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THE RELATIONSHIP BETWEEN THE COMMAND OF SCIENTIFIC KNOWLEDGE AND LANGUAGE WITH HIGH ORDER THINKING SKILLS AMONG STUDENTS

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This research aims at studying the level of relationship between the command of scientific knowledge and language with the high order thinking skills among students. A total of 180 Form 2 students from secondary schools in Skudai was engaged as the samples for this study. The method used in this study was a descriptive survey. The instrument used in this research is Test Set. Data obtained were analysed as descriptive analysis. The results showed that students achievements for the three aspects studied: knowledge, scientific language and thinking skills were of moderate level which was pass and made the minimum proficiency level. The results also showed that scientific knowledge and language have positive relation to the high order thinking skills among the students. The correlation value between the knowledge and thinking skills was high that is +0.70. Next, the correlation value was moderate between the scientific knowledge and language at +0.62. For the correlation value was moderate between the scientific language and high order thinking skills, that is +0.53. Based on the results of this study, a few suggestions were submitted to assist the schools to identify their students understanding in science and also on the improvement for future research.

Keywords: Knowledge, Scientific Language, Thinking Skills.

1. INTRODUCTION

Kevin *et al.* (2012) stated that knowledge involves facts and important information collection for a particular subject. Meanwhile, thinking is a human ability to form concept, give reason and make decisions. Particularly for science subject, studies have shown that students had difficulty learning it (Johnstone, 2006). Abstract characteristics of science making it difficult to be learnt for most students (Tsaparlis, Hartzavalos dan Nakiboglu, 2013). The high command of knowledge is important for students to have high order thinking skills and became among the critical aspects that are emphasised into a country's education quality. Students that are inable to grasp the basic knowledge will face a problem to learn a particular subject. A study by Russian researchers Hodson and Hodson (1998) showed that, knowing a subject language is a basic component in understanding the subject. This situation

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calls for the usage of accurate language in teaching and learning process is important to form a solid knowledge concept. Therefore, scientific knowledge and language has become a key component that is thought to heighten a student's ability to think at a high level. This situation also can be observed from the current scientific literacy definition that encompasses literacy, knowledge delivery, and applications relevant to science oriented issues (Seah, 2016). Thus, the research aims to identify the level of command of knowledge, scientific language and high order thinking skills of students in science subject and to identify the relationship between the scientific knowledge and language proficiency toward the students higher order thinking skills achievement.

2. KNOWLEDGE, SCIENTIFIC LANGUAGE AND THINKING SKILLS OF STUDENTS

In this 21st century, the need for students to be someone that can deal with the world's globalisation must start with mastering the knowledge of science. Science education needs to enable individuals to make decisions and take reasonable actions that impact the life and welfare of the community and the environment (Harlen 2010). Science literacy focus among which is the knowledge and understanding of scientific concepts and the process involved for a student to make decisions, get involve in community and economic productivity (NRC, 1996). The importance of understanding scientific language well is also needed because it influences the scientific concept formation. This role of scientific knowledge and language will influence the student to think more critically. A study by Ennis found that there are a few cognitive capabilities that contribute to the ability to think critically, among others is to make inferences (Viera dan Viera 2016). The use of accurate scientific language and precise prior knowledge will assist the critical thinking process.

However, past studies showed that having an intelligent mind does not necessarily mean that one has the thinking ability unless one mastered this thinking skill. All these thinking skills are not merely naturally occurring skill but it is an acquired skill that need to be trained to attain desired individual students. A study by Rojas-Drummord dan Mercer (2003) also found that students need to be taught to think at a high level. The skills to think, reason and apply have become important for students to master, to solve daily problems or anything more complicated. This ability has become a basis for the thinking skill in science and mathematics (Henry and Marie, 2012). A study by Byrnes (2001) found that students that have reasoning skills and application will allow the students to be more skillful in solving problems, have more tendency to make the right decision and be someone that is better in thinking. This is because thinking skills to reason and apply is one of the high level thinking skills. However, many studies proved that this thinking ability is still difficult to possess (Henry and Marie, 2012; Johari *et al.,* 2014). Many studies also found that this skill has not been emphasised enough at the school level (Byrnes, 2001). Instead, the general presumption of educators that students will indirectly learn it on their own particularly for science subject National Centre for Education Statistics, 2003). However, school students clearly still do not have the higher order thinking skill just yet (Jacqueline, 2006). Moreover, university students are formally taught to think by reasoning and applying, but only a handful can fairly grasp it (Robert, 2004). These studies showed that higher order thinking skills required students to obtain formal learning of it that is concept formation using accurate scientific language.

