

Indicators of Asian Achievement in Chemistry: Implications to the Philippine Setting

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ABSTRACT

This paper aimed to determine the indicators, which could contribute to the Chemistry achievement of selected Asian countries according to the data set provided by the 2015 Trends in Mathematics and Science Survey results. Educational data mining was employed to capture patterns, comparison and correlation among selected Asian countries (Hong Kong, Japan, Malaysia, Singapore, South Korea, Taiwan and Thailand) using TIMSS results in Chemistry and other Science domains achievements, learning resources, school climate, instructional considerations, and student affective aspects. This study found out that the average Chemistry achievement of the Asian countries was significantly higher than the world achievement. Through exploratory analysis, it was revealed that high achievers among the Asian countries have moderate to high perspective towards school climate, instructional considerations and student affective aspects, while those average or low achievers had high perspective towards the said factors. The study concluded that, out of the 15 factors included in the study, nine had positive correlation yet only prior achievement in Science, home educational resources, Science laboratory resources, computer use and prevalence of bullying could significantly determine the achievement of learners in Chemistry. Implications on spiral progression, resource allocation, safe, orderly and harmonious environments, and inspiring stories in instruction were derived for application in the Philippine context to maximize and enhance learning in Chemistry.

Keywords: *Asian achievement; Chemistry achievement; TIMSS*

INTRODUCTION

Due to the fast growing development in scientific fields, Science education has become a priority across the globe due to it being a driving force of development (Chetty, 2012), and a fundamental key in solving issues in the global arena (Wieman, 2008). In fact, education ministries recognize the core importance of Science education in the curriculum (So and Cheng, 2009) where learners are prepared into becoming informed and participative citizens who can utilize and apply scientific principles and skills in solving problems in the 21st century society (Department of Education, 2016). As such, the learners are inculcated with scientific literacy and

values. Organization of Economic and Co-operation and Development (2017) articulated that scientific literacy is shown in the ability of learners to be engaged in activities where they become reflective citizens. Scientific literacy, in this sense, can be measured as the Science achievement obtained by countries from international examinations such as Program for International Student Achievement (PISA) and Trends in Mathematics and Science Survey (TIMSS). The latter examination is the major achievement test for Math and Science in the primary and middle grade levels in the basic educational system (Scott, n.d.). Science framework for TIMSS highlights the assessment of the four main fields, namely Biology, Chemistry, Physics and

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Earth Sciences, and of the three cognitive domains, namely knowledge, application and reasoning.

TIMSS has shown many trends in Science education of the participating countries. The comparison between 2011 and 2015 results revealed that 15 out of the 34 participating countries have increased significantly their achievement; 15 have neither increased nor decreased their achievements, and 4 have significantly decreased in their achievements (International Study Center, 2015). These, together with other trends, have shown to have implications to the educational systems of countries. Topçu et al. (2016), for instance, have found out that teacher effectiveness is a significant predictor of achievement, thus recommending education systems in Turkey and South Korea to invest in effective teaching practices in Science and Mathematics education fields. Perry (2017) analyzed the 2015 results of Northern Ireland, and recommended that the country's system further consider, among others, the involvement of teachers in continuing professional development, the decline in performance, and the principal's concerns around a lack of good quality school infrastructure like laboratories and computer rooms. Sumintono (2015) highlighted the drastic action of Malaysian education ministry to address the low achievement in Science of their learners through improvements in the curriculum, incorporating more problem-based and project-based content areas and cultivating high order thinking skills, which is targeted to be completed in 2017. Visser, Juan and Feza (2015) argued that educational system should not be contained solely in school level, pointing the needs of public interventions in other venues, especially the home environment where the learners originate. These are some studies generalizing the implications of TIMSS results to the policy-making for Science education improvement and paradigm shift, as well as building of public support for school improvements.

