EVALUATION OF THINKING SKILLS LEVEL IN SCIENCE LEARNING AMONG LOWER SECONDARY STUDENTS IN PENANG

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LIST OF ABBREVIATIONS

HCHS	HC High School
HOTS `	Higher Order Thinking Skills
IGCSE	International General Certificate of Secondary Education
KSSM	Standard Based Curriculum for Secondary Schools (*Kurikulum Standard Sekolah Menengah*)
LOTS	Lower Order Thinking Skills
OECD	Organisation for Economic Co-operation and Development
PISA	Programme for International Student Assessment
PPSMI	*Pengajaran dan Pembelajaran Sains dan Matematik dalam Bahasa Inggeris*
PT3	*Pentaksiran Tingkatan Tiga*
SGGS	SG Girls' School
SIS	S International School
SPM	*Sijil Pelajaran Malaysia*
SPSS	Statistical Package for the Social Sciences
TIMSS	Trends in International Mathematics and Science Study
UPSR	*Ujian Pencapaian Sekolah Rendah*

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ABSTRACT

One of the major goals of education is to cultivate the thinking skills of students. However, this seems to be a challenge in Malaysian education system because schools tend to put a greater emphasis on the mastery of subject matter instead of the course of action towards achieving the learning outcomes that can promote the students' higher order thinking and problem solving skills, thus, resulting in the regression of students' thinking skills. This research was designed to evaluate the level of thinking skills among lower secondary school students in Science learning in Penang by using an instrument known as the higher order thinking level test (HOTLT). The test consisted of 20 open-ended questions which were developed based on the cognitive domain of the revised Bloom's Taxonomy. The test was distributed to a total of 113 participants from national, private and international schools. The overall findings indicated that majority of the lower secondary students were in the lower order thinking skills (LOTS) level with mean score of 2.46 out of 5 (49.2%) while the mean score for higher order thinking skills (HOTS) level was 6.29 out of 15 (41.93%). A significant difference was discovered between national and private schools as well as between private and international schools in terms of their levels of thinking skills (LOTS and HOTS) where p-value < 0.01 respectively. The Pearson Correlation test results revealed that a significant relationship existed between the LOTS and HOTS levels of the same type of school (for national and international schools only) and between the LOTS and HOTS levels of the same type of syllabus (KSSM and IGCSE) where p-value < 0.05 respectively. The findings of the study concluded that there is still a huge room for improvement in the context of HOTS among the lower secondary students in Science learning.

Keywords: *LOTS, HOTS, lower order thinking skills, higher order thinking skills, thinking skills, lower secondary school students, higher order thinking level test, Science learning*

CHAPTER 1 INTRODUCTION TO THE STUDY

1.1 Introduction

In today's era of 21st century education, the concept of 6 C's which encompasses Critical thinking, Collaboration, Communication, Creativity, Culture or Citizenship and Connectivity or Character education, has become a ubiquitous topic of discussion among educators. At the moment, schools are giving their best shot in educating their students to become critical thinkers and problem solvers in the real world, as well as honing the students to become effective communicators who can collaborate with others, embrace cultures, cultivate creativity and maintain a good connection with one another (Anugerahwati, 2019). In the past, only 4 C's were covered in the 21st century learning, mainly Critical thinking; Creativity; Collaboration and Communication. However, in the recent years, research experts have included additional two C's: Miller (2015) invented the terms Connectivity and Citizenship whereas Fullan (2015) represented the two C's with Character education and Culture, respectively.

Critical thinking denotes the way students process any information by sorting out, analysing and probing the knowledge they have received, and then integrating it to suit their comprehension (Miller, 2015; Fullan, 2015). Collaboration refers to the ability of students to cooperate with each other using their joint skills, knowledge and qualities while Communication indicates the fluency in articulating thoughts and details in a lucid and effective manner. Creativity implies the skill of students to invent something original using their knowledge and flair in an innovative way. Next, Culture or Citizenship refers to the capability of students to think like global citizens and embrace the values, norms and beliefs of the members of their society (Miller, 2015; Fullan, 2015). Lastly, Connectivity or Character education refers to the skills of students in fostering meaningful connections with others and at the same time, maintaining the essential personal traits such as being compassionate, responsible, honest and reliable to make the world a better place to live in.

In this day and age, thinking skills have become the essence of the education system because information is effortlessly accessible anywhere, anytime and by anyone. It is because of the vast amount of information that is available everywhere that students have to go the extra mile to filter and pick the relevant information wisely in order to build their higher order thinking skills, also known as critical and creative thinking skills (Paul, 1995). The relationship between the concept of thinking skills and the current paradigm can be explained in such a way that thinking is an active course of action and the focus lies on the quality of that course of action instead of merely on the quality of the outcome ensuing from that course (Jacobs & Farrell, 2001). In other words, thinking is a journey, not a destination. Aside from that, the effort to merge the school with the world beyond also serves as a bridge between the concept of thinking skills and the current paradigm (Jacobs & Farrell, 2001). This move supports the notion that learning is not an accumulation of lower-order facts to be memorised and later regurgitated on the test papers (an act of rote learning), instead school is an institution that teaches us to utilise our knowledge to make the world a better place.

Malaysia has also implemented thinking skills by shifting away from the exam-oriented system and increasing the number of items that can stimulate higher order thinking skills (HOTS) among pupils in national level examinations. As an example, the examinations for lower primary school students (Year 1 to Year 3) in Malaysia have been abolished since January 2019 and are replaced with Classroom-Based Assessment (PBD) such as observation, monthly tests, quizzes and projects (Aziz & Abu Karim, 2018). Additionally, the concept of HOTS has made its way into the national level examinations for primary and secondary education such as *Ujian Pencapaian Sekolah Rendah* (UPSR), *Pentaksiran Tingkatan Tiga* (PT3) and *Sijil Pelajaran Malaysia* (SPM) by including 40% of HOTS based questions in both UPSR as well as PT3, and 50% in SPM (Hassan et al., 2016; Ramasamy et al., 2016).

1.2 Background of Study

1.2.1 Thinking Skill

Thinking skill is one of the most fundamental skills that can be cultivated in a learning setting (classroom) and is the recipe for the academic success of students (Nessel & Graham, 2007). In general, thinking skills can be categorised into two types, which are higher order and lower order thinking skills (Ismail et al., 2016). Essential skills in our everyday life such as critical thinking, logical thinking and reasoning skills are the building blocks of the concept of higher order thinking (HOT) (Marshall & Horton, 2011). This concept is derived from the cognitive domain of Bloom's taxonomy which was introduced back in 1956 (Forehand, 2010). Conversely, lower order thinking skills (LOTS) include skills such as memorisation and comprehension (Tikhonova & Kudinova, 2015). For instance, the ability to remember the existing knowledge that one possesses and the ability to grasp what one knows. According to the author of Teach Like a Champion: 49 Techniques that Put Students on the Path to College (K-12), Doug Lemov (2010), he stated in his book that that the more proficient one is at acquiring the "lower-order" skills, the more proficient one can become at acquiring the higher order skills. Hence, HOTS and LOTS are interrelated and the former cannot be cultivated and boosted independently without the latter, considering LOTS serve as the foundation of the thinking processes (Tikhonova & Kudinova, 2015).

1.2.2 Higher Order Thinking Skills (HOTS) and Lower Order Thinking Skills (LOTS)

Higher order thinking skills (HOTS) can be defined as competence in the application of knowledge, skills and values in various aspects such as problem solving, decision making, reasoning, reflection, innovation and invention (Ministry of Education, 2013). In order to equip students with the 21st century skills, it is crucial for educators to adopt a futuristic approach by integrating HOTS elements into their lessons to transmit the skills of thinking critically, creatively and innovatively to students in order to cultivate critical and creative thinkers. Nevertheless, educators frequently reckon that this imperative goal is not meant for all students to accomplish (Zohar et al., 2001) because they have the assumption that activities involving higher order thinking are relevant only for high achievers, while low achievers, who can hardly acquire the fundamental knowledge, are deemed to be incapable of coping with such arduous cognitive activities (Zohar, 1999).

Lower order thinking skills (LOTS) are the groundwork of skills necessary to transform into higher order thinking (Tikhonova & Kudinova, 2015). These are usually the skills that are ingrained in the education systems and involve tasks like reading and writing. There are several scholars who have emphasised that students' performance in answering LOTS questions is better than that of HOTS questions because the questions posed in the textbooks and asked by educators are always revolving around LOTS (Alfaki, 2014; Hayikaleng et al., 2016; Keshta & Seif, 2013; Khan & Inamullah, 2011). Hence, in lower order thinking, the knowledge acquired is simply necessary to be remembered and comprehended, without the need to be applied to any real life situations such as problem solving, decision making and meeting the needs of the job market. While LOTS questions can aid students in instilling their confidence, educators should not overemphasise on the former (Hayikaleng et al., 2016) but instead engage students with more of higher order thinking questions that are thought-provoking, less rigid and well-organised with only relevant information in order to enhance their level of critical thinking (Hollingsworth, 1982).

1.2.3 Science Curriculum

Science is a broad field that comprises two elements, mainly scientific knowledge and the acquirement of scientific knowledge (Ozgelen, 2012). The scientific knowledge can be further branched into general information (facts), hypothesis, laws and concepts. On the other hand, the acquirement of scientific knowledge can be achieved by applying problem solving, critical thinking, reasoning, reflective and diverse science process skills which foster the implementation of HOTS in Science education (Krau, 2011; Miri & Uri, 2007; Nuthall, 1999; Pappas et al., 2013; Yao, 2012; Zohar & Dori, 2003). The main objective of science education is to facilitate learners in cultivating their HOT skills to allow them to overcome the daily life obstacles (Saido et al., 2015).

Studies on thinking skills have shown that developing students' HOTS in the learning process assists students in becoming more attentive of their own thoughts as well as boost their cognitive growth and academic performance (Donald, 2002; Perkins et al., 1993). Furthermore, when students experience uncommon predicaments, doubts, queries or quandaries, their HOT skills are stimulated. As a result, students are given an opportunity to transmit the scientific knowledge they have acquired and apply it to different circumstances (Gillies et al., 2014) in order to find a solution to the problems encountered.

In Malaysia, the Science curriculum at the lower secondary level (Grades 7 to 9 or Form 1 to Form 3) is designed to facilitate students to cultivate literacy in science and technology for daily life purposes. Students are taught to overcome problems and involve in decision making process to enhance their quality of living by equipping themselves with scientific knowledge, skills and values. In brief, the lower secondary Science curriculum is divided into six themes which are: Man and the Diversity of Living Things, Matter in Nature, Management and the Continuity of Life, Forces and Motion, Technological and Industrial Development in Life, and Astronomy and Space Exploration ("The Science Curriculum in Primary and Lower Secondary Grades – TIMSS 2015 Encyclopedia", 2019).

1.3 Problem Statement

One of the major goals of education is to cultivate the thinking skills of students. However, this seems to be a challenge in Malaysian education system because schools tend to put a greater emphasis on the mastery of subject matter instead of the course of action towards achieving the learning outcomes that can promote the students' higher order thinking and problem solving skills, thus, resulting in the regression of students' thinking skills (DeWitt et al., 2016). To be specific, there is a lack of critical thinking skills (Nagappan, 2000) among Malaysian secondary school students because educators were unable to grasp the prerequisites to inculcate such thinking skill in their pupils (Choy & Cheah, 2009). In fact, a study has shown that the practice of Higher Order Thinking Skills (HOTS) in the education system of Malaysia at the moment has been ineffective (Yen & Halili, 2015) considering the variety of obstacles faced ranging from time constraint (Sparapani, 1998), students' attitudes and motivation (Sparapani, 1998), teachers' competency and perception (Rajendran, 2002; Zohar, 2013; Zohar & Schwartzer, 2005), assessment (Zohar, 2013, p. 239), learning environment (Rashid & Hashim, 2008) and insufficiency of resources (Zohar, 2013).

Furthermore, the lack of problem solving and higher order thinking skills among Malaysian students has also become a concern of employers because these essential skills are necessary in a workplace (Ministry of Education [MOE], 2015). Employers do not emphasise specialised career skills that can be acquired during on-the-job training as highly as fundamental skills such as problem solving (Bassham et al., 2012). Studies have also shown that Malaysian students fall short in the aspect of knowledge application and they are not critical thinkers when being presented with new circumstances (MOE, 2012).

On top of that, studies on the implementation of thinking skills in the curriculum have discovered that teachers were baffled by the meaning of thinking skills and they were unable to discern between the various levels of thinking (Marzano et al., 1988; Nagappan, 2002). Apart from that, teachers reported that they encountered obstacles in incorporating thinking strategies into their existing teaching style (Jones, 2008). This finding is supported by Nagappan (1998, 2001) who discovered that teachers might be incapable of employing their knowledge of thinking skills in their classroom practices because they were not sufficiently geared up. Additionally, Nagappan (2001) also reported a significant finding in his study whereby slightly more than a quarter of teachers (26%) did not reserve any time for teaching higher order thinking, whereas more than three quarters of teachers (77%) reserved only less than 10% of their lesson time in teaching higher order thinking. This has led to the conclusion by other researchers that it is imperative for both novice and experienced educators to undergo training on instructional strategies to facilitate their understanding of critical thinking and problem solving techniques (Nagappan, 2010; Suhaili, 2014).

In addition, Malaysian students had scored below average in Science (420), Mathematics (421) and reading literacy (398) in the Programme for International Student Assessment (PISA) in 2012 (OECD, 2014). On the other hand, although

Malaysian students have shown significant improvement in the recent PISA 2018 performance (mean scores of 440 in Mathematics; 438 in Science and 415 in reading literacy), the students' scores still fell short below the Organisation for Economic Co-operation and Development (OECD) average in these subjects (Chin, 2019a; "Malaysia - Country Note - PISA 2018 Results", 2019). According to Ramos et al. (2013), there is a positive correlation between the students' level of HOTS and their performance in Science (Physics). Hence, it can be generally concluded that the poor performance of Malaysian students in PISA 2018 is due to the low level of HOTS of students.