2.1 The Role of Knowledge in Shaping the Accurate Concept

A good command of science knowledge has been a main goal in developed countries. The main target of science education of most countries of the world is the community has science literacy. It includes our country that abides to the Malaysian Education Development Plan 2013-2025 (PPPM 2013-2025). Furthermore, it is a continuation from the 60:40/ science: literature Policy that states science students are expected to fulfil the economic needs of highly skilled workers. Among the efforts to allow students to have science literacy, scientific knowledge development has to be taken into account (Peters, 2012). Students's knowledge toward science is observed to be able to help students understand content knowledge and build concept framework of the way our world functions (Peters, 2012). Accurate knowledge is the fundamental substance that students have in forming a correct concept for the students to expand their ideas to the next level. However, many past studies have shown that science is a difficult subject to learn. This situation happened because students often relate daily experiences with the new scientific knowledge that they have just learned. As an example, the concept of force. In the subject of physics, students will encounter this concept through an idea by Newton that "Law of Newton" is one that defines the terminology of force. The concept of force is applicable to phenomena far wider than the classroom physics (Olsen, Turmo dan Lie, 2001). Contrariwise, there were studies that showed students used contrasting concepts of force in different contexts (Angell, 1996; Halloun and Hestenes, 1985; Kupier, 1994). This application showed that students saw knowledge "microscopically" does not consolidate with the theories learned but more toward different fragments or contexts (Olsen, Turma dan Lie, 2001). These studies clearly indicated that students are not able to think at a higher level because they were having difficulty applying the scientific knowledge that they have obtained.

2.2 Usage of Language in Science

The importance of language used in the learning of science has been discussed at length and emphasised on various perspectives (Seah, 2016). Accurate usage of language certainly help the understanding of the concepts formed. Science learning is also acknowledged as one of the new language learning considering there are incomprehensible conceptual words and have specific meaning in science, and sometimes may have contrasting meaning in daily life (Wellington dan Osborne, 2001). Furthermore, there are specific terminologies registered for every subject that carries a meaning as a set of definition that is suitable with definite functions in language, accompanied with words and structures that state the meaning (Halliday, 1975). In science education, scientific "registry" contains components of marks and symbols in the scientific language and components of daily language. There is a huge quantity of terminologies "registered" in Chemistry used in daily life that carry different meanings (Markic, Broggy and Childs, 2013). A study by Bailey *et al* (2012) found that students often misidentified light years as a measurement of time. Another study by Bar *et al* (1997) also found that students from the age of 18 considered gravity as a force that restrains human onto earth and causes thing to fall down, which it actually has no association with the idea of force by Newton. Alongside that, another example of difference in definition between scientific language and daily used language is element and compound (Markic, Broggy and Childs, 2013). A study by Schmidt (1991) found that in the event the word "neutralisation" is used, students will imagine a neutral mixture is formed. Besides that, a language study on the subject of Chemistry at O-level by Greenwood (1990) resulted in showing only five per cent of the students were able to use the correct terminologies such as residue, pungent, and dense. A previous study has shown that students often troubled by scientific language. Scientific language has definitions that are not only required to be understanding the exact word, but it also involves a whole context of the word's definition. This proved that scientific language is difficult to be mastered by students eventhough the skill is a vital part in imploring a definite concept.

3. STUDY DESIGN

The methodology used in this study was the descriptive survey method. This method was selected considering the correlation research is one of the descriptive type research that assumed the relationships between variables (Wan, 2013). A total of 180 of Form 2 students from secondary schools in the district of Skudai were randomly selected to participate in this study. The sample size was sufficient for correlation study as the size has to be no less than 30 for the data obtained from samples of less than 30 will have an effect on accurate and meaningful estimation (Wan, 2013). The instrument used in this study is test set. The test set was divided into two parts. The first part, Part A was on language proficiency that is scientific language. The second part is about knowledge and higher order thinking skills. The first part involved questions on scientific language. The scientific language questions were adapted from the Lynch et al (1978) instrument. The Lynch et al (1978) instrument was chosen as it was specially designed to test secondary school students proficiency in scientific language. Furthermore, the instrument has often been used as reference in studies involving scientific language such as the studies by Wolff and Manuela (2000), and Dodick, Argamon and Chase (2008). However, modifications have to be done coincidentally with the current question design such as Pentaksiran Tingkatan 3 that focused on subjective open-ended questions according to PPPM. Meanwhile, in Part B the questions were designed through the process of adaptation from the Higher Order Thinking Skills Resource Materials developed by the Curriculum Development Division applying the TIMSS *Released Item* questions, starting from the year 2003 to 2007. These materials were chosen because they were used to test the knowledge and skills of students. Theses TIMSS questions were developed by a community of education experts that hailed from different fields of science (TIMSS, 2002b). An "International Quality Control Monitors" (QCMs) was established to evaluate and carry out a review of the questions to ensure their quality (TIMSS, 2003). Each procedure involved in preparing the TIMSS questions was carried out thoroughly, with high validity and credibility.