Contributory to the improvement of the Science education program of countries is the achievement obtained in Chemistry. Chemistry education is vital in knowledge generation and innovation, as efforts in Chemistry are shown in its functionality and relevance in content, practice and applicability (Emendu, 2014). Functionality of the field is exemplified in its applications in food security, agriculture, industries and transportation (Bhargava, 2016). Relevance of the field is seen in the pursuit of a sustainably developed society that takes into account ecological, economic and societal impacts (Eilks et al., 2014). This functional and relevant nature of Chemistry education make it fundamental in Science education, and thus, factors affecting education (i.e. teaching, learning and assessment)

in Chemistry are important to be investigated. In fact, several studies in national and local levels were conducted to identify these factors, especially those that could indicate Chemistry achievement. Hassan et al., (2015) sampled 45 teachers and 200 students, and found out that teacher training, English language proficiency, and instructional facilities affected low achievement in Chemistry. Udoh (2012) and Oginni et al. (2013), studied learning environment and school factors as possible correlates, and revealed that school location, laboratory adequacy, practical class frequency and home characteristics were positively correlated to Chemistry achievement. Moreover, Yüksel and Geban (2014) sampled 252 students, and found out that academic self-concept and logical thinking were significant predictors of academic achievement. Kan and Akbas (2006, 2007) investigated affective factors, and identified attitude, self-efficacy, motivation and anxiety as influences of Chemistry achievement. Furthermore, Tizo and Palmes (2013) showed that scholarship grants and Chemistry attitudes were significantly associated to Chemistry achievement, while Gutierrez (2014) identified students' ethnicity, and teachers' concern and encouragement as significant correlates to Chemistry achievement. Pedagogical studies conducted in the Philippines suggested that innovation teaching approaches and strategies such as career-oriented performance tasks (Espinosa et al., 2013), context-based teaching (Magwilang, 2016) and integrated macro-micro-symbolic approach (Sanchez, 2017) led to improved Chemistry achievement.

Though there are studies that investigate the association of factors to Chemistry achievement, there has been a gap in the read literature that deals with the big data provided by TIMSS. Trends and implications derived from TIMSS achievement and contexts results are important in improving the educational system, as well as developing paradigm shifts in curriculum development of countries, including the Philippines. In fact, the 2003 TIMSS results of the country had serious implications to the educational system, which may connote "bahala na" and "puwede na" culture towards Science and Chemistry as a subject and as an innovation (Dela Cruz, 2012), which eventually led to a change in the system to Revised Basic Education Curriculum. Since the Philippines is located in Asia, it is important to note that TIMSS results and trends in selected Asian countries may give insights and implications to how Chemistry education be implemented in the country. Therefore, the paper investigated the association between Asian achievement in Chemistry and several contexts derived from TIMSS. Specifically, the paper sought to (a) compare between Asian achievement and world achievement, as well as

between Chemistry and other Science domains, and (b) determine the relationships between such achievement and contexts (learning resources, school climate, instructional considerations and affective considerations). The results of this paper were deemed useful, as these provide insights in improving Chemistry education in the country and the world at large, hence, the conduct of the study.

METHODS

The study utilized educational data mining (EDM) as this emerging design captures and creates pattern from big data sets that come from educational settings (Kumar and Vijayalakshimi, 2011). Through the use of EDM, comparison and correlation are done between and among seven participating countries found in Far East Asian region based on achievement and context results primarily from the 2015 TIMSS. The selected countries include Hong Kong (special administrative region in China), Japan, Malaysia, Singapore, South Korea, Taiwan (Chinese Taipei) and Thailand. These countries are chosen due to their geographic and cultural proximity to the Philippines.

The data involved in this study were mined from the databank of 2011 and 2015 TIMSS. Prior achievement of the participating countries in the fourth grade of 2011 TIMSS was used for

comparison with the 2015 Chemistry achievement. Other than this, data on achievement and contexts were obtained from the 2015 TIMSS dataset. The context data (learning resources, school climate, instructional considerations and student affective aspects) were chosen since these may be possible correlates to Chemistry achievement based on literature review.