The alarming performance of students in the recent international assessment (PISA 2018) calls for more research to be conducted on evaluation of the students' level of thinking skills in Science and Mathematics, in order to realise the aim of Malaysia to score beyond the global average and emerge in the top one-third of participating countries in international assessments by the first quarter of the 21st century (2025), conforming with the Malaysia Education Blueprint 2013-2025. Therefore, the focus of this research is to evaluate the level of thinking skills among lower secondary students in Science learning in Penang.

1.4 Research Objectives

There are three objectives in my study which are:

a) To evaluate the thinking skills level of lower secondary school students, specifically from age 13 to 15, in Science learning in Penang by using an instrument known as the higher order thinking level test (HOTLT).
b) To identify whether there is a significant difference and relationship respectively between the type of school and the level of students' thinking skills in Science learning by conducting paired sample T-Test and Pearson Correlation test respectively.
c) To explore if there is a significant relationship between the type of syllabus implemented by the secondary school and the level of students' thinking skills in Science learning by conducting Pearson Correlation test.

In order to achieve these three research goals, three research questions were formed as the following:

1) What is the current level of thinking skills among lower secondary school students in the learning of Science in Penang?
2) Is there any relationship between the type of school which students are enrolled in and their level of thinking skills in Science learning?
3) Is there any relationship between the type of syllabus implemented by the secondary school and the level of thinking skills of students in science learning?

1.5 Significance of Study

Considering the significance of thinking skills in determining the academic achievement of a student, a thorough comprehension of the application of thinking skills and their evaluation among students is an essential objective in science education (Saido et al., 2015). The findings of this study can expand the horizon of knowledge in evaluating the level of thinking skills of students in science learning as portrayed by the evaluation of thinking skills in Science learning among lower secondary students (age 13 to 15) in Penang.

Apart from this, the outcomes of this study are potentially useful to educators and curriculum developers. For instance, Science educators could spot the students' weak points through the evaluation of their students' level of thinking skills, and tackle them by implementing learning tasks which can especially promote the enhancement of higher order thinking skills. Similarly, curriculum developers could benefit from the findings of this research project by utilising these findings to gauge the effectiveness of a new science curriculum in implementing HOTS as well as formulate strategies to inculcate higher order thinking process among science students. Additionally, educational leaders also play a crucial role in encouraging science teachers to constantly acquire thinking skills by attending in-service professional development programmes on the methods to employ the science curriculum to infuse an in-depth understanding of scientific theories and their uses in everyday life among students.

In a nutshell, this study can potentially benefit the education stakeholders of different types of school ranging from national school and private school to international school. This is because the findings can provide a better insight on the level of thinking skills of the lower secondary students from their respective type of school in Science learning. This can help cater to the diverse needs of students that engage in different syllabi (KSSM or IGCSE) and academic settings (national, private or international school) by encouraging course developers and Science educators to incorporate thinking skills particularly the higher order thinking elements in their course materials and lessons respectively using various approaches that are able to spark learners' interest in the application of higher order thinking in Science education.

1.6 Definition of Terms

There are several key terms used to describe the variables in this study. The definitions of these terms will be further explained as follows:

a) National school

A school owned and funded by the government that offers primary and secondary education following the Malaysian National Curriculum such as Primary School Standard Curriculum or *Kurikulum Standard Sekolah Rendah* (KSSR) for primary students (Year One to Year Six) and Secondary School Standard Curriculum or *Kurikulum Standard Sekolah Menengah* (KSSM) for secondary students (Form One to Form Five) ("Types of School in Malaysia", 2020).

b) Private school

A school funded by the tuition fees paid by students and owned by non-government or non-state bodies, which offers preschool, primary and secondary education using the Malaysian National Curriculum such as KSSR for primary students (Year One to Year Six) and KSSM for secondary students (Form One to Form Five) ("Difference between International Schools and Private Schools in Malaysia", 2019).

c) Chinese Independent High School

A private secondary school established by the Chinese community and uses Mandarin as the medium of instruction (Low, 2015). Most Chinese Independent High Schools in Malaysia are following the Unified Examination Certificate (UEC) syllabus (Low, 2015) while some also offer the International General Certificate of Secondary Education (IGCSE) syllabus as another alternative ("升学辅导处", 2016).

d) International school

A private school that offers preschool, primary and secondary education following the International Curriculum such as Cambridge International Examination or International Baccalaureate and uses English as the medium of instruction ("Difference between International Schools and Private Schools in Malaysia", 2019).

e) Thinking skill

A type of cognitive skill that can be divided into two branches, mainly the lower order thinking skills (LOTS) and higher order thinking skills (HOTS).

f) Thinking skills level

The six categories of cognitive domain of revised Bloom's Taxonomy namely Remember, Understand, Apply, Analyse, Evaluate and Create (Krathwohl & Anderson, 2009).

g) Lower Order Thinking Skills (LOTS)

A set of skills which encompass the first two cognitive domains of revised Bloom's Taxonomy, namely Remember and Understand ("Higher Order Thinking: Bloom's Taxonomy", 2020).

h) Higher Order Thinking Skills (HOTS)

A set of skills which encompass the upper four cognitive domains of revised Bloom's Taxonomy, namely Apply, Analyse, Evaluate and Create ("Higher Order Thinking: Bloom's Taxonomy", 2020).

i) International General Certificate of Secondary Education (IGCSE)

An English language curriculum which is developed by Cambridge International Examinations (CIE) that leads to the world most renowned international certification from the University of Cambridge for completion of secondary education ("Cambridge IGCSE", 2019).

j) *Kurikulum Standard Sekolah Menengah* (KSSM)

A Malaysian National Curriculum that is offered by the Ministry of Education for secondary students (Form One to Form Five) and which uses Malay language as the official medium of instruction except for language subjects ("Types of School in Malaysia", 2020).

k) Age group

The range of age of the lower secondary students (13 to 15 years old) that were involved in the study.

1.7 Limitations of Study

The major challenge encountered during my research process was the application for approval to conduct my research study in three different types of schools (national, private and international) in Penang. There were some Principals that were willing to let me run my study in their schools while there were some who were reluctant to do so.

The process to get the approval from S International School was fairly smooth because the Principal found the research topic interesting and she was very cooperative throughout our liaison via email exchange. She had also arranged for her staff, the Head of Science (Secondary) to assist me in my research study.

However, it was quite taxing to obtain the permission to conduct my research in a private school. During my phone conversation with the administration staff of CL Private High School (CLPHS), she mentioned that it is the school policy to only allow their in-house teachers to conduct research in their school and that an outsider is not allowed to do so. I pleaded with her to kindly reconsider and she agreed to forward my request to the Academic Department. Not long later, I received an email of rejection from CLPHS with the reason that they were preparing for their examination and it was inconvenient for them to proceed with the study.

Upon receiving the email of rejection, I decided to instantly call the only private high school left in Penang apart from CLPHS that offers IGCSE course, and that is HC High School. I am really thankful that after a thorough consideration, the Principal eventually gave me the green light to conduct my study in her school despite the fact that her students' exam period was also around the corner.

In addition, the process to get the approval from a national school was also tedious because it required me to obtain the permission letter from the Penang State Education Department (JPN) prior to conducting my study in their school. Given the short amount of time, I decided to look for another alternative in order to not delay the progress of my research. I contacted the principal of my alma mater, SG Girls' School (SGGS) and fortunately, due to the fact that I am an alumnus of the school, I was granted the approval to conduct my research there.

Another limitation in this study is the different age groups among the students from international school compared to those of national and private schools. My research participants from the international school consisted of Grade Eight students, ranging from 13 to 14 years old, whereas my research participants from both national and private schools consisted of Form Three students (15 years old). The age gap between the research participants from different schools may influence the results of the students' level of thinking skills as different ages bring about different levels of maturity and critical thinking. For instance, Dwyer and Walsh (2020) hypothesised in their study that the performance of students with more mature age (which improves the possibility of higher metacognitive engagement) in critical thinking would be significantly better than those of younger students.

Apart from that, there is also a lack of private high schools, specifically the Chinese Independent High Schools in Penang that offer the Cambridge curriculum known as IGCSE syllabus. At the moment, there are only two such schools in Penang that offer IGCSE syllabus while the other private high schools follow the Unified Examination

Certificate (UEC) syllabus. Therefore, this has caused the exposure of private high schools to IGCSE syllabus rather limited as compared to international schools that are mostly adopting this Cambridge curriculum.

Furthermore, this study is only conducted on lower secondary students from different types of school and not their Science teachers as well. This may be a limiting factor due to the fact that teachers from different types of school have different understanding and orientation on the methods used to integrate thinking skill elements into their Science teachings. This is because teachers from each school receive different trainings and professional development opportunities from their respective institutions. Hence, the outcomes produced for learners (students) will also differ because in order to efficiently inculcate thinking skills in students, the teachers must first acquire thinking skills. If teachers from the different types of school are included in this study as well, the findings may indicate whether there is a significant relationship between the level of the teachers' thinking skill in Science teaching and the learners' thinking skill level in Science learning.

1.8 Summary

This project report is divided into five chapters. Chapter One offers a glimpse of what this research project is all about by explaining the background of the study, problem statement, research objectives, significance of the study, definitions of the key terms used in this report as well as the limitations of the study. Ultimately, this chapter provides a deeper insight on the purpose of this research which is to evaluate the thinking skills level amongst lower secondary students in Science learning in Penang.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This chapter underlines the history of the teaching of HOTS in Malaysian educational settings as well as the timeline of the Science education in Malaysia by describing about the Science syllabi that have been implemented ever since Malaysia achieved its independence from British. Next, this chapter also describes about the levels in the original and revised Bloom’s Taxonomy which is extensively applied by educators worldwide in their teaching practices, followed by the association between critical thinking and higher order thinking. Some issues of implementation of thinking skills in Malaysian schools are also further elaborated before ending the chapter with the conceptual framework of this study.

2.2 History

2.2.1 Teaching of Higher Order Thinking Skills in Malaysian School

The teaching of higher order thinking skills in Malaysian schools began in the early 1990’s (Rajendran, 2001). Nevertheless, countless endeavours in enhancing students’ thinking skills have occurred even prior to this period. In order to equip the educators with the necessary skills to teach thinking skills, a number of workshops and crash courses on teaching thinking skills such as De Bono’s ‘CoRT Thinking Tools’, ‘Optimal Learning’, ‘Accelerated Learning’ and ‘Critical and Creative Thinking’ had been conducted since four decades ago (1980s) in Malaysia (Rajendran, 2001).

One of the aims of Malaysian secondary school education as underlined by the Curriculum Development Centre (1989, p.2) is to cultivate and boost the students’ academic competence in regards to creative, critical and rational thinking in the curriculum. Hence, this has led to the instructional practices of thinking skills in educational institutions with the purpose of improving the thinking abilities of students in order to enable them to analyse, create, justify, form conclusions and generate concepts that are productive and practical (Curriculum Development Centre, 1989, p.6). In addition, the focus on teaching cognitive skills has been mentioned in the Integrated Curriculum for Secondary Schools (ICSS) which was devised in 1988, where every teacher is necessitated to apply teaching approaches and strategies which will trigger, promote and cultivate the thinking skills of students (Curriculum Development Centre, 1989, p.27).

When incorporating the thinking skills programme in schools in 1993, the Ministry of Education (MOE) discovered four models that could be put into practice in the classrooms (Curriculum Development Centre, 1993). The first model was developed by Robert Swartz and Sandra Parks, and it is commonly known as the ‘Boston Model’ in Malaysia. The second model is called the ‘KWHL Model’, where K represents ‘knowledge’; W represents ‘what’; H represents ‘how’; and L represents ‘learnt’. The third model which was developed by Edward de Bono comprises CoRT 1 (Widening and Perception) and CoRT4 (Creative and Lateral Thinking). The final model which was developed by John Arul Phillips and Fatimah Hashim is called ‘Programmed Instruction in the Learning of Thinking Skills (PILTS)’. In addition to the inclusion of these four models in the new curriculum for teaching thinking skills, the Ministry of Education also supplied teachers with techniques, approaches, tasks and model lesson plans that portrayed how thinking skills could be simultaneously taught with the subject matter using the ‘infusion approach’(Rajendran, 2001). Teachers are strongly advised to devise their own lesson plans based on the models considering the model lesson plans cover ample subjects. Furthermore, textbook authors were also asked to bring in thinking skills component into their materials (Rajendran, 2001).

In the following year (1994), the MOE declared a policy which underlined that the minimum number of questions which will assess students’ analytical and creative thinking skills must not be less than 60% of the national examination questions by the year 2000 (Rajendran, 2001). In the most recent initiative to fulfil the aspiration of the Malaysia Education Blueprint 2013-2025 to develop students to become critical and creative thinkers, questions that stimulate the application of higher order thinking skills have penetrated into the national level examinations since 2013 and they will subsequently be stepped up until 2020 (Chin, 2019b).

2.2.2 Science Education in Malaysia

After achieving independence from British, Malaysia carries on with the science curriculum originated from England. Studies have shown that Malaysia had implemented three types of science curriculum from 1968 to 1981 (Tan, 1991; Lee, 1992), which were the Scottish Integrated Science Syllabus for Form One to Form Three students, the Nuffield Secondary School Science Curriculum and the Nuffield O-Level Pure Science Syllabus for the Form Four and Five students who were taking the art and science streams respectively.

Thair and Treagust (1997; 1999) opined that the science syllabus in developing countries such as Malaysia and Indonesia were merely adopted from developed countries without any attempt to adapt the syllabus to fit the local circumstances. As a result, this has jeopardised the teaching-learning experience in the classroom. For instance, the deficiency in laboratory apparatus for conducting experiments as well as the lack of experienced teachers to implement the science curriculum has instigated many issues in the classroom (Sumintono, 2015). Moreover, Tan (1991) has listed out the struggles connected with the foreign science curriculum, classified as conceptual, pedagogical and psychological problems. Conceptual problem arose when Malaysian students encountered trouble in relating science experiments of the syllabus derived from Western culture with their everyday lives. As for pedagogical problem, the conventional teaching method in Malaysian schools is lying towards the teacher-centred approach but the foreign curriculum focuses more on student-centred approach. In terms of psychological problem, the exam-oriented education system in Malaysia leaves the teachers no choice but to complete the syllabus within a stipulated timeframe, and because of the restricted time, the teachers tend to take the easy way out by revealing the results of science experiments orally, instead of letting the students discover things for themselves by carrying out experiments (an act of spoon-feeding).

