following year with a month–long summer vacation in August.

Table 1. Current Japanese School System

LEVEL		DURATION	AVERAGE ENTRANCE AGE
Pre-school (optional)		3	3
Elementary		6	6
Secondary	Lower (Junior)	3	12
	Upper (Senior)	3	15
University	Bachelor	4	18
	Masters	2	22
	Doctoral	3	24

Table2. Educational System in the Philippines

LEVEL		DURATION	AVERAGE ENTRANCE AGE
Pre-school (optional)		3	3
Elementary		6	6
Secondary		4	12
Tertiary	Collegiate	4	16
	Masters	2	Above 20
	Doctorate	3 or more	Above 22

In contrast, the educational ladder in the Philippines as seen in table 2 has a 6−4−4 structure that is, six years of elementary or primary education (some private schools require seven years), four years of high school or secondary education, and another four years of higher education for a degree program (except for some courses like Engineering, Law and Medical Sciences which require five or more years of schooling).

The 1987 Philippine Constitution mandates the establishment of a system of free public education in the elementary and high school levels. The entry age for elementary education is 6 years effective School Year 1995−96; for secondary education, it is 12−15 years; and for higher education, it is 16−19 years. Pre–school education is optional. Some private schools offer seven years of primary education. In line with this, education in the Philippines is free and compulsory for children ages 6 through 12 while secondary education is free but not compulsory for ages from 13 to 16.

There are two types of secondary schools according to curricular offerings: the general high school and the vocational high school. General high schools offer the four–year general academic secondary curriculum while vocational high schools offer the same secondary curriculum with additional vocational courses. Science high schools offer an enriched Science, Mathematics and English curriculum in addition to the requirements of the secondary education curriculum.

Higher education is divided into collegiate, masters and doctorate levels in various programme or disciplines. Foreign students are allowed to pursue higher education in some 150 colleges and universities in the Philippines.

The responsibility of administering, supervising and regulating basic education (elementary and secondary education) is vested in the Department of Education (DepEd) while that of higher education is with the Commission on Higher Education (CHED). The post–secondary technical–vocational education is under the Technical Education and Skills Development Authority (TESDA) which is also in charge of skills orientation, training and development of out–of–school youth and unemployed community adults.

Schools open in June and close in April. There is a two–week Christmas break before classes resume in January. The Philippines uses a bilingual medium of instruction. Certain subjects are taught in English and the rest in the national language which is Filipino.

Secondary Science Curriculum in the Philippines

Alongside the creation of the different types of secondary school in the Philippines, is the existence of different curricula. General public high schools (GPHS) implement the Basic Education Curriculum (BEC) since 2002; the Philippine Science High School (PSHS) follows its own curriculum, and so does the Regional Science High School (RSHS). A brief discussion of each curriculum is as follows.

A. The Basic Education Curriculum (BEC)

The 2002 BEC is a restructuring of the 1983 Elementary Education Curriculum and the 1989 Secondary Education Curriculum which aims at raising the quality of the Filipino learners and graduates while empowering them for lifelong learning, which requires the attainment of functional literacy. Under the BEC, there are five (5) learning areas; four of which are the “tool” subjects namely: Filipino, English, Science and Technology, Mathematics; and a fifth one, which is a cluster of subject areas, called *Makabayan*. This experiential area constitutes a “Laboratory of Life”.

The science subjects are different in each year level, comprising Integrated Science for the First Year; Biology for the Second year; Chemistry for the Third year and for the Fourth year, the choice between Advanced Chemistry (track A) and Physics (track B).

B. The Philippine Science High School (PSHS) Curriculum

The PSHS System is an attached agency of the Department of Science and Technology (DOST). Created to develop a “pool of feeders” in Science and Technology professions, the PSHS has a core curriculum which aims to develop the scholar in all discipline. Students experience a common first year, with a demanding

Mathematics and English curriculum, and exposure to Earth Science and Technology Preparation. Then students go through a process that allows them to follow either a science stream or a technology stream in their second year. Admission to the PSHS is through the PSHS National Competitive Examinations. Carefully selected among the upper 10% of the country's elementary school students, applicants take the two-step screening process namely, Scholastic Aptitude Test (SAT) consisting of tests in Verbal, Abstract Reasoning and Mathematics, and the Science and Math Aptitude Test (SMAT) consisting of tests in Science and Mathematics. In the second year, transfer students may be admitted to fill in vacated slots after passing an accreditation test.