Table 1 below summarizes the TIMSS data used by the study. It is noted in the table that 2015 Chemistry achievement served as the baseline data for comparative and correlational analyses. A total of 15 possible factors or indicators were used in the study.

The data were treated with two analyses, namely t-test for small and single samples and Pearson r correlation test. The former (t-test) is used to compare the Chemistry achievement of the selected Asian countries to the achievement of Asia and the world. The latter (Pearson r) is used to determine the relationship between Chemistry achievement and context results. Moreover, analysis of variance is employed to compare the four Science domains. All tests are subjected to $\alpha = 0.01$ for high significance, and $\alpha = 0.10$ for partial significance.

Table 1. TIMSS Data Included in the Study.

Year	Grade Level	Data Category	Possible indicators (as used in the study)
Achievement Data			
2011	4	Physical Science	(1) Prior achievement
2015	8	Science Domains: Chemistry achievement & other domains achievements	
Context Data			
2015	8	Learning Resources	(2) Home resources (3) Science lab (4) Computer use
		School Climate	(5) Sense of belongingness (6) School discipline (7) Safety and order (8) Student bullying
		Instructional Considerations	(9) Instructional time (10) Science investigations (11) Effect of students' needs
		Student Affective Aspects	(12) Engaging teaching (13) Science liking (14) Confidence (15) Science valuing

RESULTS AND DISCUSSION

Chemistry Achievement of Selected Asian Countries. As seen in Table 2, leading economies in Asia, namely Hong Kong, Japan, Singapore, South Korea and Taiwan, had Chemistry achievements significantly higher than the world mean achievement. This means that the learners from these countries performed better than what is normally performed in the world. This could be due to the fact that these leading economic societies value education as a premium. In fact, these countries provided great effort in reshaping and reforming their Science curricula and school systems, including

Chemistry programs, in the past and recent years (Lau, 2014). Singapore, for instance, persisted in establishing Chemistry education back in the 1960s, involved local and international academic agencies in the process, and experienced several reforms in the program including the supplementation of basic education curriculum with out-of-school learning experiences such as industrial visits and scientific television programs (Chia, 2010). Collaboration among government agencies and partnerships with the private and international groups anchored reforms in Science education, thereby leading to improved curricula and enhanced student achievement (Malik, 2010).

Table 2. Chemistry Achievement of Selected Asian Countries.

Country	Achievement	t-value	p-value	Performance Level ^a
Hong Kong	536	5.435**	0.000	Above Ave.
Japan	570	9.110**	0.000	Above Ave.
Malaysia	473	1.375 ^{ns}	0.177	Average
Singapore	593	11.596**	0.000	Above Ave.
South Korea	550	6.948**	0.000	Above Ave.
Taiwan	579	10.083**	0.000	Above Ave.
Thailand	445	-4.401**	0.000	Below Ave.
Average	535	5.327**	0.000	Above Ave.
Asian Achv.	490		World Achv.	486

^a Performance level as compared to the world achievement at 486

* Significant, ^{ns} Not significant

On the other hand, Malaysia and Thailand had Average and Below Average achievements, respectively. Though investment in Science education in these countries covers a big portion of the national budget, the lower achievement might be due to the nature of teaching-learning process. Schools have paid more attention to lower-order thinking skills, have not integrated higher-order thinking skills in curriculum and assessment (Education for All National Review Report: Malaysia, 2015), and have employed strongly teacher-dominated pedagogy (Coll et al., 2014). To counteract such achievement, Malaysia is making drastic actions in improving Science education, including that of Chemistry, adapting challenges and trends in 21st century education (Sumintono, 2015). Likewise, Thailand shifted the mindset of Thai students from being less active learners to more active participants in a learner-centered classroom using constructivist-based approach (Coll et al., 2014; Faikhamta and Ladachart, 2016).