This serves as a wakeup call for Malaysia and hence, the Curriculum Development Centre was established in 1972 to conduct research and development on the curriculum locally (Tan, 1991). This had led to the introduction of a newly integrated science curriculum at both primary and high school levels in the late 1980s which catered to the local needs. This new curriculum is intended to implement the child-centred approach but Tan (1991) remarked that the teaching culture is still inclining towards the teacher-centred style.

In 2003, the Malaysian education system made a radical move by implementing the PPSMI (*Pengajaran dan Pembelajaran Sains dan Matematik dalam Bahasa Inggeris*) policy, which employed the use of English as the medium of instruction for Mathematics and Science subjects at primary and secondary school levels (Heng & Tan, 2006). However, numerous studies by Heng and Tan (2006) as well as Phang (2010) have shown that this policy, which had a short amount of preparation time (about six months) and was implemented in a hassle, had backfired. This is mainly due to the fact that until the moment this policy was implemented in 2003, Malaysian teachers did not receive any training to teach Science and Mathematics in English (Sumintono, 2015). After receiving plenty of condemnation, political pressure and empirical research evidence, the Malaysian government eventually decided to withdraw the PPSMI policy in 2009 and it officially terminated in 2012 ("PPSMI dimansuhkan mulai 2012", 2009).

In the most recent Malaysia Education Blueprint (2013-2025), it is stated that the current science curriculum will be integrating more problem-based and project-based activities, formative assessments and a fast-track pathway for high achievers to finish their secondary education in four instead of five years (KPM, 2013). This education blueprint also stresses that Malaysian students need to develop high order thinking skills (HOTS) to remain competitive worldwide, to be equipped with skills sought by the industry and job market as well as to meet the demands of the challenges imposed by the standards of international assessments such as TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme for International Student Assessment). To realise this aspiration, national examinations and school-based assessments in Malaysian schools have incorporated HOTS questions in their test papers by 2016 which included an upsurge of 80% for the Form 3 Assessment (PT3), 75% rise for SPM core subjects and 50% rise for SPM electives (Sumintono, 2015). Furthermore, the level of difficulty for Science paper in public examinations will also be heightened to correspond with HOTS, which is believed to advance the standard of science education in the future (Sumintono, 2015).

2.3 Bloom's Taxonomy

The cognitive domain of Bloom's Taxonomy was introduced by an educational psychologist, Dr Benjamin Bloom in 1956 (Forehand, 2010) and revised by an ex-protégé of Bloom, Anderson and Krathwohl in 2001. There are six categories of the cognitive process dimension, with increasing level of difficulty for each level to signify the progression from the lower level to a higher level of cognitive processing (Clark, 2010). These categories in the Bloom's Taxonomy for cognitive development are also arranged hierarchically from concrete to abstract (Pappas et al., 2013). Figure 2.1 shows the original Bloom's taxonomy while Figure 2.2 shows the revised taxonomy.

Figure 2.1

Original Bloom's Taxonomy (Bloom, 1956)

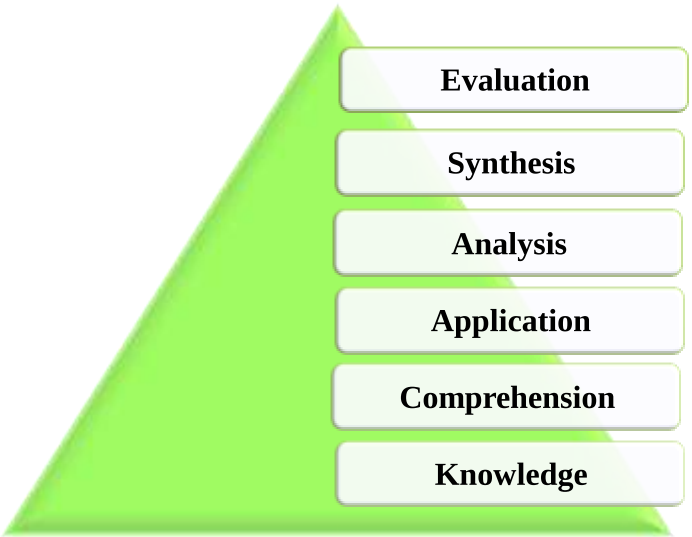
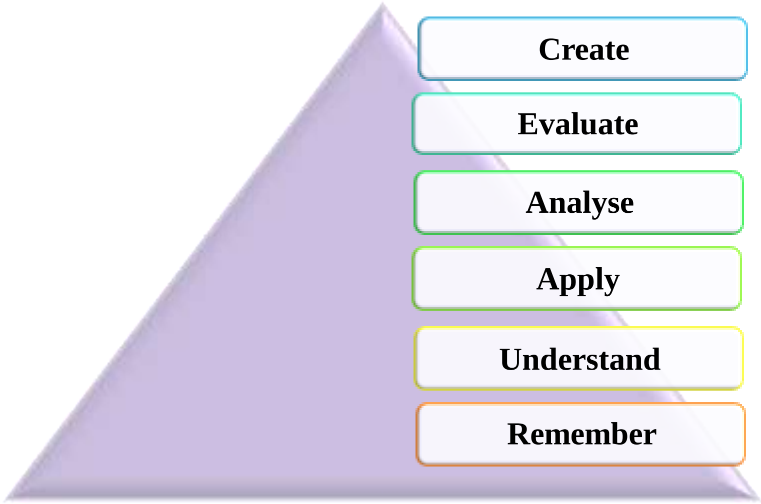


Figure 2.2

Revised Bloom's Taxonomy (Anderson & Krathwohl, 2001)



Referring to Figure 2.2, the bottom three categories (Remember, Understand and Apply) call for fundamental cognitive skills such as recognising or recalling information (Remember), interpreting or summarising messages (Understand), executing or implementing procedures (Apply) and thus, these categories are deemed as lower order thinking skills (LOTS) (Forehand, 2010; Yahya et al., 2012). On the other hand, the three remaining categories of revised Bloom's taxonomy (Analyse, Evaluate and Create) (Clark, 2010) need students to utilise their higher order thinking skills (HOTS), therefore enhancing their academic performance (Forehand, 2010; Yahya et al., 2012). However, according to The Learning Center of University of North Carolina ("Higher Order Thinking: Bloom's Taxonomy", 2020) and the British Council of Malaysia ("Higher Order Thinking Skills", 2020), LOTS is made up of the first two fundamental constructs of the cognitive domain of revised Bloom's Taxonomy, which are Remember and Understand while HOTS is made up of the last four constructs of this revised taxonomy, which are Apply, Analyse, Evaluate and Create. This view where Apply category is considered as a part of HOTS is further supported by the Ministry of Education of Malaysia that has named the four levels of thinking skills in HOTS as Apply, Analyse, Evaluate and Create (MOE, 2016), which correspond with the final four categories of the cognitive domain of revised Bloom's Taxonomy.

2.4 Relationship between Critical Thinking and Higher Order Thinking

The term critical thinking carries various interpretations as cited by multiple researchers. Ennis (1987) stated that critical thinking is a sensible and contemplative cognitive process that is directed on determining one's belief and action, and his definition is used prevalently because it encapsulates the essence of critical thinking, which are decision making and reasoning skills. On the other hand, Bailin et al. (1999) opined that critical thinking entails judgment, especially exceptional judgments. Bailin (2002) claimed that judgments are to be made based on conditions and benchmarks. Furthermore, she added that critical thinking often arises as a result of problem solving, theories evaluation, carrying out investigation, tasks interpretation and engagement in creative activities (Bailin, 2002).

Resnick (1987) described that higher order thinking can be identified when it takes place because it is intricate; it does not have a fixed algorithm, it frequently leads to plenty of solutions, and it includes ambiguity occasionally. Moseley et al. (2005) had reviewed 35 thinking taxonomies and came to a conclusion that two taxonomies had captured their attention for being "strongly guided in theory and practice" (Moseley et al., 2004, p.3) as well as being absolutely practical for application in all school levels. These two taxonomies were Anderson and Krathwohl's (2001) and Marzano's (2001, updated by Marzano and Kendall in 2007). The former taxonomy is a revised version of Bloom's taxonomy (Bloom et al., 1956) and it offers a constructive method to evaluate curriculum outcomes and organise educational goals (Moseley et al., 2005).

According to FitzPatrick and Schulz (2015), the revised Bloom's Taxonomy is a model that underlines domains of knowledge and cognitive processes which are applicable to determining the order of thinking sought by curriculum outcomes. The Anderson and Krathwohl's taxonomy (2001) consists of six cognitive processes (remember, understand, apply, analyse, evaluate, create — with increasing level of difficulty) of which the first three categories represent the lower order thinking while the remaining three represent the higher order thinking (Clark, 2010). Ennis (2003) considered the higher levels of the taxonomy to be critical thinking. This view is supported by Paul and Elder (2006), who recognised three aspects of critical thinking as analytic, evaluative and creative, which corresponds with the top three categories of the revised Bloom's taxonomy (Analyse, Evaluate and Create).

2.5 Issues in Implementation of Thinking Skills in Malaysian Schools

In Malaysia, in spite of the abundance of researches conducted on thinking skills, be it from the teachers' or students' perspectives, the students are still falling behind in terms of their thinking skills (Othman & Mohamad, 2014). Educators who are responsible in inculcating thinking skills such as critical and creative thinking skills in their respective subject matter should first acquire high level of thinking skills, before they can transfer the skills to their students. However, Hashim (2004) found that the hugest hindrance to the teaching of critical and creative thinking is the short of knowledge and comprehension, together with the complementary thinking skills among teachers. A study has also found that the level of creativity of the science and mathematics teachers under study lies on the moderate side (Aznizah, 2004). This should not be acceptable simply because teachers play a crucial role in cultivating the interest of students in science and mathematics subjects (Aznizah, 2004).

On top of that, Choy and Cheah (2009) reported that there seemed to be lack of understanding among teachers on the prerequisites needed to develop critical thinking among students. Despite the perception that teachers are promoting critical thinking in the classroom, they are really just highlighting on the understanding of the subject content, which indirectly instils rote learning instead of a meaningful learning culture within the students.

Mahyudin et al. (2004) added that a lot of teachers do not have the sufficient competence in integrating thinking skills in their teaching methodology. This is rather worrisome due to the fact that even after 11 years of primary and secondary schooling, numerous students are still incapable of transferring the knowledge gained in school to solve problems in the real world (Hashim, 2004).

Apart from that, research on thinking skills was mainly left on the library shelves to accumulate dust instead of being used to enlighten the related educational stakeholders in the Ministry and schools. Hence, these stakeholders were hindered from putting the research framework to good use with the excuses that in Malaysian context, most educators have difficulty in accessing the relevant literature, do not have the urge to self-improve, are too preoccupied with teaching and getting their students ready for examinations or are contented with their present teaching approaches regardless of the waning educational qualities (Othman & Mohamad, 2014).

2.6 Conceptual Framework

Figure 2.3

Evaluation of Thinking Skills in Science Learning Framework

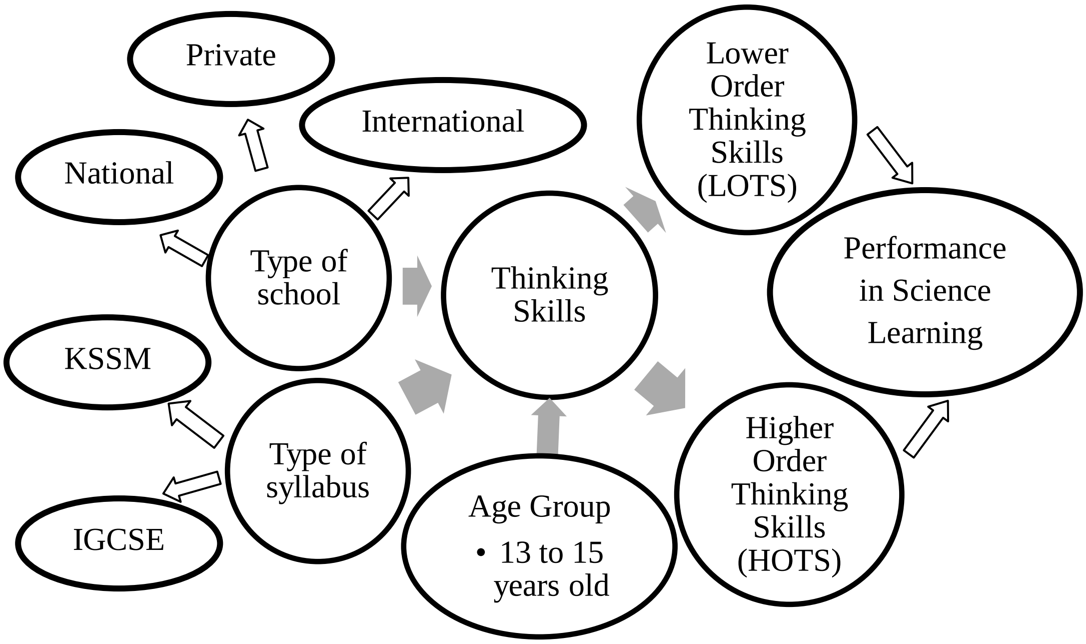


Figure 2.3 shows the conceptual framework of the evaluation of the thinking skills level among lower secondary students in Science learning in Penang. The independent variables in this study are the type of school and the type of syllabus while the dependent variable in this study is the performance in Science learning. The age group of the research participants is ranging from 13 to 15 years old, which fits the category of lower secondary students (Grade Seven to Grade Nine; an equivalent of Form One to Form Three). The research participants are selected from three types of school, which are national, private and international schools. There are

two types of syllabus that are being adopted which are the KSSM syllabus (national school) and the IGCSE syllabus (private and international schools).