C. Regional Science High School (RSHS) Curriculum

In line with the provisions of Article XIV Section 10 of the 1986 Philippine Constitution, that, Science and Technology should be given priority in education as an important tool in shaping the country's development and progress, and in consonance with R.A. 8496 (An Act to Establish the Philippine Science High School System and Providing Funds Thereof), the Regional Science High School (RSHS) was created. Like the PSHS, the curriculum of the RSHS has enhanced Science, Mathematics and English subjects. To meet the demand, selection of the RSHS students is also rigid. Admission to the RSHS consists of three (3) phases, namely : Mental Ability Test, Proficiency Test in Science, Mathematics, English and Filipino, and finally, an interview after passing the second phase. Furthermore, a student may qualify for the entrance examination if he belongs to the upper 10% of the graduating class and have at least a grade of 85 in Science, Mathematics and English and 83 in all other subjects during the second grading period.

Earth and/or Environmental Science Education

A. Japan

Earth Science (ES) is treated as a unit along with other sciences in the compulsory education starting from grade3. Science in elementary school and lower secondary school encompasses Physics, Chemistry, Biology and Earth Science. There is no subdivision between sciences in the elementary school. It is only "science". Science is divided into two parts in the lower secondary school ; the first includes Physics and Chemistry while the second consists of Biology and Earth Science.

Topics in ES at the lower secondary level are divided as follows : 7th grade–Geology ; 8th grade–Meteorology and 9th grade–Astronomy. It is taken as a separate subject in the senior high school along with Biology, Chemistry and Physics. Science is a yearly 70−95 hours subject at elementary school level, 85−105 hours at lower secondary school level. Earth science, on the other hand, is taught 23 hours a year each for 7th and 8th grade and 18 hours a year for 9th grade.

B. Philippines

The mandates of the 2002 Basic Education Curriculum that is attainment of quality education especially in Science Education was mulled over by curriculum planners and subsequently, Earth Science was clearly realized as a vital subject. This is taken up as part of the Science lessons from grades 3 to 6.

The Earth and Environmental Science as a subject in secondary school, particularly of the first year, deals with the study of the Earth, its origin, features and the components of its environment. The course is divided into three major topics : the Earth, the Stars and Galaxy and the Environment. Environmental Science is integral to the study of the Earth as it focuses on the environment, resources, problems and issues, addressed in an interdisciplinary manner.

Earth Science is a separate subject in the science high school curriculum but in general public high schools ; it is incorporated in the Integrated Science subject of the first year. Consequently, there are a varying number of class hours per year spent for studying ES in different schools. PSHS is 96 hours ; RSHS is 200 hours while it is about 60 hours in GPHS.

Methods and procedures

Research questions

This study seeks to find if there is a correlation between science curriculum and the cognitive level in Earth Science of students in the Philippines and Japan. In an attempt to find the answer to this central objective, the following questions were also addressed : (1) Is there a significant difference in the cognitive level in Earth Science of Filipino students attending different types of secondary schools, in which varied science curricula are implemented? (2) What are the strengths and weaknesses of the different Science curricula implemented in various secondary schools in the Philippines? and (3) Is there a significant difference between Filipino and Japanese secondary school students in terms of their cognitive level in Earth Science?

The questionnaire

With the desire to find the answers to our research questions, we used a questionnaire (Amponsah–baa, 2004) in Earth Science. The test consists of 30－item multiple choice questions that covered the three main areas of Earth Science namely : Geology, Astronomy and Meteorology. Some of the questions were lifted from the TIMSS test item pool (TIMSS, 2003).

