STUDENTS' SCIENCE MANIPULATIVE SKILLS DURING TRANSITION FROM PRIMARY TO SECONDARY SCHOOL

HIDAYAH BINTI MOHD FADZIL

FACULTY OF EDUCATION
UNIVERSITY OF MALAYA
KUALA LUMPUR

2014

STUDENTS' SCIENCE MANIPULATIVE SKILLS DURING TRANSITION FROM PRIMARY TO SECONDARY SCHOOL

HIDAYAH BINTI MOHD FADZIL

THESIS SUBMITTED IN FULFILMENT OF
THE REQUIREMENT FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

FACULTY OF EDUCATION
UNIVERSITY OF MALAYA
KUALA LUMPUR

2014

UNIVERSITI MALAYA

ORIGINAL LITERARY WORK DECLARATION

Name of Candidate: Hidayah binti Mohd Fadzil (I.C/Passport No: 851013-14-5862)
Registration/Matric No: PHA090003
Name of Degree: Doctor of Philosophy
Title of Project Paper/Research Report/Dissertation/Thesis ("this Work"):
Students' Science Manipulative Skills During Transition From Primary To Secondary School
Field of Study: Science Education

I do solemnly and sincerely declare that:

(1) I am the sole author/writer of this Work;
(2) This Work is original;
(3) Any use of any work in which copyright exists was done by way of fair dealing and for permitted purposes and any excerpt or extract from, or reference to or reproduction of any copyright work has been disclosed expressly and sufficiently and the title of the Work and its authorship have been acknowledged in this Work;
(4) I do not have any actual knowledge nor do I ought reasonably to know that the making of this work constitutes an infringement of any copyright work;
(5) I hereby assign all and every rights in the copyright to this Work to the University of Malaya ("UM"), who henceforth shall be owner of the copyright in this Work and that any reproduction or use in any form or by any means whatsoever is prohibited without the written consent of UM having been first had and obtained;
(6) I am fully aware that if in the course of making this Work I have infringed any copyright whether intentionally or otherwise, I may be subject to legal action or any other action as may be determined by UM.

Candidate's Signature Date

Subscribed and solemnly declared before,

Witness's Signature Date

Name:
Designation:

STUDENT'S SCIENCE MANIPULATIVE SKILLS DURING TRANSITION FROM PRIMARY TO SECONDARY SCHOOL

ABSTRACT

Manipulative skills and abilities include skills in the handling and manipulation of materials and apparatus in the context of scientific investigation, as well as the ability to follow instructions and make accurate observation. Students lack exposure to hands-on activities at primary level and this could lead to deficiency in manipulative skills and they will carry this problem to secondary school. Transition to secondary school is a challenging process for students whereby they have to adapt with academic, social and emotional issues to fit into their new environment. Thus the purpose of this study was to explore and investigate the acquisition of students' manipulative skills during the transition from primary school (end of Year Six) to secondary school (early Form One). A qualitative study was employed in this research. The participants were selected using the purposive sampling technique. This study was conducted for a period of 11 months and involved 10 participants where the same students were tracked during their transition from the end of Year Six in primary school to the middle of Form One in secondary school. The *Manipulative Skills in Transition Tasks (MSTT)* instrument has been constructed by the researcher and was completed by the students in order to understand their ability in using four (4) scientific apparatus which are the measuring cylinder, thermometer, Bunsen burner and microscope. The primary data collection techniques used in this study were observation of students doing the MSTT tasks, interviews and examination of the students' scientific drawing. Data from early, mid and late transition were analyzed using the constant comparative method of data analysis. Two dimensions emerged during data analyses which were *technical skills* and *functional aspects of performing laboratory task*. Each dimension can be explained through the understanding of elements and sub-elements, respectively. The findings described students’ manipulative skills during transition. Findings indicated that there is a gap in manipulative skills during transition and this needs to be addressed. If not, the gap may impede the students’ continuity in the acqusition of manipulative skills during early, mid and late transition. The findings also show that students’ cognitive ability did not reflect their true ability in manipulative skills. Based on the findings, the *Meniti Peralihan* (MeP) resource guide has been developed. The resource guide provides an appropriate method to identify the students level of competency in manipulative skills during transition. The evaluation of the appropriateness of this resource guide has been conducted on 39 primary and secondary school science teachers. They found the resource guide useful in assisting them to enhance the students’ maniplative skills during transition. Further collaboration between primary and secondary school should also be considered in order to bridge the gap during transition.