In this study, the performance of the lower secondary students in Science learning is determined by their level of thinking skills which can be further categorised into lower order thinking skills (LOTS) and higher order thinking skills (HOTS). These two orders of thinking skills are evaluated through a test instrument known as the Higher Order Thinking Level Test (HOTLT) which consists of 20 items developed based on the six categories of the cognitive field of the revised Bloom's Taxonomy; namely Remember, Understand, Apply, Analyse, Evaluate and Create. The LOTS level of students are reflected by the sum of scores for questions covering Remember and Understand categories whereas the HOTS level of students are mirrored by the total scores for questions encompassing Apply, Analyse, Evaluate and Create categories.

The students' level of thinking skills may be influenced by several factors such as the type of school where they come from, the type of Science syllabus that they are following as well as their age group. Different types of school employ different techniques in incorporating thinking skills into the Science lessons due to the variety in teaching styles. Besides, the learning environment in each school varies from one another. For instance, private and international schools can usually afford to have more sophisticated facilities, science laboratories and equipment as they are privately funded by the tuition fees of students as compared to national school that receives funding from the government. Thus, students from private and international schools are more likely to receive greater exposure to a learning environment that is able to spark their interest in Science learning as well as to enhance their creative and critical thinking skills.

On top of that, the difference in syllabus may also be a factor in deciding the level of students' thinking skills in Science learning. This is because the scope of learning varies for each grade. For example, in KSSM syllabus, the topic of "Biodiversity" is covered in Form 2 Science while in IGCSE syllabus, the similar topic of "Living Things in Their Environment" is covered in Grade 7. On the contrary, the topic of "Reproduction" is covered in Form 1 Science of KSSM syllabus and will only be taught in Grade 8 Science of IGCSE syllabus. Hence, although the topics from both syllabi overlap each other, they are taught in different grades. This means that students who are following the IGCSE would have a better comprehension of the "Biodiversity" topic earlier than the students who follow the KSSM syllabus but students who follow KSSM syllabus will grasp the topic of "Reproduction" earlier than their counterparts who are adopting the IGCSE syllabus.

2.7 Summary

In a nutshell, the Science education in Malaysia has gradually been moving its emphasis towards the direction of development of thinking skills. While the effort to empower learners to become creative and critical thinkers in order to remain competitive worldwide in this 21st century is still ongoing, Science educators should also incessantly engage in professional development activities and trainings that can enhance their thinking skills in order to keep up with the pace of the ever progressive field of Science.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 Introduction

Chapter 3 discusses about the research methodology in depth in order to provide answers to the following research questions:

i) What is the present thinking skills level among lower secondary school students in the learning of Science in Penang?

ii) Is there any relationship between the type of school which students are enrolled in and their level of thinking skills in Science learning?

iii) Is there any association between the type of syllabus implemented by the secondary school and the level of thinking skills of students in science learning?

Generally, it relates to the research design which includes the population, samples and sampling method, location of research, instrumentation, pilot study, data collection and data analysis.

3.2 Research Design

This is a quantitative research to evaluate the thinking skills level of lower secondary students in Science learning in Penang. As defined by Bryman (2012, p.35), a quantitative research is "A research strategy that emphasises quantification in the collection and analysis of data…" This study measures the level of thinking skills of students from the national, private and international schools who are following either the Standard Curriculum for Secondary Schools (*Kurikulum Standard Sekolah Menengah* or KSSM) syllabus or the International General Certificate of Secondary Education (IGCSE) syllabus in Science learning by administering a test known as the Higher Order Thinking Level Test (HOTLT). This test assessed the LOTS and HOTS of the study samples through the test items which were meticulously constructed according to the six categories of the cognitive domain of revised Bloom's Taxonomy (Remember, Understand, Apply, Analyse, Evaluate, and Create). Overall, the study took two weeks for me to complete (19th February 2020 to

3rd March 2020), beginning from the moment of attainment of approval from the principals to conduct the study in their respective schools to the moment of completion of study in all the three schools.

In this research, the quantitative approach was employed because the quantitative results of the study may be representative of a whole population or a subpopulation because it includes a larger study sample (Carr, 1994) which provides more credibility to the study (Powers D. & Powers A., 2015). Apart from sampling, the data analysis process in a quantitative research can be expedited with the help of statistical software such as SPSS (Connolly, 2007).

In a nutshell, this is a quantitative research that employed the correlational design as correlational statistic is employed to portray and quantify the relationship between two or more variables (Creswell, 2012).

3.3 Population, Samples and Sampling

This study involved 113 research participants from three different types of school; 31 participants selected from a national school (SGGS), 37 participants from a private school (HCHS) and 45 participants from an international school (SIS). The participants from the national and private schools are aged 15 years old whereas the participants from the international school are in Grade Eight (13 to 14 years old). The participants were required to fulfil several criteria such as: i) The age of participant must range between 13 to 15, ii) Participants are taking Science subject, following either the KSSM or IGCSE syllabus in their respective schools and iii) Participants are willing to take part in this research.

The sampling technique which was adopted in this research is known as the homogenous sampling, which is a type of purposive sampling technique. The research participants were selected collectively by their Science teachers based on the availability of the classes, hence easing the flow of the data collection since the participants were studying in the same classrooms in their respective schools. This homogenous sampling technique was chosen in order to achieve a homogenous sample whose units possess the same (or approximately similar) features (example:

age and education background) (Thornhill et al., 2009). In this case, the research participants must be within the age group of 13 to 15 and taking Science subject of either KSSM or IGCSE syllabus in order to fulfil the key objective of this study, which was to evaluate the thinking skills level of lower secondary students in Science learning, in Penang. Furthermore, purposive sampling technique allows the researcher to save time and money (Dudovskiy, 2019) because of the selective nature of this technique. For instance, employing this sampling technique in my study had served as a good preliminary filter for the specific study criteria in terms of age group, type of school and type of syllabus, hence, saving me from the hassle of accepting participants that might not be the right fit for my research. Additionally, purposive sampling technique is apt when the number of primary data sources that are able to add value to the study is inadequate (Dudovskiy, 2019). As a matter of fact, there are only two private schools (Chinese Independent High Schools) in Penang that offer IGCSE syllabus at the moment, and I was already denied the permission to carry out my study in one of the schools, rendering me with the only choice left, which was HCHS.

3.4 Location of study

This study was conducted in three types of secondary schools in Penang, namely a national school; a private school and an international school. The national and private schools are located in the city of George Town (capital city of Penang state) whereas the international school is located in Bayan Lepas town.

3.5 Instrumentation

The instrument which was employed in this study is called a higher order thinking level test (HOTLT) which consisted of 20 open-ended questions and was self-constructed based on the six categories in the cognitive area of the revised Bloom's Taxonomy (Remember, Understand, Apply, Analyse, Evaluate and Create). According to Badger and Thomas (1991), open-ended questions call for intricate thinking and generate diverse answers. Such questions also provide an opportunity for students to look for solutions of their choice when they encounter any problems. Hence, this can aid students in building up their confidence level when answering questions with such format (Cooney et al., 2004). Scholars have also remarked that providing open-ended questions is an effective evaluation technique because such questions are able to offer valuable input about the performance of students more evidently than multiple-choice questions or closed-ended questions, therefore, providing educators with better direction to advance their teaching practices to the next level (Badger & Thomas, 1991; Husain et al., 2012).

Prior to the development of the higher order thinking level test (HOTLT), an items specification schedule (ISS) (Appendix A) was constructed based on the Standard Based Curriculum for Secondary Schools (KSSM) for Science Form 1 and Form 2. Since I was a former tutor teaching lower secondary Science subject, I developed this test instrument (Appendix B) myself as I could not get access to the test instrument from a similar study on "Higher Order Thinking Skills Among Secondary School Students in Science Learning" by Saido et al. (2015). After the development of the test instrument, the test items were sent for an expert review and the test validity was verified by a psychometrician, Dr. Balasubramaniam from Teachers Training Institute Penang Campus.

This instrument was a kind of aptitude test that was self-developed according to the cognitive domain of the revised Bloom's Taxonomy which consists of six categories mainly remember, understand, apply, analyse, evaluate and create (Anderson & Krathwohl, 2001). In accordance with the prior studies (Pappas et al., 2013; Scott, 2003; Yahya et al., 2012; Zohar & Dori, 2003), the first three categories of revised Bloom's taxonomy (remember, understand and apply) evaluate the students' LOTS while the remaining three categories (analyse, evaluate and create) assess the students' HOTS. However, the Ministry of Education (2016) of Malaysia has classified the four thinking levels in HOTS as Apply, Analyse, Evaluate and Create which correspond with the last four categories of the cognitive domain of the revised Bloom's Taxonomy. By taking into consideration that the ultimate objective of this study was to evaluate the level of thinking skills of lower secondary students in Science learning in Penang, the outcomes of this study would follow the classification of the four thinking levels in HOTS that are set by the Ministry of Education. Hence, all Applying-based, Analysing-based, Evaluating-based and Creating-based questions are considered to be HOTS questions.

In order to evaluate the students' level of LOTS, there were a total of five LOTS questions which were made up of three Remembering-based and two Understanding-based questions. On the other hand, there were a total of 15 HOTS questions (five Applying-based questions, three Analysing-based questions, five Evaluating-based questions and two Creating-based questions) prepared to assess the students' level of HOTS. In order to determine the total score of a student in this aptitude test, each correct answer would be awarded a mark whereas no mark would be awarded to an incorrect or blank answer. Therefore, the sum of marks for all LOTS questions (Remember and Understand) would indicate the score for the LOTS level whereas the total marks obtained for all HOTS questions (Apply, Analyse, Evaluate and Create) would signify the students' HOTS level. The total score of a student in this aptitude test was determined by summing up the marks for both LOTS and HOTS questions.

Some examples of the LOTS and HOTS questions in the test are as follows:

1) Identify two structures which are present in plant cells but absent in animal cells. **[Remembering] (1 mark)**
2) What would happen to the number of white blood cells produced when one is attacked by flu? Deduce why this happens**. [Understanding] (1 mark)**
3) 82.8 cm^3 of water is frozen into ice with a density of 0.92 g/cm^3. What is the volume of the ice? **[Applying] (1 mark)**
4) Why is salt not found in the Periodic Table? **[Analysing] (1 mark)**
5) Why is the urethra considered a part of the male reproductive system but not the female reproductive system? **[Evaluating] (1 mark)**
6) You are a nutritionist who has been invited to a school to deliver a talk on "The Benefits of Balanced Diet". Develop a food menu that can be used to educate your audience on the importance of maintaining a balanced diet. Your menu should include all the seven classes of food. **[Creating] (1 mark)**

3.6 Pilot study

Before proceeding with the data collection, a pilot study was carried out. The higher order thinking level test (HOTLT) was distributed to five research participants in the pilot study in order to validate the coherence of the instructions and test items, apart from determining the average time for completion of the test. During the pilot study, the participants were also given a feedback form (Appendix C) to fill up after the completion of the test in order to receive their opinions about the test items for room of improvement. It was discovered from the pilot study that the average time taken for completion of the test was approximately 40 minutes and that no amendment was needed as the test items were clearly understood by the research participants.

3.7 Data Collection

The data collection technique which was adopted in this study was self-administration of the final edition of the open-ended test known as the Higher Order Thinking Level Test (HOTLT) after attaining the ethical approval (Appendix D) from the principals of each type of school (SG Girls' School: national school; HC High School: private school; S International School: international school) to conduct a study in their respective schools. Before administering the test, all the research participants involved were informed about the purpose of this research. The identities of the participants were assured to be kept confidential throughout and after the study regardless of their scores in the test. The participants were also given a firm reminder to answer the questions by themselves without discussion with their peers or referring to any external resources available in order to prevent from obtaining invalid and unreliable results. Then, each participant was also given a separate answer sheet for them to write their answers on and they were reminded not to write on the question papers too, so that the same question papers were able to be reused in the next school. The duration of the test was 40 minutes. After the completion of the test, the question papers as well as the answer sheets were collected separately.

3.8 Data Analysis

In this study, the frequency count was employed to determine the level of thinking skills of students from different types of school and following different types of syllabus in Science learning in Penang. A five-point Likert Scale (Ramos et al., 2013) was used to categorise the scores of the students in the Higher Order Thinking Level Test (HOTLT) into their corresponding levels (Low, Below Average, Average, Above Average and High) of lower order thinking skills (LOTS) and higher order thinking skills (HOTS).

Then, descriptive statistics was used to explain the level of thinking skills (both LOTS and HOTS) of the research participants by comparing the mean scores of the students within the same type of school as well as the overall results of the students from all three schools combined based on the six categories of the cognitive domain of revised Bloom's Taxonomy, which are Remember, Understand, Apply, Analyse, Evaluate and Create.

Finally, the data obtained was analysed using the Statistical Package for the Social Sciences (SPSS) software, version 21 by performing paired sample T-test and Pearson Correlation test. The paired sample T-test was utilised to explore if there was a significant difference between the type of school and the level of students' thinking skills in Science learning. On the other hand, the Pearson Correlation test was applied to identify if there was a significant relationship between i) the type of school and ii) the type of syllabus with the level of students' thinking skills in Science learning respectively.

3.9 Summary

This chapter has explained the research methodology in depth by elaborating on the quantitative method approach employed in this study, the reason for the choice of the approach and the outline of the research design. Next, the samples and sampling method employed in this study as well as the location of research were also described. Then, the type of instrument used in this study and the execution of pilot study were explained before the chapter was concluded with a thorough discussion of the data collection and data analysis process.