The Philippines last took TIMSS in 2003, when the country got a Chemistry achievement of 342 while the world achievement mean was 474. This indicated

that the country had Below Average performance compared to the rest of the world. This Philippine result may be improved through following what high Asian achiever countries do, that is, to change the educational landscape of the country. This became a realization when the Philippines shifted its educational system from the congested and less advantageous system to the decongested and more competitive system called K to 12 Basic Education (Sergio, 2012), a similar initiative done by Singapore, Malaysia and Thailand (Lau, 2014; Sumintono, 2015; Coll et al., 2014). The paradigm shift provides comparable goals, content and duration to those given in leading country achievers (Sergio, 2012), as well as it offers facilitative approaches such as contextualized learning, inquiry-based approach and science-technology-society approach (DepEd, 2016), thereby improving Chemistry education in the country.

Asian Achievement of Chemistry vs. Other Science Domains. Chemistry achievement by the select Asian countries is not significantly different from the achievements obtained in Biology, Physics and Earth Science. This means that the Science

achievements are comparable, inferring that these countries have curricular considerations in giving equal instructional time for these domains in their Science subjects. Japan, for example, covered the four Science fields in the 8th grade curriculum: electric currents (Physics), chemical changes, atoms and molecules (Chemistry), animal lives and living

things transitions (Biology) and weather and its changes (Earth Science) (Ministry of Education, Culture, Sports, Science, and Technology, 2008). Giving consideration to ample time in teaching Science leads to a significant positive effect on student achievement (Lavy, 2010).

Table 3. Comparison between Chemistry and Other Science Domains in Selected Asian Countries.

Country	Achievements				F-value	P-value
	Chem	Bio	Phys	Earth Sci		
Hong Kong	536	549	540	558	0.0200 ^{ns}	0.9954
Japan	570	570	570	574		
Malaysia	473	466	480	460		
Singapore	593	609	608	565		
South Korea	550	554	564	554		
Taiwan	579	565	560	581		
Thailand	536	549	540	558		

^{ns} Not significant

Another reason taken into consideration might be the interconnected approach in teaching Science concepts and principles, where one domain is used to explain other domains in the grade level or the next. This emphasis on interconnectedness is essential for the formulation of quality curricula, as well as the implementation of learning activities in the student-centered classroom (Antoniјеvić, 2006).

The comparable achievements among Chemistry and the other domains of Science may be taken into consideration by the paradigm shift system adopted by the basic education sector in the Philippines. The country's Science curriculum consists of the four domains of Science, namely Matter; Living Things & their Environment; Force, Motion & Energy; and Earth & Space, which are all taught in every grade level in certain sequence similar to Japan's curriculum. Moreover, these four domains are presented in increasing level of complexity from one grade level to another in an approach called spiral progression (DepEd, 2016). Spiral progression in Science is considered learner-centered, sophisticated and advanced by Filipino Science teachers (Orbe et al., 2018), which was observed to be effective in teaching Science courses (Resurreccion and Adanza, 2015), and provided improved understanding with deepened learning among the students (de Ramos-Samala, 2018). Furthermore, due to the interconnectedness and spiral progression, aspiring Science teachers take a baccalaureate degree in Science rather than the specific Biological or Physical Sciences to suit themselves as teachers of the four areas of Science. Therefore, teachers's knowledge,

skills and values should be developed further to implement Science education, especially Chemistry education: an instruction that is dynamic, realistic and productive (Orbe et al., 2018). As such, qualified teachers and well-suited facilities should be present.

Chemistry Achievement and Prior Achievement in Science. Based on Table 4, there is a highly significant difference between the 2011 Physical Science achievement and 2015 Chemistry achievement gotten by the Asian countries. This means that the learners' achievement when they were still in 4th grade had a positive impact to their achievement in Grade 8. This could be due to the fact that prior achievement motivated the learners to attain higher achievement in the future. Prior achievement can significantly predict student engagement, thereby leading to positive association to the further achievements (Li et al., 2017), as achieved knowledge could be developed over time (Claro et al., 2016).