The respondents

In the Philippines, 240 8^{th} graders from three secondary schools in Quezon City were the respondents for this study since Earth Science was taught in their first year level. These schools differ in terms of the Science curricula they implement. As a counterpart, the same study was also conducted in Japan, where the test was administered to 191 8^{th} graders in Junior High School (JJHS) in the Chiba (Tokyo area) and Kumamoto (semi–rural Southern Kyushu) prefectures. All respondents in this study were of ages of 13－14 years.

Data and analysis

Participants' responses were encoded and then analyzed through the Statistical Package for Social Sciences (SPSS) data file. In SPSS, the percentage validity of the students' response for each question was determined. To find out if there is a significant difference between the two variables, the data were further analyzed using the chi–test. Data collected were cross tabbed to find if there is a significant difference in the performance of students from different schools.

Rationale of the Methodology

The Science curriculum has always been the object of reform in education. It is constantly improved to meet the need of the times. However, the starting point for change is always a vital step for curriculum planners and educators. Thus, the result of this study can be used as a reference as it gives a concrete current cognitive level of Filipino and Japanese students in the study of Earth Science. Furthermore, the current disasters that devastated South Asia and even affected some countries in East Africa, revealed a low level of awareness to natural calamities among the populations. Knowledge about natural phenomena is not only for the sake of learning but also essential for survival. The Philippines and Japan are both located in seismically–active zones of the world. As such, to measure the extent of people's environmental and geographical awareness is a must.

Results

Results are summarized in the following statements. All tests for statistical significance were carried out using the Chi–square test (Continuity correction), for 2 x 2 table with one (1) as a degree of freedom.

1. Frequency of correct responses. The distribution of frequencies of responses of students in both

countries varies greatly. Overall 75 to 100% of all Filipino participants gave the correct responses in most items. However, frequencies of 55% and below were noted in some items. In the case of Japanese students, frequencies of 55 to 92% were recorded in half of the total number of items (figure 1).

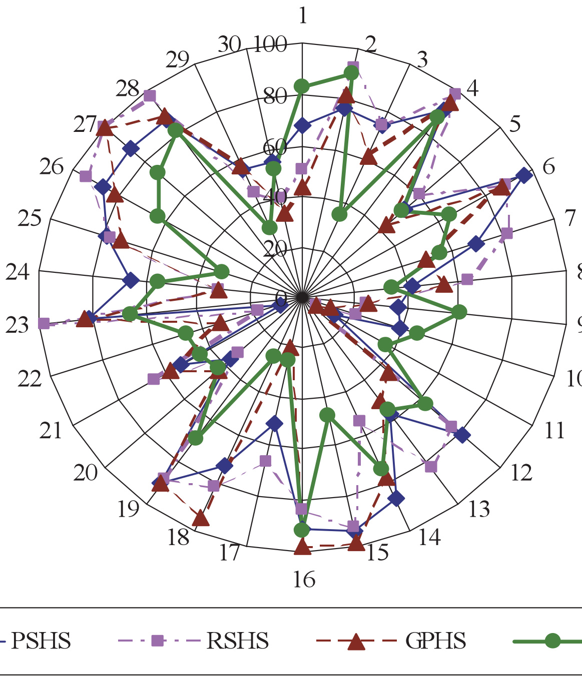

Fig.1 Filipino and Japanese Students' Frequency of Correct Responses (%)

2. <u>Mean frequency of correct responses</u>. Among the Philippine schools, mean frequency of correct responses by students from RSHS and PSHS are both high (65−66%), while that of the GPHS is the lowest (60.3%). From the same figure, we can also say that Filipino high school students performed slightly better than their Japanese counterparts (JJHS) (56.5%) in the Earth Science test (figure 2).