KEMAHIRAN MANIPULATIF SAINS PELAJAR SEMASA TRANSISI DARI SEKOLAH RENDAH KE SEKOLAH MENENGAH

ABSTRAK

Kemahiran manipulatif merupakan kemahiran dalam mengguna radas dan bahan dalam penyelidikan saintifik. Ini termasuk kebolehan untuk mengikuti arahan dan membuat pemerhatian yang tepat. Kurangnya pendedahan dalam aktiviti ‘hands-on’ di peringkat sekolah rendah boleh mengakibatkan masalah dalam penguasaan kemahiran ini. Sekiranya masalah ini tidak diatasi, ia akan dibawa ke peringkat sekolah menengah. Transisi dari sekolah rendah ke sekolah menengah adalah proses yang mencabar bagi murid yang mana mereka perlu berdepan dengan isu akademik, sosial dan emosi untuk menyesuaikan diri dengan persekitaran baru. Oleh yang demikian, tujuan kajian ini adalah untuk meneroka dan mengkaji penguasaan kemahiran manipulatif murid semasa transisi dari sekolah rendah (akhir Tahun 6) ke sekolah menengah (awal Tingkatan 1). Kajian ini merupakan kajian kualitatif. Peserta bagi kajian dipilih melalui teknik persampelan bertujuan. Kajian ini dijalankan selama 11 bulan dan melibatkan 10 orang peserta kajian, di mana pengkaji melibatkan peserta yang sama semasa proses transisi dari akhir Tahun Enam di sekolah rendah sehingga pertengahan Tingkatan Satu di sekolah menengah. Instrumen *Manipulative Skills in Transition Tasks (MSTT)* telah dibina oleh pengkaji dan ditadbir untuk memahami kebolehan murid dalam penggunaan empat (4) alatan utama di makmal iaitu silinder penyukat, termometer, penunu Bunsen dan mikroskop. Teknik pengumpulan data yang digunakan ialah melalui pemerhatian semasa mereka menjalankan tugasan dalam MSTT, temu bual dan analisis lukisan saintifik. Data yang diperoleh semasa peringkat awal, pertengahan dan akhir transisi dianalisis menggunakan kaedah analisis perbandingan berterusan. Dua dimensi utama

muncul semasa analisis data iaitu *kemahiran teknikal* dan *aspek fungsian dalam perlaksanaan kerja makmal*. Setiap dimensi ini dapat diperjelas melalui elemen dan sub-elemen mengikut dimensi masing-masing. Dapatan ini dapat menjelaskan kemahiran manipulatif murid semasa tempoh transisi. Dapatan juga menunjukkan terdapat jurang dalam kemahiran manipulatif semasa transisi dan perlunya jurang tersebut dirapatkan. Jika tidak, jurang ini akan mengganggu kesinambungan dalam pemerolehan kemahiran manipulatif semasa peringkat awal, pertengahan dan akhir transisi. Dapatan kajian ini juga turut menjelaskan bahawa kebolehan kognitif murid tidak mencerminkan kebolehan sebenar mereka dalam kemahiran manipulatif. Berdasarkan dapatan kajian, bahan sumber Meniti Peralihan (MeP) telah dibina. Melalui bahan sumber ini satu kaedah yang sesuai untuk mengenal pasti tahap penguasaan kemahiran manipulatif murid semasa transisi telah disediakan. Penilaian terhadap kesesuaian bahan sumber ini telah dijalankan oleh 39 orang guru sains sekolah rendah dan menengah. Guru-guru mendapati bahan sumber ini boleh digunakan untuk membantu mereka dalam mempertingkatkan kemahiran manipulatif murid semasa transisi. Kerjasama di antara sekolah rendah dan menengah juga harus dipertimbang dalam usaha merapatkan jurang dalam penguasaan kemahiran manipulatif semasa peralihan.

ACKNOWLEGEMENTS

In the name of Allah, the Beneficient, the Merciful.

My sincerest thanks and appreciation go to my supervisor Associate Professor Dr. Rohaida Mohd. Saat for her patience and guidance in leading me through this work. Her encouragement, insight and keen sense of criticsm have enabled me to see this thesis through to its completion. My thanks also go to Professor Dr. Esther Daniel and Dr. Rose Amnah for their constructive comments. Thank you to Tokyo Foundation and The Ryoichi Sasakawa Young Leaders Fellowship Fund (Sylff), for endowing my study and to Universiti Malaya for giving me the opportunity to pursue the doctoral study.

My special thanks also go to the Headmaster, Principal and staff of the schools who have allowed me to conduct my study there. I would also like to extend my gratitude to Educational Planning and Research Department, Ministry of Education and Selangor Education State Department for allowing me to conduct this study without much hassle.

My warmest thanks go to my parents, Mohd Fadzil and Zubidah Ishak, for placing a high premium on academic achievement and for their encouragement and prayer throughout my life. To my husband Iskandar Zulkarnaen who always stood by my side in time of hardship, thank you for your unconditional love and understanding. Last but not least, I would like to thank my friends for the insightful comments, support and company.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 4: FINDINGS

CHAPTER 5: SUMMARY, DISCUSSION, CONCLUSION, IMPLICATION AND SUGGESTION OF THE STUDY

LIST OF TABLES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

INTRODUCTION

For decades people have realized the role of science as a catalyst in unveiling the secrets of nature and resources endowment, to transform them into beneficial products and services through human creativity and innovativeness in science and technology applications. In line with Malaysia's aspiration to be a fully developed and industrialized nation by 2020, much emphasis has been placed on the importance of science and effective teaching and learning of science in schools. The creation of scientific and progressive society that is innovative, creative and able to contribute to future scientific and technological development is highly placed in the national agenda.