In coherence with spiral progression, prior achievement plays an important role. Prior achievement connotes prior knowledge, previous experiences and preparatory skills, which are needed in the understanding of concepts in the present. Therefore, vertical articulation becomes an essential characteristic of a good spirally progressive Science curriculum (de Ramos-Samala, 2018). This suggests that Science teaching in the elementary level should introduce the basic Chemistry concepts and skills, which are taught by Filipino teachers in spiral progression, so that learners will be equipped with

Table 4. Association between 2015 Chemistry and 2011 Physical Science Achievements.

Country	Achievement		t-value	p-value
	Chem (2015)	Phys Sci (2011)		
Hong Kong	536	539	0.9307**	0.0070
Japan	570	589		
Malaysia	473	-		
Singapore	593	598		
South Korea	550	597		
Taiwan	579	569		
Thailand	536	-		

** Highly significant

- Not taken the 2011 Grade 4 TIMMS

the foundations essential for high school Chemistry concepts. In turn, high school teaching should include review phase in their lesson implementation to establish a link between the learners' prior knowledge to the present topic.

Learning Resources. The Chemistry achievement of Asian countries had a significant association with that of the home education resources. This suggests that the availability of educational resources, such as books, computers, calculators and study tables in the learners' homes provided them more means to use these for studying and learning concepts in Chemistry. Parents buy these available resources at home in order to encourage active and independent learning, which could most likely increase participation and interest in school (Spelling, 2005). Home works utilizing such resources provide opportunities for applying and deepening

of the understanding of concepts (Ontario English Catholic Teachers' Association, 2016). Home environment resources play important roles in learners' achievement in Science in general (Juan and Visser, 2017; Oginni et al., 2013).

Also revealed in the table is the positive and significant association of the Science laboratory resources to the Chemistry achievement of the learners. In this regard, laboratories provide a venue for learners to apply the chemical concepts and processes through the hands-on-minds-on activities, including experimentations. Hong Kong, in particular, has laboratories for all schools since the Junior Secondary Science Curriculum was implemented in 2000. This curriculum embeds investigative approach in teaching which involves learners to identify problems, create designs for solutions, do practical work and use analysis in interpreting results. The

Table 5. Correlation between Chemistry Achievement and Achievement by Learning Resources.

Country	Achievement ^a	Home Resources ^b	Science Lab ^c	Computer Used ^d
Hong Kong	1.10	1.07	1.11	1.13
Japan	1.17	1.12	1.17	1.16
Malaysia	0.97	0.99	0.96	1.00
Singapore	1.22	1.20	1.22	1.20
South Korea	1.13	1.07	1.14	1.12
Taiwan	1.19	1.14	1.17	1.16
Thailand	0.92	1.01	0.93	0.95
Average	1.10	1.08	1.10	1.12
Statistics	r-value	0.927**	0.995**	0.989**
	p-value	0.003	0.000	0.000

^a Country over world achievement ratio^b "Most Resources" achievement ratio^c "With Science Laboratory" achievement ratio^d "With Computer" achievement ratio

** Highly significant

science laboratory promotes important meaningful learning outcomes for learners (Hofstein, 2004; Oginni et al., 2013), thus is a determinant of high achievement in Chemistry.

Same with home education and Science laboratory resources, computer use had positive and significant relationship with the Chemistry achievement of learners. This may be due to the utilization of computer as a venue of multiple media where learners could understand chemical concepts and processes in a more multisensorial means. Due to this multisensorial nature of computers, these tools are used to motivate and activate learners, thereby creating an avenue for creative thinking and critical understanding of Science, particularly to Chemistry (Lanoven, 2008). Instructional tasks, which involve computer use provide different ways of expressing knowledge, therefore have positive impact to student achievement (Sun and Bradley, n.d.).