In summary, the duration of the entire study was two weeks beginning from the obtaining of ethical approval from principals of the school to the conduct of pilot study and finally, the completion of the actual study in all of the three schools. In average, the study in each school took approximately an hour to complete with the first ten minutes allocated for briefing of the research purpose and distribution of the test question papers, the next forty minutes for the research samples to complete the Higher Order Thinking Level Test and the last ten minutes to collect the completed answer sheets and question papers. All the data collected from the study underwent analysis by using descriptive and inferential statistics.

CHAPTER 4 FINDINGS AND DISCUSSION

4.1 Introduction

Chapter 4 discusses on the results obtained during the study by analysing the descriptive data such as the mean and standard deviation of the Higher Order Thinking Level Test (HOTLT) results of students from different types of school, as well as inferential data produced by statistical tests such as T-test and correlation. The purpose of conducting T-test is to identify if there was a significant difference between the type of school and level of thinking skills while the purpose of conducting correlation is to determine if there was any association between a) type of school and level of thinking skills and b) type of syllabus and level of thinking skills. All the findings obtained are represented in the forms of tables and figures.

4.2 Findings

This section is divided into three parts, mainly (i) Demography, (ii) Analysis of descriptive data and (iii) Analysis of inferential data. Part (i) discusses about the research participants and type of school, type of school and level of thinking skills as well as type of syllabus and level of thinking skills. Next, Part (ii) will provide a comprehensive analysis of the descriptive data obtained from the results of the research participants from each type of school. Lastly, Part (iii) will offer a thorough analysis of the inferential data produced by paired sample T-test and Pearson Correlation test.

4.2.1 Demography

a) Research participants and type of school

The test instrument was distributed to a total of 113 research participants from three different types of high schools in Penang, encompassing the city of George Town where both SG Girls' School (national) and HC High School (private) are located, as well as Bayan Lepas town where S International School (international) is situated. There were a total of 31 Form Three students from SG Girls' School (SGGS), 37

Form Three students from HC High School (HCHS) and 45 Grade Eight students from S International School (SIS) that participated in the study as displayed in Table 4.1.

Table 4.1

Demographic data of research participants

Type of high school	Number of school	Number of students	Age
National (SGGS)	1	31	15
Private (HCHS)	1	37	15
International (SIS)	1	45	13 to 14
Total	3	113	13 o 15

Note. SGGS : SG Girls' School

HCHS : HC High School

SIS : S International School

b) Type of School and Level of Thinking Skills

This study was conducted in three types of school, namely the national (SGGS), private (HCHS) and international schools (SIS) with 31, 37 and 45 research samples respectively. Hence, in order to determine the level of lower order and higher order thinking skills of students from these different types of school in science learning, the frequency count was employed in Figure 4.1 and Figure 4.2 respectively. Prior to the evaluation of the students' level of thinking skills in Science learning, a five-point Likert Scale was utilised to categorise the higher order thinking level test (HOTLT) scores of students (Ramos et al., 2013) into their corresponding levels of lower order thinking skills (LOTS) and higher order thinking skills (HOTS) as portrayed in Table 4.2 and Table 4.3 respectively.

Table 4.2

Level of Lower Order Thinking Skills (LOTS) of Students in Science Learning

Scale	Test score	Description
1	1	Low Level LOTS
2	2	Below Average Level LOTS
3	3	Average Level LOTS
4	4	Above Average Level LOTS
5	5	High Level LOTS

Table 4.3

Level of Higher Order Thinking Skills (HOTS) of Students in Science Learning

Scale	Test score	Description
1	1 to 3	Low Level HOTS
2	4 to 6	Below Average Level HOTS
3	7 to 9	Average Level HOTS
4	10 to 12	Above Average Level HOTS
5	13 to 15	High Level HOTS

Based on Figure 4.1 and Figure 4.2, majority of the students from HCHS acquired an average level of LOTS and HOTS while most of the students from both SGGS and SIS possessed a below average level of LOTS and HOTS respectively. There were only four students from HCHS, a student from SGGS and none from SIS that showed high level of LOTS. On the contrary, SGGS with a total of nine students (out of 31), showed the highest proportion of students that acquired a low level of LOTS, followed by SIS with eleven students (out of 45) while only a student (out of 37) from HCHS demonstrated a low level of LOTS. This finding is corresponding to the level of HOTS whereby SGGS with a total of eight students (out of 31), also showed the highest percentage of students among the three schools that portrayed a low level of HOTS, followed by SIS with eleven students (out of 45) while none from HCHS showed a low HOTS level. Additionally, SIS topped the position with thirteen students (out of 45) acquiring an above average level of HOTS followed by HCHS with seven students (out of 37) and lastly, SGGS with three students (out of 31).

From the study, it was also found that only two students from HCHS obtained the high HOTS level.

Figure 4.1

Type of School and Level of Lower Order Thinking Skills (LOTS) of Students in Science Learning

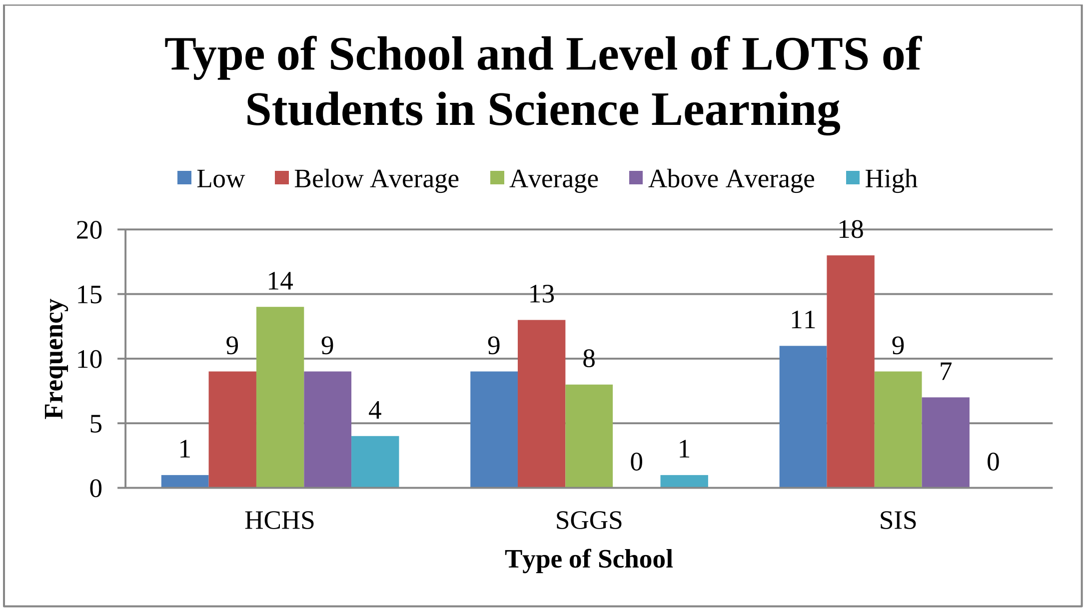
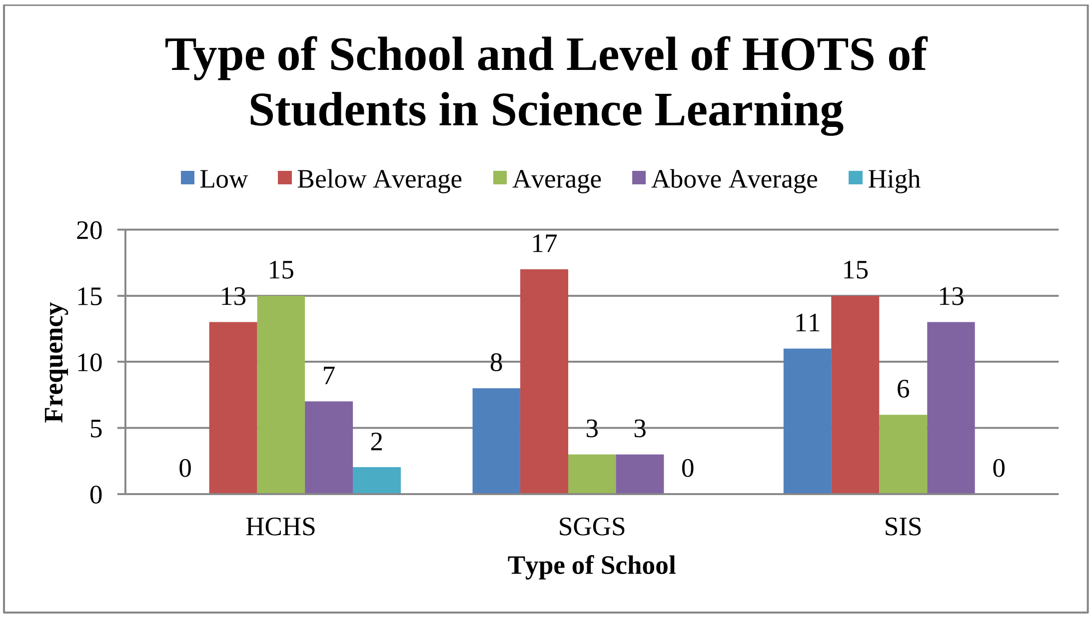


Figure 4.2

Type of School and Level of Higher Order Thinking Skills (HOTS) of Students in Science Learning



c) Type of Syllabus and Level of Thinking Skills

The curricula followed by the schools where this study was conducted can be divided into two, mainly the Malaysian national secondary syllabus or better known as Standard Curriculum for Secondary Schools (*Kurikulum Standard Sekolah Menengah* or KSSM) which is practised by national schools and the British national curriculum known as International General Certificate of Secondary Education (IGCSE) which is adopted by most international schools and some private schools in Penang.

In this study, students from SGGS (national school) were following the KSSM syllabus whereas students from both HCHS (private school) and SIS (international school) were adopting the IGCSE syllabus. Therefore, there were a total of 31 students who were following the KSSM syllabus and 82 students who were following the IGCSE syllabus. Hence, in order to determine the level of lower order and higher order thinking skills of students following different types of syllabi in science learning, the frequency count was employed and represented in the form of bar charts in Figure 4.3 and Figure 4.4 respectively. Similarly, the same five-point Likert Scale (Ramos et al., 2013) as shown in Table 4.2 and Table 4.3 was also used to categorise the higher order thinking level test (HOTLT) scores of students (following different syllabi) into their corresponding levels of LOTS and HOTS.

Referring to Figure 4.3 and Figure 4.4, majority of the students who follow both KSSM and IGCSE syllabi acquired a below average level of LOTS and HOTS respectively. There were only five students in total who obtained a high level of LOTS; one from the KSSM syllabus while another four were from the IGCSE syllabus. On the other hand, there was none taking the KSSM syllabus that managed to achieve the above average level of LOTS whereas 16 out of 82 students that were following the IGCSE syllabus had successfully acquired the above average level of LOTS. Students who were following the IGCSE syllabus also showed a slightly higher percentage frequency (28.05%; 23 out of 82) in obtaining an average LOTS level as compared to that of KSSM syllabus (25.81%; 8 out of 31).

Besides, the findings showed that students who followed IGCSE syllabus fared better in answering HOTS-based questions as compared to those who took KSSM syllabus. This is reflected on their level of HOTS whereby approximately a quarter of the IGCSE followers scored either an average or above average level of HOTS whereas only about 10% of KSSM followers managed to achieve such levels. Nevertheless, the number of students who acquired high level of HOTS was considerably low as illustrated from the findings of the study that only two students following IGCSE syllabus managed to obtain this level.

Figure 4.3

Type of Syllabus and Level of Lower Order Thinking Skills (LOTS) of Students in Science Learning

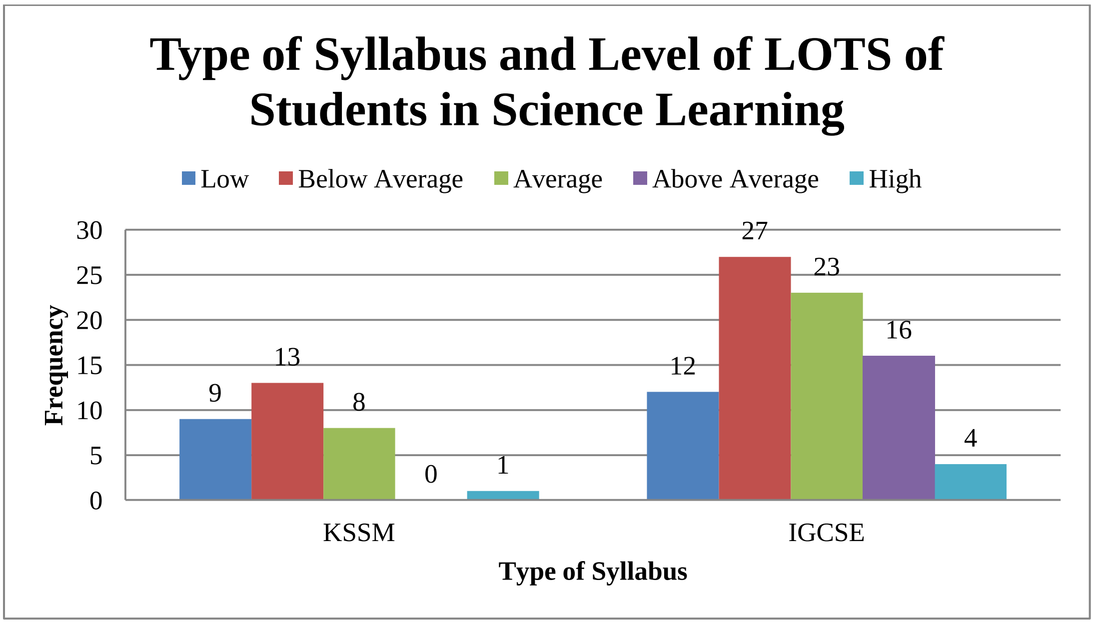
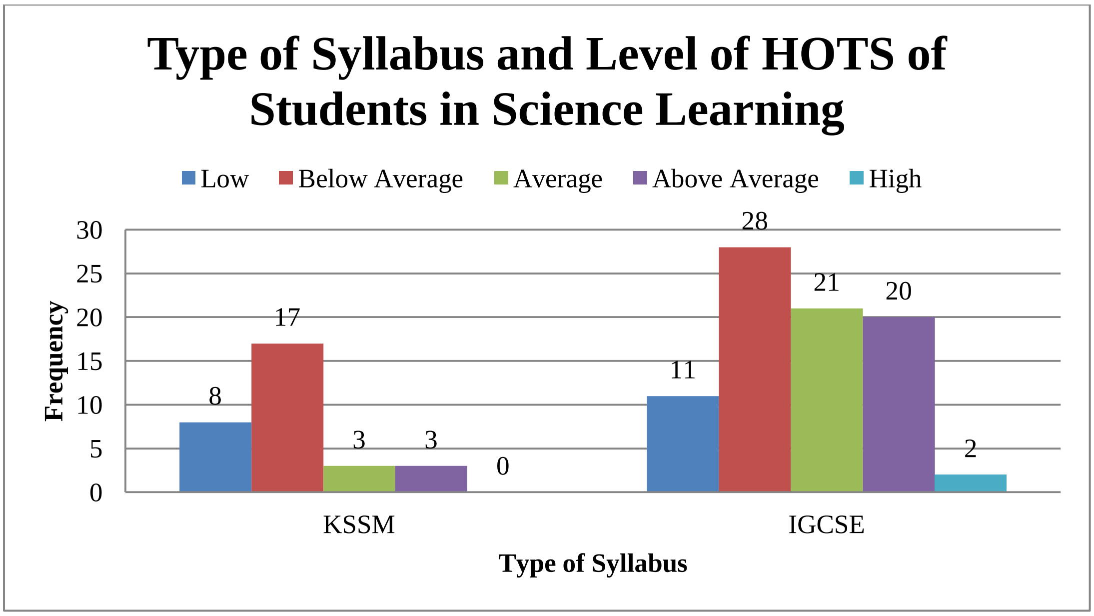