4. DATA ANALYSIS

Data analysis applied was descriptive analysis. Data obtained from the collected test sets were analysed manually and also using SPSS. The per centage of correct answers recorded were used to determine the accomplishment in the basis of lower secondary grade standards drawn by the Ministry of Education (SAPS, 2015). Next, the data were analysed using descriptive statistics using the SPSS software. The results obtained were compared against the interpretation of the correlation coefficient table (Wan, 2013) shown in Table 1 and is to be the direction of the discussion.

TABLE 1: CORRELATION COEFFICIENT INTERPRETATION

Coefficient	*Description*
±0.9 to 1.00	Very high correlation
±0.70 to 0.9	High correlation
±0.50 to 0.70	Moderate correlation
±0.30 to 0.50	Low correlation
0.00 to ±0.30	Scant, if any, correlation

5. RESULTS AND DISCUSSION

Research question 1

What is the level of proficiency of knowledge, scientific language and higher order thinking skills among students in the subject of science?

In reference to Table 2, the first question was the easiest to be answered by the students on the basis of the number of students giving the correct answers to every element was higher than question 2. Results shown that the majority of students can only answer well at the level of identifying and explaining the concept of knowledge involved. Both elements were basic elements within the knowledge cognitive domain. This shows that students have the ability to answer questions on knowledge at basic level only. The findings of this study were not encouraging as the knowledge aspects that was the focus in this study was themed Human and the Diversity of Life, and Materials in Nature. The topic was the most basic that the students would have duly be at a higher level of proficiency. The students performance was still unsatisfactory although they should have already be proficient in as soon as they are in secondary school. There was no noticeable change in eventhough they have gone through formal science learning eversince they were in primary school. The results obtained in this study were in accordance to the results of the country's public examinations assessment for the science subject that showed a majority of students are at the moderate level (PPPM, 2012). International level study which is *Trends in International Mathematics and Science Study* (TIMSS) also gathered that knowledge dimension of the majority of students was at a low level with a score of 403 compared to our neighbouring country Singapore that scored 588, a high level (TIMSS, 2011).

TABLE 2: STUDENTS CORRECT ANSWER FREQUENCY FOR EACH KNOWLEDGE DOMAIN CONSTRUCT

Cognitive Domain elementknowledge	*Question number*	*Number of Students*	*Per centage*
Identifying	1	180	100
	2	180	100
Explanation	1	170	94.44
	2	155	86.11
Elaborate	1	27	15.00
	2	27	15.00
Illustration with example	1	128	71.11
	2	54	30.00

Table 3 shows Area terminology construct that indicated the majority of students were able to answer correctly was 117 students (65.00 per cent). Terminology constructs of Compound and Mixtures, however, were given the lowest correct answers of only by 11 students (6.11 per cent). The Area terminology was probably the one obtained the most correct answer due to it also being used in Mathematics which carries the same meaning that is total surface. Meanwhile, Mixture terminology garnered the least correct answer from the students due to the majority of students gave unrelated definitions of Mixture. The Mixture terminology contains the concept of solution is only taught in Form 2 science subject. However, the result showed that students gave the least number of correct answer for this terminology. This shows that students have not identified with the concept of solution behind the terminology. The result was also supported by a study by Lynch (1978) that found students from various levels of school students were able to answer about Area terminology better than about mixture. For the mixture terminology, upper secondary students answered better on the definition (Lynch, 1978). Students faced the difficulty to learn scientific language not only due to its vocabulary, but it was also about grasping the theoretical concept that requires understanding the scientific language terminology (Markic *et al.*, 2013).

TABLE 3: THE FREQUENCY OF CORRECT ANSWERS BY STUDENTS FOR EACH SCIENTIFIC LANGUAGE CONSTRUCT

Terminology	*Number of Students answered correct answer, χ*	*% Correct answer* $= \frac{\chi}{180} \times 100$
Mass	81	45.00
Length	97	53.88
Area	117	65.00
Volume	66	36.66
Solid	93	51.66
Liquid	83	46.11
Gas	83	46.11
Element	47	26.11
Compound	11	6.11
Mixture	11	6.11