Overall, Chemistry achievement is positively and significantly correlated with the availability and access of learning resources at home and in the school. However, these learning resources essential for learning and teaching are lacking in Filipino homes and schools. Philippine Statistics Authority (2017) reported that only a very small portion, at 2.3% to 4.0%, of the income of the masses are spent to education and educational resources, suggesting a lack of resources at home. Agham columnist Marbella (2014) wrote that DepEd reported a lack of science laboratories in public elementary and secondary schools, as well as an inadequacy of modern equipment in schools with laboratories,

indicating a dearth in venues where students do Chemistry experimentations. Case studies on ICT in the Philippines conducted by Kubota et al., (2016) revealed that there is limited number of computers and no Internet connection in rural and suburban areas, showing a lack of computer facilities in schools. The learning resources that learners from among the masses lack are important tools in Chemistry education. Therefore, allocation for these learning resources for schools should be given emphasis in the planning of budget for the education sector. In particular, Science laboratories should be built in every school in order to provide venues for hands-on, minds-on tasks using the investigative approach. Equally important is the decrease of the students-to-computer use ratio, so as to offer more independent work among the students and to give them opportunity to discover Chemistry, and the Sciences, secondhand but enriched.

School Climate. The environment where the learners are plays an important role in the achievement of students. Four variables were statistically analyzed, and found out that sense of belongingness had significant negative correlation with student achievement, while school discipline and safety and order did not have a significant association. This could mean that high achieving countries tend to have learners who do not feel high sense of belongingness in school. This could be due to the overly structured environment of the Asian schools, which give premium to education, and thus have more demands expected from them. Due to this demand, learners may have negative feelings towards the school that they think they do not belong (Ho,

Table 6. Correlation between Students' Chemistry Achievement and the School Climate.

Country	Achievement ^a	Sense of Belongingness ^b		School Discipline ^c		Safety and Order ^d		Student Bullying ^e	
Hong Kong	AA	9.4	S	11.4	H	10.7	VSO	9.6	N
Japan	AA	9.4	S	10.5	M	8.9	SO	10.9	N
Malaysia	A	10.1	S	10.8	H	9.8	SO	9.3	N
Singapore	AA	9.8	S	11.7	H	11.3	VSO	9.7	N
South Korea	AA	9.4	S	11.0	H	9.8	SO	11.1	N
Taiwan	AA	9.4	S	11.1	H	10.1	SO	11.3	N
Thailand	BA	10.6	HS	10.4	M	10.1	SO	8.8	M
Average	AA	9.7	S	11.0	H	10.1	SO	13.7	N
Statistics	r-value	-0.814*		0.603 ^{ns}		0.167 ^{ns}		0.723*	
	p-value	0.026		0.152		0.720		0.066	

^a AA (Above average), A (Average), BA (Below average)

^b HS (High sense of belongingness), S (Average sense), L (Low sense)

^c H (Hardly any problems), M (minor problems), MS (moderate to severe)

^d VSO (Very safe and orderly), SO (Average safe and orderly), LSO (Less safe and orderly)

^e N (Almost never occurring), M (About monthly), W (About weekly)

* Partially significant, ^{ns} Not significant

2009). Despite this negativity, they work efficiently in school, thereby having higher achievement.

School discipline and safety and order in school had no significant relationship with the student achievement. This means that problems on school discipline and the extent of the school safety and order do not have impact on Chemistry achievement despite studying in a highly disciplined environment. Japan, for example, has a big problem on disciplinary issues, such as classroom violence towards teachers and learners, which did not obstruct their high achievement in mathematics and sciences. School disciplinary and safe environment do not directly influence student learning attainment (Ishida and Miwa, 2012).

Less bullying experienced by the learners had a partially significant association with their achievement in Chemistry. This means that when students are not, or less threatened by bullying inside the school, they tend to perform better and achieve higher achievement. No or less bullying creates a positive atmosphere where learners feel safe inside the classroom, thus they are not hindered to attain academic success in themselves (Block, 2014).