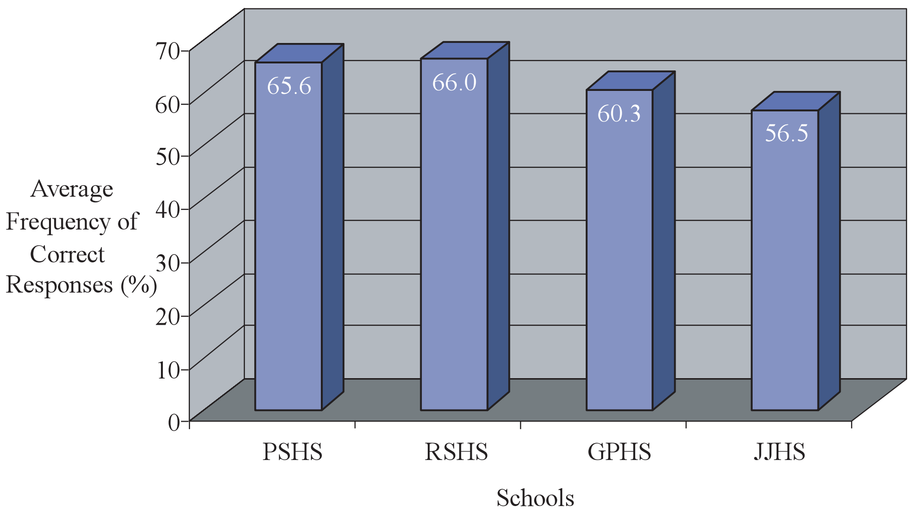

Fig.2 Philippines and Japan Secondary Schools Average Frequencies of Correct Responses in the Earth Science Test (%)

3. Cross tabulation results. The cross tabulation between GPHS and SHS (both PSHS and RSHS) showed that there is a significant difference in the percentage of correct responses in 10 items. Among these items, six (6) have a very high level of significance, that is, at 1%, while the rest are significant at 5%. In most items, the GPHS has lower frequency of correct responses and this strongly proves that in the Philippines, students from SHS perform better than those from GPHS (table 3).

Table 3. Crosstabulation Results for Philippine Schools

Items with Significant Differences	School with Lower Percentage of Frequency	Extent of Learning
1	GPHS	O
7*	GPHS	O
10	GPHS	X
12*	GPHS	O
13*	GPHS	O
16	SHS	O
17*	GPHS	O
18*	SHS	O
22*	SHS	O
24	GPHS	O

Legend:
* = 1% significance level
unmarked = 5% significance level
GPHS = General Public High School
SHS = Science High School
O = Learned
X = Unlearned

The cross tabulation between JJHS and SHS revealed that there were 6 items in which the percentages of correct responses have significant differences at 1% level. There were four out of 6 items where students from Philippines have a higher frequency of correct responses. This suggests then that Filipino students performed slightly better than the Japanese (table 4).

Table 4. Crosstab of Items Between JJHS and GPHS

Items With Significant Differences	Country With Lower Frequency	Extent of Learning
1*	P	O
3*	J	O
6*	J	O
8*	J	O
12*	P	O
26*	J	O

Legend: O = Learned in both countries; J = Japan; P = Philippines

Furthermore, the cross tabulation of JJHS and SHS student's responses in items whose basic concepts were learned disclosed that there were 10 items where there was a significant difference. All except one is significant at 1% level (table 5).

Table 5. Crosstab of Items Between JJHS and SHS

Items With Significant Differences	Country With Lower Frequency	Extent of Learning
1*	P	O
3*	J	O
4	J	O
6*	J	O
7*	J	O
8*	J	O
12*	J	O
13*	J	O
22*	P	O
26*	J	O

Discussion

From figure 1, we can see that Filipino students from all types of secondary schools performed well in item numbers 2 (atmosphere), 4 (fossils), 6 (sunrise and sunset direction), 15 (satellite), 16 (astronomy), 18 (earthquake), 19 (planets), 23 (erosion), 25 (occurrence of Earth's seasons), 26 (tectonics), 27 (moon) and 28 (atmosphere). The average frequencies of correct responses in these items were from 75 to 100%.

For other items in the Earth Science test, the frequencies of correct responses were either very low or well-dispersed in the graph based on the same figure. Filipino students showed very low performance for items 10 (fossils), 20 (length of day and night), 22 (measuring air temperature), 29 (soil profile) and 30 (interpreting diagram) despite the fact that these topics were taught at different year levels. The average frequencies of correct responses were 55% and below. Among these, even students from science high schools gave incorrect responses to questions 10 and 22. This implies that these concepts were not explained-well or emphasized to them.