In the context of education in Malaysia for the science subject, thinking skills is a mental process that requires an individual to interrelate knowledge, skills and attitude possessed by a student to enable them to understand and shape the environment and thinking skills can be categorised into critical thinking and creative thinking (Curriculum Development Division, 2011). Table 4 shows the majority of students that is 110 students (61.11 per cent) were in the lower level. Only six students (3.33 per cent) were at the high level. Meanwhile, 64 students (35.56 per cent) were at moderate level. The results of this is study is parellel to an international level research *Trends in International Mathematics and Science Study* indicating that only three Malaysian students qualified into the highest group which is the "*Advanced Benchmark*" in 2007 (IEA, 2008). The per centage of students that were in the group with higher order thinking was less than ten per cent. This per centage dwindled by two per cent compared to 1999 which had five Malaysian students being in the highest ranking group. According to Bassham *et al.* (2005), many studies had proven that there was a great relationship between thinking skills and students' achievement in which low thinking skill imposed lower achievements. Out of 74 countries, Malaysia's performance ranked within the lowest one third group for science, far below the international average and OECD (PPPM, 2012).

TABLE 4: STUDENTS THINKING SKILLS ASPECT FREQUENCY

Level	*Number of Students*	*Per centage (%)*
Low	110	61.11
Moderate	64	35.56
High	6	3.33
Total	180	100

Generally, Table 5 indicated that all three aspects that were evaluated were at moderate, pass, and passing minimum skill levels. The knowledge aspect scored the highest mean of 68.26%, followed by thinking skill aspect of 42.3% and lastly the scientific language aspect scored 41.06%. The knowledge aspect acored more than 50.00% which indicated that students had good basic science knowledge but have limited scientific language proficiency. The thinking skills score of the students apparently was not encouraging.

TABLE 5: STUDENTS MEAN SCORE

Aspect	*Mean score (%)*	*Level*	*Achievement*
Knowledge	68.26	Moderate	Pass, and passing minimum skill
Thinking skills	42.37		
Scientific language	41.06		

Research question 2

What type of relationship exists between knowledge and scientific language achievements toward high order thinking skills of students?

Table 6 displayed the correlating values of the knowledge, scientific language and hogh order thinking skills aspects. The moderate correlation value between knowldge and scientific language aspects is +0.62. Next, the high correlation value between the knowledge and high order thinking skills is +0.70. For the moderate correlation value of scientific language and high order thinking skills is +0.53. The aspects of knowledge and scientific language aspects clearly have positive relationship with high order thinking skills. The resulting correlation values exhibited higher correlation between knowledge and high order thinking skills, compared with scientific language. However, scientific language still do have positive relationship with thinking skills. Moreover, scientific knowledge also haspositive relationship with scientific language. This situation portrays the need for students to better master the high order thinking skills requires good scientific knowledge. The good command of science knowledge is by mastering the scientific language. All three aspects interrelate with each other and support science learning. This interrelation is parellel with a study by Seah (2016) that found science learning needed support not only from the kognitive aspect that is the knowledge, but also the main aspect starts wtih the scientific language used during teaching.

TABLE 6: THE CORRELATION BETWEEN KNOWLEDGE AND SCIENTIFIC LANGUAGE WITH HIGH ORDER THINKING SKILLS OF STUDENTS

		Knowledge	*Scientific language*	*Thinking skills*
Knowledge	Person Correlation	1.00	0.62	0.53
	SIG (2 -TAILED)		0.00	0.00
	N	180.00	180.00	180.00
Scientific language	Person Correlation	0.62	1.00	0.69
	SIG (2 -TAILED)	0.00		0.00
	N	180.00	180.00	180.00
Thinking skills	Person Correlation	0.53	0.69	1.00
	SIG (2 -TAILED)	0.00	0.00	
	N	180.00	180.00	180.00

6. CONCLUSION

The study proved that knowledge and scientific language aspects are required to master thinking skills better. Students' knowledge and the difficulty to be proficient has been established on several factors by past researchers such as diSessa (1993), and Taber and Garcý´a Franco (2010). The scientific knowledge component has always been the main consideration to shape science literacy (Tsaparlis, Hartzavalos and Nakibog¢lu, 2013). However, it is different for the scientific language aspect that has not been getting due attention eventhough there were studies that emphasised use of scientific language compared to other subjects (Shanahan and Misichia, 2011). The shortage of empirical references for approaches of language function in science teaching studies (Hand *et al.*, 2010; Jagger and Yore, 2012) called for the findings of this study to be taken seriously. However, this study only involved Form 2 students in the Skudai district and only emphasised on a fraction of the aspects of science literacy. Therefore, it is suggested that further research is to be carried out in other districts and the evaluated aspects are broaden to include all aspects of science literacy. This study can be a point of reference for schools as a bench mark of students's level and capacity in the effort of schools to nurture science litaracy among the students.

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