Though the results of most school climate factors were not significantly associated with Chemistry achievement, it is also good to note that having a conducive and sensitive learning environment could boost achievement in the learners' academics. In fact, a study by Gorgonio (2017) found out that learners' belongingness in school is central in quality relationships between students and personnel, where

teaching and learning process becomes relational and productive. Moreover, an investigation by Magulod (2017) revealed that there is a significant association between school performance and school effectiveness factors including safe and orderly environment for learners. Furthermore, a qualitative study by Gabiana (2017) stated that bullying could lead to dropouts and decreased achievement, and that less of bullying creates positive environment where they are not hindered to attain academic success, including in Chemistry (Block, 2014). The results of the abovementioned Filipino studies imply that schools should provide positive discipline in order to create a safe, orderly and harmonious environment where learners cooperate and value the tasks there are immersed in. Interesting lessons and purposive learning experiences should be employed to the class, in order to provide conducive, relevant and meaningful learning environment.

Instructional Considerations. Based on Table 7, instructional time and effect of limited teaching due to students' needs do not significantly affect Asian countries achievement in Chemistry. Time and students' needs do not drive the academic performance for better achievement due to the fact that these factors are not unusually changed within the span of the instructional year. Due to these insignificant changes, instructional time and students' needs are not considered as indicators for academic success (Baker et al., 2004).

On the other note, the science investigations have significantly yet negatively associated to the Chemistry achievement of the learners. This means

Table 7. Correlation between Students' Chemistry Achievement and Instructional Considerations.

Country	Achievement ^a	Instructional Time ^b	Science Investigations ^c	Effect of Students' Needs ^d
Hong Kong	AA	102	10.1 LH	10.6 SL
Japan	AA	131	9.9 LH	12.5 NL
Malaysia	A	130	10.4 LH	9.8 SL
Singapore	AA	106	9 LH	11 SL
South Korea	AA	94	9.3 LH	9.8 SL
Taiwan	AA	144	8.9 LH	10 SL
Thailand	BA	110	10.1 LH	10 SL
Average	AA	116.7	9.7 LH	10.5 SL
Statistics	r-value	0.082 ^{ns}	-0.770*	0.473 ^{ns}
	p-value	0.861	0.043	0.283

^a AA (Above average), A (Average), BA (Below average)

^b Instructional time presented in hours per year

^c Time for Science investigations, UH (upper or half of the lesson), LW (lower half)

^d NL (Not limited), SL (Somewhat limited), VL (Very limited)

* Partially significant, ^{ns} Not significant

that though the teachers have limited utilization of the eight instructional tasks, the learners still have higher achievement. Better learning is not enclosed in one structured approach but is determined by the appropriateness of the pedagogy in teaching topics in Chemistry (Ganyaupfu, 2013).

In the K to 12 basic education system of the Philippines, Chemistry and other Science domains are given equal time allotment (i.e. one grading period each). Increasing or decreasing instructional time could imply an imbalance in the teaching of Science areas, which will disrupt the teaching-learning process as learners track the spiral progression approach in Science. Moreover, the use of a structured set of recommended pedagogies may not adhere with the implementation of the Science curriculum because pedagogies should be contextualized to the needs of the learners, where a repertoire of pedagogies may be used such as problem-solving approach, science-technology-society approach and inquiry-based approach. Learners may benefit from contextualized lesson implementation rather than following structured pedagogies because they will be engaged in varied minds-on, hands-on and hearts-on activities centered on situations that challenge the learners to be critical and creative thinkers (Department of Education, 2016). Furthermore, students' needs may not give significant effect, as the curriculum provides mechanisms to provide instruction according to the needs of the learners. Therefore, the use of 21st century pedagogies as well as innovative teaching such as career-oriented performance tasks (Espinosa et al., 2013), context-

based teaching (Magwilang, 2016) and integrated macro-micro-symbolic approach (Sanchez, 2017) lead to meaningful understanding of Chemistry and to relevant applications in the students' life.

Affective Considerations. Three student affective aspects have insignificant association with student achievement. These are students' views on engaging teaching, science interest and confidence. This means that when learners view Chemistry teaching as engaging and interesting, better achievement does not always happen. Learners may be imbued more of the process of the activity but not the understanding of the lesson, or they are more interested on other Science topics but not Chemistry topics. These situations characterize that engagement, interest and confidence towards the subject do not lead to successful academic endeavor. It is in the hardwork that the learners give when immersed with the instructional activities (Sjöberg and Dahlstrand, 1987).