Comparing the Filipino and Japanese students, the JJHS students did better than their Filipino counterparts in some items such as 1, 9, 10, 11 and 22. These questions were on erosion, calculation of velocity of stars, fossils, minerals in rocks and measuring the air temperature. However, Filipinos did better than the Japanese students in most items, to enumerate 3, 6, 8, 15, 17, 18, 19, 23, 25, 26, 27 and 29. An explanation for this is that most of these topics were not covered in the curriculum for 8^{th} graders in Japan as seen in table 4. Based on the textbooks used in schools in Japan, rock samples were discussed (items 3 and 17) in a limited way only. Similarly, some topics in astronomy (items 15 and 19) were not tackled at all within this grade level. However, for the other items that have been discussed, this clearly indicates that students did not remember them. It is notable that Japanese students perform poorly in questions 6, 8 and 21 which are related to orientation and wind-directions.

Table 3 clearly reveals that SHS students did better than those from GPHS. Nevertheless, it is important to note that there were three (3) items where students from GPHS significantly did better than those from SHS. Since these concepts were all learned in the class, this suggests that they were not well-explained hence, a need for clarification in the class.

Let us examine these items closely.

Table 6. Frequencies for questions 16, 18 and 22

16. The study of the universe and the behavior and relationship existing between the heavenly bodies is called		
A. Astronomy*	**87.5**	97.5
B. Astrology	**10.7**	1.3
C. Geology	**1.3**	0
D. Horoscope	**0.5**	1.2

18. The scale used in measuring the magnitude of an earthquake is called______		
A. Mercalli scale	**19.4**	3.8
B. Richter scale*	**76.9**	95
C. Morgan Scale	**3.1**	1.2
D. Richard scale	**0.6**	0

22. Where can we measure the air temperature correctly?		
A. In the shade without wind.	**30**	16.3
B. In the shade with wind.*	**13.1**	32.5
C. In the sun without wind.	**34.4**	8.8
D. In the sun with wind.	**22.5**	41.3

Legend:
Science High School Percentage
General Public High School Percentage
* = Correct Answer

Both questions 16 and 18 are simple recall. The distribution of the frequencies mainly between two choices signifies confusion about the concept or that simply, students do not remember them.

Though for question 22, note that the responses varied greatly. From this result, we can say that they either had a misconception or it was not well–emphasized in the class. A review of the textbook used at the elementary level proved this hypothesis.

Tables 4 and 5 illustrated the cross tabulation of student responses in the items whose basic concepts were learned in both countries. Table 4 gave us an idea about the significant differences on the performance of the students from JJHS and GPHS while table 5 is between JJHS and SHS.

Summarizing the two tables, there were three items where Filipino students' frequency of correct responses was lower than that of Japanese. Let us look at these items closely.

From the above table, we can see clearly that for item no.1, Filipino students are confused about the terms of transportation, erosion, sedimentation and weathering. An analysis of the textbooks used in Philippine schools revealed that these topics are discussed in the Earth Science or Science classes. More so, hands–on activities are provided for better understanding of them. These concepts are actually related to each other. Philippine textbooks, however, discussed these concepts distinctly from each other. On the other hand, Japanese textbooks showed that the linkage of these concepts is pointed out to the students at the start of the chapter and understanding is enhanced by a hands–on activity. At the end of the chapter, again, the linkage of these concepts is emphasized.

Similarly, item no.12 implies a confusion of the concept among students at GPHS as suggested by the distribution of frequency of student responses.

Finally, the frequencies recorded from Philippine schools for item number 22 suggest that the scientific way of taking the air temperature was not given emphasis in the class. It could also be linked to the lack of the instrument hence deprive the students a hands–on experience which helps enhance understanding of the concept. Hands–on experiment is important because it involves the acquisition of sensory information about the phenomenon being investigated (Reiner 2004).

Alternatively, in the case of Japanese students, let us analyze some of the items where their performance showed disparity with that of Filipinos particularly in items 3 and 8. We zero in on these items since the frequencies of the correct responses were below 50% as seen in table 8.