Figure 4.4

Type of Syllabus and Level of Higher Order Thinking Skills (HOTS) of Students in Science Learning



4.2.2 Analysis of Descriptive Data

In order to evaluate the level of thinking skills of students in Science learning from each type of school based on the six categories of the cognitive domain of revised Bloom's Taxonomy, descriptive statistics was used. The higher order thinking level test (HOTLT) comprised twenty items which aimed to assess both levels of thinking skills (high and low) as shown in Table 4.4. According to The Learning Center of University of North Carolina ("Higher Order Thinking: Bloom's Taxonomy", 2020) and the British Council of Malaysia ("Higher Order Thinking Skills", 2020), LOTS is made up of the first two fundamental constructs of the cognitive domain of revised Bloom's Taxonomy, which are Remember and Understand while HOTS is made up of the last four constructs of this revised taxonomy, which are Apply, Analyse, Evaluate and Create. Hence, there were a total of five items based on the LOTS constructs (Remember and Understand) whereas the remaining fifteen items were based on the HOTS constructs (Apply, Analyse, Evaluate and Create).

Table 4.4

Distribution of items in Higher Order Thinking Level Test (HOTLT)

Number	**Category**	**Level of Thinking Skill**	**Number of items**
1	Remember	Low	3
2	Understand	Low	2
3	Apply	High	5
4	Analyse	High	3
5	Evaluate	High	5
6	Create	High	2
Total	6	2 Low, 4 High	20

Referring to Table 4.5, the results of students from SGGS for the Higher Order Thinking Level Test reflected by the categories in the cognitive area of revised Bloom's Taxonomy indicated that SGGS students scored highest in Understand category with a mean score of 1.19 out of 2 (59.5%), followed by Create category with a mean score of 1.10 out of 2 (55%), Apply category with a mean score of 2.71 out of 5 (54.2%), Remember category with a mean score of 0.84 out of 3 (28%), Analyse category with a mean score of 0.81 out of 3 (27%) and the lowest mean score was recorded for Evaluate category with the score of 0.61 out of 5.

Table 4.5

Results of Students from SG Girls' School (SGGS)

Category	N	Minimum	Maximum	Mean	Std. Deviation
Remember	31	0	3	.84	.735
Understand	31	0	2	1.19	.601
Apply	31	1	5	2.71	1.006
Analyse	31	0	3	.81	.792
Evaluate	31	0	4	.61	1.086
Create	31	0	2	1.10	.700
Valid N (listwise)	31				

On the other hand, the results of students from HCHS in Table 4.6 showed that HCHS students scored highest in Understand category with a mean score of 1.35 out of 2 (67.5%), followed by Analyse category with a mean score of 1.95 out of 3 (65%), Remember category with a mean score of 1.81 out of 3 (60.33%), Apply category with a mean score of 2.97 out of 5 (59.4%), Create category with a mean score of 0.95 out of 2 (47.5%) whereas the mean score for Evaluate category was only 1.68 out of 5 (33.6%).

Table 4.6

Results of students from HC High School (HCHS)

Category	N	Minimum	Maximum	Mean	Std. Deviation
Remember	37	0	3	1.81	.739
Understand	37	0	2	1.35	.633
Apply	37	1	5	2.97	1.093
Analyse	37	0	3	1.95	.880
Evaluate	37	0	5	1.68	1.203
Create	37	0	2	.95	.743
Valid N (listwise)	37				

Based on the results shown in Table 4.7, students from SIS scored highest in Understand category as well, with a mean score of 1.29 out of 2 (64.5%), followed by Apply category with a mean score of 2.73 out of 5 (54.6%), Create category with a mean score of 1.00 out of 2 (50%), Analyse category with a mean score of 1.18 out of 3 (39.33%), Remember category with a mean score of 0.89 out of 3 (29.67%) and the lowest score was recorded for Evaluate category which was 1.09 out of 5 (21.8%).

Table 4.7

Results of students from S International School (SIS)

Category	N	Minimum	Maximum	Mean	Std. Deviation
Remember	45	0	2	.89	.804
Understand	45	0	2	1.29	.815
Apply	45	0	5	2.73	1.421
Analyse	45	0	3	1.18	1.134
Evaluate	45	0	4	1.09	.996
Create	45	0	2	1.00	.674
Valid N (listwise)	45				

The overall results for all of the three schools as shown in Table 4.8 indicated that these lower secondary students in Penang had an average performance in the Higher Order Thinking Level Test. The students answered best in Understanding-based questions with a mean score of 1.28 out of 2 (64%), followed by Applying-based questions with a mean score of 2.81 out of 5 (56.2%), Creating-based questions with a mean score of 1.01 out of 2 (50.5%), Analysing-based questions with a mean score of 1.33 out of 3 (44.33%), Remembering-based questions with a mean score of 1.18 out of 3 (39.33%) and finally, Evaluating-based questions with a significantly low mean score of 1.15 out of 5 (23%).

Table 4.8

Overall Results of Lower Secondary Students in Science Learning in Penang

Category	N	Minimum	Maximum	Mean	Std. Deviation
Remember	113	0	3	1.18	.879
Understand	113	0	2	1.28	.700
Apply	113	0	5	2.81	1.209
Analyse	113	0	3	1.33	1.064
Evaluate	113	0	5	1.15	1.159
Create	113	0	2	1.01	.701
Valid N (listwise)	113				

In summary, the descriptive data demonstrated that each of the three schools scored highest in Understand category but lowest in Evaluate category. By comparing all the mean scores based on each category of the cognitive domain of revised Bloom's Taxonomy respectively, it was found that HCHS obtained the highest mean scores for the first five categories (Remember, Understand, Apply, Analyse and Evaluate) but scored the lowest in the final category, which was Create. In contrast, SGGS which obtained the lowest mean scores for the first five categories (Remember, Understand, Apply, Analyse and Evaluate) managed to produce the highest score in the final category, which was Create. The overall findings of the study had justified that majority of the students were better in answering questions that promoted their lower order thinking skills as compared to questions that developed their higher order thinking skills. These findings corresponded with the results shown in Table 4.9 that indicated a larger fraction of the lower secondary students in Penang acquired the lower order level of thinking skills with a mean score of 2.46 out of 5 (49.2%) with minimum point of zero and maximum point of 5. Conversely, the mean score for higher order level of thinking skills was 6.29 out of 15 (41.93%) with minimum point of zero and maximum point of 14.

Table 4.9

Thinking Skills Level among Lower Secondary Students in Science Learning in Penang

Level of Thinking Skills	N	Minimum	Maximum	Mean	Std. Deviation
LOTS	113	0	5	2.46	1.165
HOTS	113	0	14	6.29	3.144
Total	113				

4.2.3 Analysis of Inferential Data

In order to identify if there was a significant difference between the type of school and the level of thinking skills, paired sample T-test was used as shown in Table 4.10. The results in Table 4.10 indicated that a significant difference was present in Pair 1: the HOTS level of both national and private schools (*p*-value = 0.004), Pair 3:

the HOTS level of both private and international schools (p-value = 0.004), Pair 4: the LOTS level of both national and private schools (p-value = 0.000) as well as Pair 6: the LOTS level of both private and international schools (p-value = 0.000) where the p-value < 0.01 respectively. Nevertheless, the findings showed the absence of significant difference for Pair 2: the HOTS level of both national and international schools (p-value = 0.503) and Pair 5: the LOTS level of both national and international schools (p-value = 0.833) respectively because p-value > 0.05.

Table 4.10

Difference between Type of School and Level of Thinking Skills

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	National (HOTS) – Private (HOTS)	-2.129	3.784	.680	-3.517	-.741	-3.133	30	.004
Pair 2	National (HOTS) – International (HOTS)	.548	4.501	.808	-1.102	2.199	.678	30	.503
Pair 3	Private (HOTS) – International (HOTS)	2.081	4.085	.672	.719	3.443	3.099	36	.004
Pair 4	National (LOTS) – Private (LOTS)	-1.097	1.423	.255	-1.619	-.575	-4.293	30	.000

Pair 5	National (LOTS) – International (LOTS)	.065	1.692	.304	-.556	.685	.212	30	.833
Pair 6	Private (LOTS) – International (LOTS)	1.162	1.642	.270	.615	1.710	4.306	36	.000

On the other hand, in order to identify the relationship between the type of school and the level of thinking skills, Pearson Correlation test was conducted as shown in Table 4.11. The findings in Table 4.11 indicated that a significant correlation was present between the LOTS and HOTS levels of national school (p-value = 0.041) as the p-value < 0.05 and between the LOTS and HOTS levels of international schools (p-value = 0.001) as the p-value < 0.01 respectively. However, there was no significant relationship found between the LOTS and HOTS levels of private school (p-value = 0.057) as well as between the levels of LOTS and HOTS of different schools because the p-value > 0.05. In a nutshell, a significant relationship existed only between the LOTS and HOTS levels of the same school (for both national and international schools only).

Table 4.11

Relationship between Type of School and Level of Thinking Skills

Type of School (Level of Thinking Skills)		National (HOTS)	Private (HOTS)	International (HOTS)	National (LOTS)	Private (LOTS)	International (LOTS)
National (HOTS)	Pearson Correlation	1					
	Sig. (2-tailed)	-					
	N	31					

Private (HOTS)	Pearson Correlation	.016	1				
	Sig. (2-tailed)	.931	-				
	N	31	37				
Inter-national (HOTS)	Pearson Correlation	-.201	.159	1			
	Sig. (2-tailed)	.278	.348	-			
	N	31	37	45			
National (LOTS)	Pearson Correlation	.369*	.175	-.280	1		
	Sig. (2-tailed)	.041	.346	.127	-		
	N	31	31	31	31		
Private (LOTS)	Pearson Correlation	-.215	.316	-.132	-.004	1	
	Sig. (2-tailed)	.244	.057	.437	.982	-	
	N	31	37	37	31	37	
Inter-national (LOTS)	Pearson Correlation	.242	.017	.477**	-.135	-.142	1
	Sig. (2-tailed)	.189	.918	.001	.470	.401	-
	N	31	37	45	31	37	45

*. p-value < 0.05 (2-tailed).

**. p-value < 0.01 (2-tailed).

In addition, Pearson Correlation test was also done to identify the relationship between the type of syllabus and the level of thinking skills as shown in Table 4.12. The findings in Table 4.12 indicated that a significant correlation existed between the LOTS and HOTS levels of KSSM syllabus (p-value = 0.041) as the p-value < 0.05 and between the LOTS and HOTS levels of IGCSE syllabus (p-value = 0.000) as the

p-value < 0.01 respectively. However, there was no significant relationship detected between a) the HOTS levels of both KSSM and IGCSE syllabi (p-value = 0.278), b) the HOTS level of KSSM and LOTS level of IGCSE (p-value = 0.189), c) the HOTS level of IGCSE and the LOTS level of KSSM (p-value = 0.127) as well as d) the LOTS levels of both KSSM and IGCSE syllabi (p-value = 0.470) because the p-value > 0.05 respectively. As a summary, a significant relationship existed only between the LOTS and HOTS levels of the same syllabus (for both KSSM and IGCSE respectively).

Table 4.12

Relationship between Type of Syllabus and Level of Thinking Skills

Type of Syllabus and Level of Thinking Skills		KSSM (HOTS)	IGCSE (HOTS)	KSSM (LOTS)	IGCSE (LOTS)
KSSM (HOTS)	Pearson Correlation	1			
	Sig. (2-tailed)	-			
	N	31			
IGCSE (HOTS)	Pearson Correlation	-.201	1		
	Sig. (2-tailed)	.278	-		
	N	31	82		
KSSM (LOTS)	Pearson Correlation	.369*	-.280	1	
	Sig. (2-tailed)	.041	.127	-	
	N	31	31	31	
IGCSE (LOTS)	Pearson Correlation	.242	.468**	-.135	1
	Sig. (2-tailed)	.189	.000	.470	-
	N	31	82	31	82

*. p-value < 0.05 (2-tailed).