As exposed in Table 8, science valuing and achievement had partially significant negative association. This means that, in some ways, achievement decreases as science valuing increases. However, this negative association may be because of the lack of learning resources, which hinders student academic performance even if learners have high valuing towards the sciences. Take Thailand as an example. Though Thai government introduced 15-year free education policy in 2009, many learners could not afford the cost of other educational expenses, like learning materials, due to financial

Table 8. Comparison of Students' Chemistry Achievement and the Affective Considerations.

Country	Achievement ^a	Engaging Teaching ^b		Science Liking ^c		Confidence ^d		Science Valuing ^e	
Hong Kong	AA	9.6	E	9.9	L	9.4	C	9.4	V
Japan	AA	8.4	E	9	L	8.6	NC	8.6	V
Malaysia	A	10.2	VE	10.9	VL	8.7	NC	10.4	V
Singapore	AA	9.8	E	10.3	L	9.7	C	10.2	V
South Korea	AA	8.4	E	8.6	L	8.7	NC	9	V
Taiwan	AA	9	E	9.2	L	8.6	NC	8.6	V
Thailand	BA	10.2	VE	10.3	L	9.3	C	10.7	SV
Average	AA	9.4	E	9.7	L	9.0	C	9.6	V
Statistics	r-value	-0.636 ^{ns}		-0.563 ^{ns}		-0.023 ^{ns}		-0.689 [*]	
	p-value	0.125		0.189		0.961		0.087	

^a AA (Above average), A (Average), BA (Below average)

^b VE (Very engaging), E (Engaging), LE (Less engaging)

^c VL (Very much like), L (Like), DL (Do not like)

^d VC (Very confident), C (Confident), NC (Not confident)

^e SV (Strongly value), V (Value on average), DV (Do not value)

^{*} Partially significant, ^{ns} Not significant

difficulties (OECD, 2013).

Affective aspects provide the heart of learners in the teaching and learning process. As such, extent of learners' considerations on these aspects is a set of important factors that could affect achievement in Chemistry. As such, the affective domain of the learners should be developed, not only in receiving tasks but also in characterization processes. In this regard, encourage learners to value and love Sciences in general in order to spark their curiosity. As such, Chemistry instruction should include inspiring stories of Science people.

CONCLUSIONS

Chemistry achievement in neighboring countries of the Philippines had higher achievement levels, in average than the world, attributing this primarily of the 'premium' that they give to education. High achievers among Asian countries have moderate to high perspective towards school climate, instructional considerations and student affective aspects, while those average or low achievers had high perspective towards the said factors. Specifically, Chemistry achievement was positively and significantly associated with students' prior achievement in Science, which could imply that spiral progression in Science curriculum could provide effective delivery and implementation of the science concepts and skills. Chemistry achievement also had positive and significant correlation with home educational resources, Science laboratory resources, and computer use, which means that availability of and accessibility to references, science experiments, online search, particulate animations, and theoretical simulations are essential to improved Chemistry instruction as well as enhanced critical and creative thinking. Prevalence of bullying also had positive and significant association with achievement, which signify the creation of a safe and orderly environment among the learners themselves. Lastly, Science valuing had negative yet significant correlation with achievement, which indicates costs and lack of resources as hindrance to achieve more despite of students' high extent of valuing.

Based on the findings of the study, the researcher recommended that spiral progression be continued to be employed across Science curricula; that laboratory-to-student ratio be decreased in order to increase extent of practical skills of students; that positive discipline be always observed in the learning environment; and that characterization processes be implemented to spark curiosity and appreciation towards Chemistry and Science in general. Future researchers may conduct similar educational data mining research for other domains of Science, as

well as for Chemistry achievement and contexts which will be derived from the upcoming 2019 TIMSS results and trends.

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