Table 7. Frequencies for items 1, 12 and 22

	JJHS	GPHS	SHS
1. What is the name given to the function of a river that deposits transporting sand and gravels at the river mouth?			
A. Transportation	14.7	25.0	13.15
B. Erosion	2.1	16.3	16.25
C. Sedimentation*	82.7	43.8	58.75
D. Weathering	0.5	13.8	10.65
12. Once an earthquake occurs, the shocks propagate. What do you call the first relatively small shocks?			
A. P-wave*	62.8	43.8	78.8
B. S-wave	31.9	40.0	13.15
C. L-wave	1.0	15.0	6.3
D. B-wave	3.1	1.3	0
22. Where can we measure the air temperature correctly?			
A. In the shade without wind.	11.0	16.3	30
B. In the shade with wind.*	45.5	32.5	13.1
C. In the sun without wind.	16.2	8.8	34.4
D. In the sun with wind.	24.1	41.3	22.5

Legend: * = Correct answer

To clarify this problem, a review of the textbook as well as interview among Japanese teachers and students was conducted. It was found out that elementary schools in Japan discuss only clastic not including the non–clastic and biochemical sedimentary rocks. At the Junior High School level, however, the three groups of rocks–igneous, sedimentary and metamorphic are tackled but are done separately. Again, there is a question on linkage of concepts here.

For item number 8, the results denote that the students are confused about the concept. An interview among Japanese Science teachers and students revealed that the concept of “crescent moon” is not clear to them. The waxing and waning crescent are both believed to be seen at night time.

Table 8. Frequencies for items 3 and 8

	JJHS	GPHS	SHS
3. Which one of the following is a sedimentary rock?			
A. Gabbro	18.8	11.3	5.05
B. Granite	41.9	25.0	16.25
C. Limestone*	35.6	61.3	73.8
D. Dike	2.6	2.5	4.4
8. In which direction can you find the crescent in the evening?			
A. East	32.5	23.8	32.5
B. South	16.2	3.8	4.4
C. West*	34.0	53.8	51.9
D. North	13.6	18.8	10.05

Legend: * = Correct answer

Conclusion

Based on the above results, we can say that there is a correlation between the science curriculum and the cognitive level in Earth Science of secondary school students in the Philippines and Japan. Hence, in the Philippines, students from science high schools performed better than students from general public high schools.

Filipino students in secondary schools, as a whole, did slightly better than their Japanese counterparts in Earth Science. Their slightly above average cognitive level is primarily due to several factors, among which are content, time allotment and teaching approach. In the Philippines, Earth Science was allotted more time ; consequently, more topics are dealt with as compared to Japan. However, the linkage between and among some concepts taught must be looked into both countries.

The comparison between the students of the two countries of our study shows the value of the enriched Earth Science curriculum in the Philippines. However, as suggested by the TIMSS results, our study should be broadened to a larger and more diverse population in order to meet the needs of further development of scientific skills and improvement of teaching methods to a larger area of the archipelago.

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Correlation of earth science curriculum and student cognitive level in earth science at the secondary level in the Philippines and Japan

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This study correlates the secondary school science curriculum and the student cognitive level in Earth Science in the Philippines and Japan. In particular, it aims to help determine the cognitive level of students in Earth Science at the secondary level in two countries and seeks to compare the implementation of the different curricula in different types of secondary schools of a same area in the Philippines. A descriptive research design in nature, a questionnaire in Earth Science was administered to 240 8th graders exposed to different science curricula in Quezon City (Metro Manila), Philippines and to 191 8th graders in Chiba (Tokyo) and Kumamoto (semi–rural Southern Kyushu) prefectures in Japan. Findings show that there is a correlation between the science curriculum and the cognitive level in Earth Science of secondary school students in both countries and a significant difference in the cognitive level in Earth Science of Filipino students from different types of secondary schools. Further analyses of the results reveal the strengths and weaknesses of the Science curricula implemented in both countries and provide the possible areas for curriculum improvement.

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