**. p-value < 0.01 (2-tailed).

4.3 Discussion

4.3.1 Level of Thinking Skills in Science Learning

Thinking skills, particularly in the context of HOTS are indispensable in Science education (Saido et al., 2015). In order to realise the aspiration of Malaysia as underlined in the Malaysia Education Blueprint 2013-2025, which is to achieve above the global average and emerge in the top one-third of countries taking part in global assessments like Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) by 2025, the Malaysian Ministry of Education (MOE) has established a special task force in 2012 (MOE, 2013) which includes experts and university lecturers collaborating with The Regional Centre for Education in Science and Mathematics (RECSAM) in order to cultivate HOTS among students as well as for the continuous professional development of teachers. Up till this moment, there are countless of studies that have been done on the perception of teachers and students towards the implementation of HOTS (Aziz et al., 2017; Ganapathy & Kaur, 2014; Hasim et al., 2015; Sulaiman et al., 2017) but there is little insight on the evaluation of students' level of thinking skills especially in the subject of Science. Considering the target candidates in major global assessments such as TIMSS and PISA coming from Malaysia are between the ages of 14 and 15 (lower secondary), hence the main objectives of this study were to evaluate the thinking skills level in Science learning among lower secondary students in Penang apart from identifying whether there is a relationship between the type of school and type of syllabus with the level of thinking skills.

The overall results of the students in the Higher Order Thinking Level Test as shown in Table 4.8 revealed that all the three schools scored the highest in Understand category but lowest in Evaluate category of the cognitive domain of the revised Bloom's Taxonomy with the overall mean scores of 1.28 out of 2 (64%) and 1.15 out of 5 (23%) respectively. This has augmented the finding that majority of the students performed better in answering questions that reflect their LOTS level rather than their HOTS level as shown in Table 4.9 with mean scores of 2.46 out of 5 (49.2%) for LOTS and 6.29 out of 15 (41.93%) for HOTS. The higher standard deviation for HOTS also indicates that there was a high dispersion from the mean score of HOTS.

Hence, it proves that the students were able to answer a wide range of questions according to different levels of HOTS. On the contrary, the lower standard deviation for LOTS indicates a smaller dispersion from the mean score of LOTS. This justifies the fact that students were only able to answer a narrow scope of LOTS questions.

Research suggests that one of the reasons the level of students' cognitive skill is inclining towards LOTS is because of the reliance of Science teachers on textbooks during lesson delivery (Ismail et al., 2017), which often leads to students receiving only the superficial understanding of facts and theories presented in the textbooks. Heavy reliance on textbook is a drawback because the information and syllabus in the textbook only undergo revision once in a number of years (Ismail et al., 2017) and this will hinder the students from obtaining the latest knowledge in various Science fields. Besides, students will not be prompted to think out of the box if their teachers are merely teaching based on the content of Science textbooks. A study by Ramasamy et al. (2016) cited that only 31% of teachers have access to a diversity of educational resources to inculcate HOTS in their respective subjects, one of which is the use of thinking maps such as i-Think. However, in the same study, the author also reported that the teachers were unclear about the distinction between HOTS and i-Think. In a nutshell, the lack of HOTS-stimulating educational resources is proven to have impacted the implementation of HOTS among teachers in their teaching practices (Ramasamy et al, 2016).

4.3.2 The Difference in the Level of Thinking Skills in Science Learning by Type of School

The results in Table 4.10 show significant differences between i) the HOTS levels of both national and private schools, ii) HOTS levels of both private and international schools, iii) LOTS levels of both national and private schools as well as iv) LOTS levels of both private and international schools. The analysis of the study found that the LOTS and HOTS levels are highest among students from private school and lowest among students from national school. Additionally, the LOTS and HOTS levels of students from international school are only slightly better than that of national school; hence there is an absence of significant difference between the levels of thinking skills of the former and latter. This finding may be contributed by the difference in ages of the students from international school (13 to 14 years old) and the other two schools (15 years old). The difference in ages will bring about different levels of maturity and cognitive skills like critical thinking and problem solving. In a study conducted by Dwyer and Walsh (2020), the authors hypothesised that the critical thinking performance of older students would be significantly better than those of younger students due to the mature students' age which amplifies the probability of higher metacognitive engagement.

On the other hand, the medium of instruction used during the delivery of Science lessons is also a contributing factor to the students' level of comprehension in Science learning. At the moment, the medium of instruction in Science teaching used in national schools is either in Malay language or a mixture of both Malay and English languages (due to the Dual-Language programme embraced by some national schools) while in private and international schools, the medium of instruction used is fully English. Hence, students from private and international schools have the upper hand in terms of keeping abreast of the developments in science and technology because such information is primarily available in the English language (Yahaya et al., 2009). Apart from that, the tendency of national school teachers to code-switch when teaching Science (Haron et al., 2008) might hamper effective learning as students who have low proficiency in English may get confused by the juggling of languages. As a result, weaker students are likely to fall behind in their Science subject due to weak language mastery. Therefore, this explains the lower level of thinking skills of students from national school as compared to that of private and international schools.

4.3.3 The Relationship between the Type of School and the Level of Thinking Skills in Science Learning

The Pearson Correlation test results in Table 4.11 show that a statistically significant relationship existed only between the LOTS and HOTS levels of national school and between the LOTS and HOTS levels of international schools respectively. In other words, there was a continuity of the levels of LOTS and HOTS in national and international schools. The study also discovered no significant relationship between the LOTS and HOTS levels of private school. This could be attributed to the fact that private school students managed to achieve a balance between the acquisition of both lower and higher order thinking skills, a condition known as sophisticated thinking where LOTS are embedded into one's cognitive process without obstructing the development of HOTS at the same time (Tikhonova & Kudinova, 2015). On top of that, this is consistent with the findings in Figure 4.1 and Figure 4.2 where private school (HCHS) showed the most number of students who achieved high levels of LOTS and HOTS among the three schools. This finding is supported by Lemov (2010) who claimed that "The more proficient you are at "lower-order" skills, the more proficient you can become at higher order skills". In other words, these two levels of thinking skills (LOTS and HOTS) are intertwined and it is unlikely for HOTS to be cultivated individually without LOTS, considering LOTS are the fundamental cognitive processes that act as a foundation for more intricate ones.

On the other hand, the analysis of the data showed a highly significant relationship between the LOTS and HOTS levels of international school (Table 4.11). This corresponds with the findings in Figure 4.1 and Figure 4.2 that depict majority of the students from international school were still in the category of below average levels of LOTS and HOTS respectively. Interestingly, the findings of the study also showed that the number of international school students with an above average level of HOTS exceeded that of LOTS. This contradiction could be due to the fact that there is vast availability of advanced facilities in the international school (SIS) such as Science laboratories and large ICT suites which are equipped with the latest technology enhancements such as the SMART Board interactive whiteboards. This learning environment is not only conducive but can also promote higher order thinking in Science learning by engaging students in more fun-filled Science activities like conducting complex experiments and holding Science fairs or exhibitions.

4.3.4 The Relationship between the Type of Syllabus and the Level of Thinking Skills in Science Learning

The Pearson Correlation test results in Table 4.12 show that a significant relationship existed only between the LOTS and HOTS levels of KSSM syllabus and between the LOTS and HOTS levels of IGCSE syllabus respectively. This finding is justifiable because the level of difficulty of LOTS and HOTS questions differ significantly. In general, findings from Figure 4.3 and Figure 4.4 discovered that majority of the students who belonged in the categories of Average, Above Average and High levels of LOTS and HOTS respectively were students following the Science IGCSE syllabus. On the other hand, students following the Science KSSM syllabus were found to fall in the categories of Low and Below Average levels of LOTS and HOTS. This proves that IGCSE followers had a stronger mastery of thinking skills as compared to that of KSSM followers.

Moreover, the regression of the thinking skills level of national school students can also be reflected from the recent results of the 2019 *Sijil Pelajaran Malaysia* (SPM) which depict a minor decrease in the ability of candidates to apply the elements of higher order thinking skills (Apply, Analyse, Evaluate and Create) in answering examination questions (Abu Karim, 2020). This may be due to the fact that HOTS policy has only been intensely implemented in Malaysian education system in the recent years following the poor performance of Malaysian students in international assessments like PISA and TIMSS (Sumintono, 2015). For instance, the trend of the number of higher order thinking questions asked in national examinations and school-based assessments in Malaysian national schools has seen a gradual increase which comprise a whopping 80% upsurge for the Form 3 Assessment (PT3), 75% rise for SPM core subjects and 50% increment for SPM electives (Sumintono, 2015). However, this transformed emphasis on HOTS requires more time for students to get accustomed to in order for them to show favourable results that can truly mirror their thinking skills, considering the fact that the national education system is transforming from an exam-oriented system to a more holistic system that is capable of preparing our students for the future Industrial 4.0 Revolution.

In addition, there is no significant relationship found between the HOTS levels of both KSSM and IGCSE syllabi and between the LOTS levels of both KSSM and IGCSE syllabi. This could be attributed to the fact that both syllabi cover approximately similar topics although in different Grades or Forms (overlapping of chapters) as well as both syllabi also incorporate the elements of thinking skills in the learning content. One distinct feature that distinguishes between the syllabi which was noted during the study was the organisation of the content whereby IGCSE

Science curriculum is divided into three fields of Pure Science (Biology, Physics and Chemistry) whereas KSSM Science curriculum is divided based on General Science themes (Maintenance and Continuity of Life, Exploration of Elements in Nature, Energy and Sustainability of Life, Earth and Space Exploration).

4.4 Summary

The findings obtained from the study indicated that the lower secondary students from three different types of school (national, private and international) in Penang had an average performance in the Higher Order Thinking Level Test. A large percentage of the lower secondary students belonged in the lower level of thinking skills with a mean score of 2.46 out of 5 (49.2%) with minimum point of zero and maximum point of 5 while the remaining students who were in the higher level of thinking skills demonstrated a mean score of 6.29 out of 15 (41.93%) with minimum point of zero and maximum point of 14. The results of the paired sample T-test indicated the presence of a highly significant difference between i) the HOTS level of both national and private schools (*p*-value = 0.004), ii) the HOTS level of both private and international schools (*p*-value = 0.004), iii) the LOTS level of both national and private schools (*p*-value = 0.000) and iv) the LOTS level of both private and international schools (*p*-value = 0.000) where the *p*-value < 0.01 respectively. The Pearson Correlation test showed two findings of which a significant relationship only existed between i) the LOTS and HOTS levels of the same school (for both national and international schools only) and ii) the LOTS and HOTS levels of the same syllabus (for both KSSM and IGCSE respectively).

CHAPTER 5 CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

5.1 Introduction

Chapter 5 summarises the results obtained from the data analysis in the previous chapter in order to conclude the answers for all the research questions that are highlighted in Chapter One. Then, the conclusion of the study will be presented, followed by the discussion on the implications of the study as well as some recommendations for future studies will also be provided in order to delve deeper into the study of thinking skills in Science learning among students.

5.2 Summary of findings and conclusion of study

The research findings indicated that the levels of thinking skills in Science learning among the lower secondary students in Penang were ranging from below average to average level of both LOTS as well as HOTS. Majority of the pupils from both national (41.94%) and international (40%) schools possessed a below average level of LOTS whereas most students from private school (37.84%) demonstrated an average level of LOTS. Similarly, a large percentage of students from national (54.84%) and international (33.33%) schools were also found to fall in the category of below average level of HOTS while private school students (40.54%) mainly belonged in the category of average level of HOTS.

Besides, the findings also detected the absence of significant difference between the LOTS levels of national and international schools as well as between the HOTS levels of national and international schools. However, a significant difference was discovered between national and private schools as well as between private and international schools in the aspect of their levels of thinking skills (LOTS and HOTS). From this study, it was found that the private school students showed the highest level of thinking skills among the three schools tested.

Furthermore, the findings of the study revealed that a significant relationship existed between the LOTS and HOTS levels of the same type of school (for national and international schools only) and between the LOTS and HOTS levels of the same type of syllabus (KSSM and IGCSE).

5.3 Implications

The importance of acquiring thinking skills as one of the 21st century skills is irrefutable. These skills are proven to be a crucial asset for not only academic success but also to meet the challenging demands of the Fourth Industrial Revolution (Industry 4.0). Hence, a good comprehension of the process of thinking skills as well as the evaluation of these skills among students remains an important objective in Science education (Saido et al., 2015).

The findings of this research have several implications in the field of Science education. First and foremost, the findings can provide beneficial insights to school principals and administrators from different types of school in Penang, ranging from national and private schools to international schools about their respective students' level of thinking skills in Science learning in comparison to other types of school within Penang. This may not be achievable if the study was not conducted because large-scale comparison of Science results in major examinations is only done within the same type of schools across the state.

Next, the outcomes of the study will also contribute to curriculum developers as they can utilise these results to evaluate the effectiveness of the respective science curriculum (be it KSSM or IGCSE) in developing the students' thinking skills apart from providing more effective techniques or strategies that can facilitate students to become adept critical thinkers and problem solvers. The role of curriculum developers must not be underestimated as the curriculum that they devise will affect the way students perceive Science in general, which may indirectly affect their level of engagement in Science learning in the long run.

Furthermore, the results from this study serve as a good yardstick for Science educators to comprehend their students' level of thinking skills better. By understanding the students' strengths and weaknesses, Science teachers can identify the room for improvement and customise the appropriate learning tasks for their respective students based on the components of thinking skills. This is because the one-size-fits-all approach in classrooms will not work considering the variety of learning styles among students. In this way, the Science educators can cater to the needs of their students and hence, create a learning environment that encourages the use of thinking skills, particularly in the context of higher order thinking.

Apart from this, the findings of this study can bring positive impact to the Science educators. In the past, the old version of Bloom's Taxonomy was largely practised by most, if not all educators in various fields to promote higher order thinking. At the present moment, the revised version of Bloom's Taxonomy has taken over the place of the older version. Hence, through the findings of this study, it can help to clear the misconception that Science educators may have regarding the original and revised version of Bloom's Taxonomy when it involves the implementation of LOTS and HOTS in lesson delivery and construction of examination questions. This is because the hierarchy in the original version of Bloom's Taxonomy is more rigid than the revised one although both contain six individual levels (Shrum & Glisan, 2009). The training modules employed for the implementation of thinking skills among Science educators can also be updated accordingly in order to provide the most informed training and exposure to the teachers for them to effectively impart these thinking skills to their students.

5.4 Recommendations

Based on the findings of this study, I recommend conducting further studies on the present research. To begin with, I recommend narrowing down the age group of the research participants to a single age group within the lower secondary category (13, 14 or 15 years old). This can provide a more thorough finding regarding the thinking skills level of students of the same age and rule out the possibility that age is a deciding factor in determining the level of thinking skills in Science learning.

In addition, I recommend conducting a similar study (evaluation of thinking skills) on Science teachers using a different set of test instrument that has an appropriate level of difficulty for adults. By having information on the level of thinking skills among Science teachers, scholars can identify if there is any relationship between the thinking skills level of the Science teachers and the performance of students in Science learning (which is reflected by the students' scores in the Higher Order Thinking Level Test in this study).

In conclusion, I also recommend developing further from the current research by employing a bigger population of students from all three types of school (national, private and international) and including the variables of gender and race to investigate whether there is a correlation between these variables and level of thinking skills considering Malaysia is a multiracial country. By increasing the sample size, the outcomes generated are also more reliable and can better represent students from a variety of subgroups (type of school, type of syllabus and gender).

5.5 Summary

In a nutshell, this chapter has underlined all the major findings of this study and summarise them in a concise manner. On top of that, this chapter has answered all the three research questions clearly as well as elaborate on the implications that the findings of this study have on the education system, ranging from school principals and administrators to curriculum developers and Science educators. This chapter is further concluded with recommendations to improve from the current study by manipulating certain variables (age group, sample size, gender and race) in order to provide a better insight on the thinking skills level among lower secondary students in Science learning.

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APPENDICES

APPENDIX A: Item Specification Schedule

Table A1

Item Specification Schedule

Topic	No. of hours	Weightage (%)	Learning Objectives	Level of revised Bloom's Taxonomy					
				Remember	Understand	Apply	Analyse	Evaluate	Create
FORM 1									
Theme 1: Scientific Methodology									
1. Introduction to scientific investigation									
1.1 Science is part of daily life 1.2 Your science laboratory 1.3 Physical quantities and their units 1.4 The use of measuring instruments, accuracy, consistency, sensitivity and errors 1.5 Density 1.6 Steps in scientific investigation 1.7 Scientific attitude and values in scientific investigation	12	9.4	• To introduce students activities in daily life which define science as a discipline involving systematic observation and experiments on natural phenomena. • To provide understanding about the field of science, careers in science and the relevant subjects that need to be studied. • To introduce the science lab, physical quantities, density, and the use of measuring instruments and the International System of units (S.I). • To introduce the methods of acquiring knowledge of science through scientific investigation and problem solving.			i, viii(a)	viii(b)		
Theme 2: Maintenance and Continuity of Life									
2. Cell as the basic unit of life									
2.1 Cell – structure,	6	4.7	• To provide	iii, iv	v			ii, vi. vii	

function and organization			an understanding of the cell as the basic unit of life, the function of cell structure of animals and plants, unicellular and multicellular organisms as well as the organisation of cells. • To give a better understanding of the biological processes of living things such as cellular respiration and photosynthesis.						
2.2 Cell respiration and photosynthesis									
3. Coordination and responses									
3.1 Homeostasis in living things	3	2.4	• To present an understanding of the systems involved with homeostasis in humans, animals and plants.						
4. Reproduction									
4.1 Sexual and asexual reproduction	19	15.0	• To provide an understanding of the reproduction of animals and plants as well as an introduction to research in human reproduction, infertility and the prevention of pregnancy.						
4.2 Human reproductive system									
4.3 The menstrual cycle									
4.4 Fertilisation and pregnancy									
4.5 Factors affecting the development of the foetus and newborns									
4.6 Infertility and pregnancy prevention									
4.7 Plant reproduction									
Theme 3: Exploration of Elements in Nature									
5. Matter									
5.1 Matter in nature	6	4.7	• To prove that living things and non-living things have mass and occupy space.				ix(a), x	ix(b)	
5.2 Three states of matter									

			• To differentiate the physical properties and chemical properties of matter. • To compare and contrast three states of matter based on the kinetic theory in terms of the arrangement and movement of particles.						
6. Periodic Table									
6.1 Classification of elements 6.2 Mixtures 6.3 Compounds	9	7.1	• To compare the properties and applications in daily life of Earth's natural resources which exist in the form of elements, compounds and mixtures. • To identify the position of metal, non-metal and inert gases in the periodic table.						
7. Air									
7.1 Composition of air 7.2 Combustion 7.3 Air Pollution	9	7.1	• To synthesise the composition of air. • To justify the importance of oxygen, nitrogen, carbon dioxide and inert gases in daily life. • To conclude about the conditions needed for combustion and to provide knowledge about the safety						

			measures to prevent the occurrence of fire which can lead to the destruction of life and property. • To provide comprehensive understanding about air pollution, causes of air pollutants and steps to prevent and control air pollution.						
Theme 4: Energy and Sustainability of Life									
8. Lights and optic									
8.1 Usage of mirrors 8.2 Chacteristic of light 8.3 Reflection of light 8.4 Refraction of light 8.5 Dipersion of light 8.6 Scattering of light 8.7 Addition and of light substraction of light	22	17.3	• To give a better understanding about the usage of mirrors, lights, and colours to enhance our sensory perception and its role in the development of optical technology.	xiii	xi	xii			
Theme 5: Exploration of Earth and Space									
9. Earth									
9.1 System and structure of the Earth 9.2 Substance of the Earth 9.3 Main processes of the Earth 9.4 Geohazard phenomena 9.5 Age of the Earth 9.6 Earth resources and applied geology	13	10.2	• To present an understanding about the structure of the Earth and how geohazards happen. • To give a better understanding on the formation of fossil fuel, alternative energy resources and its uses.			xiv(a)		xiv(b)	
FORM 2									
Theme 1: Maintenance and Continuity of Life									
1. Biodiversity									
1.1 Diversity of organisms 1.2 Classification	6	4.7	• To provide a better understanding about			xv			xvi, xvii

of organisms			the importance of biodiversity, effects of human activities on biodiversity and the methods to conserve and preserve biodiversity including endemic and endangered species. • To differentiate organisms using a dichotomous key based on common characteristics and to characterise the major taxonomy group.						
2.0 Ecosystem									
2.1 Energy flow in ecosystem 2.2 Nutrient cycle in ecosystem	11	8.7	• To introduce about food chain and food web as well as to show the relationship between organisms in food chain and food web. • To present a better understanding about the role of living things in the oxygen and carbon cycles as well as the role of organisms in the water cycle of an ecosystem. • To explain about the interactions between organisms and application of these						
2.3 Interdependence among living organisms and the environment 2.4 Roles of human in maintaining a balanced nature									

			interactions in daily life.						
3.0 Nutrition									
3.1 Classes of food 3.2 Importance of a balanced diet 3.3 Human's digestive system 3.4 The absorption and transportation of digested foods and defecation	11	8.7	• To present an in-depth understanding about the seven classes of food, digestion, the importance of maintaining a balanced diet and the ways to practise healthy lifestyle and good eating habits.						
TOTAL	127	100.0		3	2	5	3	5	2

APPENDIX B: Higher Order Thinking Level Test (HOTLT)

TIME: 40 minutes

Higher Order Thinking Level Test (HOTLT)

Please answer the following questions on the **ANSWER SHEET** provided without the assistance of any reference materials.

i) 82.8 cm^3 of water is frozen into ice with a density of 0.92 g/cm^3. What is the volume of the ice? **[Applying]** ***(1m)***

ii) Is blood considered a cell or a tissue? Explain why. **[Evaluating]** ***(1m)***

iii) Do all plant cells contain chloroplasts? **[Remembering]** ***(1m)***

iv) Identify two structures which are present in plant cells but absent in animal cells. **[Remembering]** ***(1m)***

v) What would happen to the number of white blood cells produced when one is attacked by flu? Deduce why this happens. **[Understanding]** ***(1m)***

vi) Why is the urethra considered a part of the male reproductive system but not the female reproductive system? **[Evaluating]** ***(1m)***

vii) Predict the outcome when two ova are fertilised by two separate sperms at the same time in the fallopian tube. **[Evaluating]** ***(1m)*** viii)

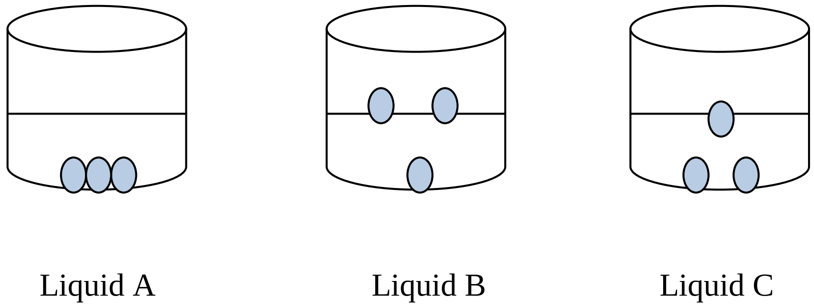

Diagram 1

Diagram 1 shows three marbles with the densities of 1.0 g/cm^3, 1.2 g/cm^3 and 1.5 g/cm^3 placed in cylinders containing three types of liquid with different densities.

a) Identify which liquid has the density of 1.1 g/cm^3. **[Applying]** ***(1m)***

b) Identify which liquid is a honey with the density of 1.4 g/cm^3. **[Analysing]** ***(1m)***

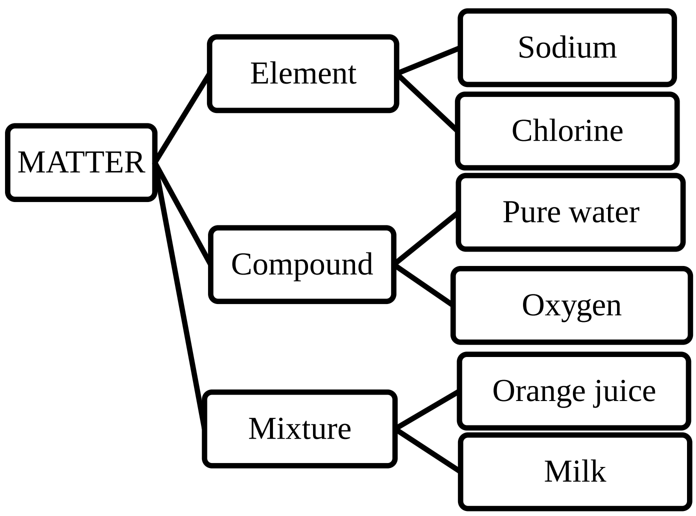

Diagram 2

ix) a) One of the matter in Diagram 2 has been wrongly classified. Correct the error. **[Analysing]** ***(1m)***

b) Explain your answer in (a). **[Evaluating]** ***(1m)***

x) Why is salt not found in the Periodic Table? **[Analysing]** ***(1m)***

xi) During a thunderstorm one night, Sarah saw a tree being struck by the lightning. A few seconds later, she heard a loud rumbling sound of the thunder. Why did Sarah manage to see the lightning first before she could hear the thunder? **[Understanding]** ***(1m)***

Diagram 3

xii) Diagram 3 shows the image of a clock as seen by Ben in a mirror. What is the actual time at the moment? **[Applying and analysing]** ***(1m)***

xiii) Identify the three primary colours of light. **[Remembering]** ***(1m)***

xiv) a) As a geologist, Ryan came across three types of rocks (igneous, sedimentary and metamorphic) in one of his studies. He identified these rocks as granite, limestone and marble. Which rock(s) do you think that Ryan could possibly discover fossils in? **[Applying]** ***(1m)***

b) Explain your answer in (a). **[Evaluating]** ***(1m)***

xv) Which animal is suitable to be used to control the population of mice in an oil palm plantation? **[Applying]** ***(1m)***

xvi) Mr. Billy grows some maize plants in his garden. During harvesting season, he notices that there are mice feeding on his sweet corns. Form a tool / natural deterrent that can help Mr. Billy solve this infestation problem effectively. **[Creating]** ***(1m)***

xvii) You are a nutritionist who has been invited to a school to deliver a talk on "The Benefits of Balanced Diet". Develop a food menu that can be used to educate your audience on the importance of maintaining a balanced diet. Your menu should include all the seven classes of food. **[Creating]** ***(1m)***

The End.

APPENDIX C: Higher Order Thinking Level Test Feedback Form

Higher Order Thinking Level Test Feedback Form

Name :

Age :

School :

Date :

1. How do you feel about your achievement on this test? Pick one.
   - ☐ Fantastic!
   - ☐ Great
   - ☐ Pretty good
   - ☐ Okay
   - ☐ Not so good
   - ☐ I feel bad!

2. What do you think of the level of difficulty for each question? Tick (√) on **ONLY** one column for each question.

Question	Easy	Moderate	Difficult
i			
ii			
iii			
iv			
v			
vi			
vii			
viii (a)			
viii (b)			
ix (a)			
ix (b)			
x			
xi			
xii			
xiii			
xiv (a)			
xiv (b)			
xv			
xvi			
xvii			

3. Overall, do you find the level of difficulty of the test questions appropriate for your age? If no, state your reason.
    - ☐ Yes
    - ☐ No (Please state your reason below.)

    ____

4. Do you think this test is a good method to evaluate your higher order thinking skills?
    - ☐ Yes
    - ☐ No (How can I improve?)

      Area of improvement: ____________________________

5. On average, how much time do you spend on learning Science in a week?

	Hours		Minutes

6. In your opinion, how well do the Science classroom lessons, activities, assessments, projects and/or assignments in your school prepare you for this test?
    - ☐ Extremely well!
    - ☐ Good
    - ☐ Average
    - ☐ Poor

    Explain and please state area(s) of improvement.

    ____

Thank you for taking the time to provide your invaluable feedback. ☺