Under the Tenth Malaysia Plan, the Malaysian government will continue its effort towards attaining the status of K-economy (knowledge-based economy) advancing from P-economy (production-based economy). With the advent of information technology and knowledge-based economy, the mastery of science and technology among school students is vital to produce knowledgeable and competent human capital with adequate capabilities and creativity in leading this nation towards attaining developed nation status by 2020. Various projects and programs are being continuously carried out in order to deliver the National Mission priorities of improving the education system, increasing innovation and ensuring holistic human capital development. In order to achieve the status of a developed nation, the government is providing better and more advanced education services and provisions, training and ICT programs, infrastructure and facilities, in the attempt to create high quality human capital with first class mentality. As a nation that is progressing towards developed nation status, Malaysia needs to create a scientifically-oriented, progressive, and knowledgeable society which will contribute to scientific and technological developments in the future. This is also in line with the Malaysian National Education Philosophy which elucidates that education is an on-going effort towards developing an individual in a holistic and integrated manner in order to produce well-balanced Malaysian citizens who are responsible and capable of achieving a high level of personal well-being and be able to contribute to the betterment of society and nation (Ministry of Education, 2006).

In concurrence with the National Education Philosophy, the National Philosophy of Science Education states that science education in Malaysia nurtures a science and technology culture by focusing on the development of individuals who are competitive, dynamic, robust and resilient and able to master science and technological knowledge (Ministry of Education, 2006). With this philosophy, the science curriculum in Malaysia is aimed at producing students with science knowledge and scientific skills who are able to master scientific knowledge and technological competency. Furthermore, the science curriculum is also aimed at producing well-balanced individuals who are competent in Science and Technology and hence, have the required foundation to pursue their education in the field of science.

The first chapter of this report introduces the fundamental aspect of the study starting with a discussion on the research background, statement of problem, research objectives, research questions, significance of the research, limitations of research and definition of terms used in this study.

BACKGROUND OF RESEARCH

The main objective of science education is to provide students with knowledge and scientific skills that enable them to solve problems and make decisions (Ministry of Education, 2006). Scientific skills are essential in scientific investigation. Skills required for scientific investigation are science process skills, manipulative skills and thinking skills (Figure 1.1). Science process skills enable students to carry out scientific investigation systematically. Students can formulate their questions and carry out experiments to get answers scientifically. On the other hand, manipulative skills in scientific investigation are psychomotor skills that enable students to use and handle science apparatus, laboratory substances and specimens in the approved manner. Thinking skills act as a foundation for thoughtful learning. They can be developed through students' active participation in the process of teaching and learning (Ministry of Education, 2006).

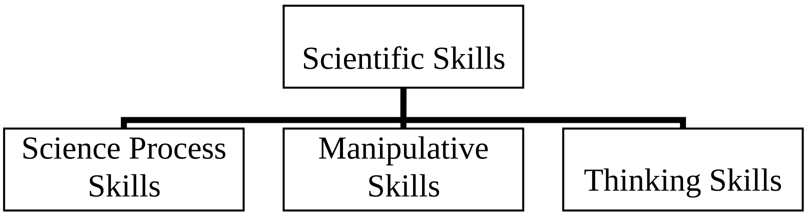


Figure 1.1 Components of scientific skills in Malaysia science curriculum for primary and secondary schools

Students' interests in Science and Technology subjects may appear very early in primary schools. Longitudinal surveys suggest that this phenomenon remains stable between the age of 11 to 15 (Organisation for Economic Co-operation and Development, OECD, 2006). Conversely, previous studies have shown a significant negative impact on students' attitudes and attainment towards science learning during the phase of transitioning from primary to secondary school (Braund & Driver, 2002;

Braund, Crompton, Driver, & Parvin, 2003; Campbell, 2002; Diack, 2009; Galton, 2002; Galton, Gray, & Ruddock, 2003; Thurston et al., 2010). The decline in work rate in science and technology subjects and erosion of interest in science and technology subject arises from the student high expectation of these subjects prior to transfer, the lack of curriculum continuity and non-harmonization of teaching approaches (Galton et al., 2003). Campbell's (2002) research on students' perception of science in primary and secondary schools found that primary school students were enthusiastic about science because of its distinctiveness and the exciting experiments but their expectations of continuing to learn science through a predominantly practical approach were not fulfilled. Indisputably, students' interest and enthusiasm in the understanding of science can be grasped by performing experiments and creating concepts at first hand in the laboratory, and certainly not by only reading about theories.

Many studies on the role of laboratory activities in science have been conducted involving variables such as students' attitudes and attainment towards scientific experiment (Johnston & Shuaili, 2001; Jyh & Chin, 2010), manipulative skills (Azizi, Shahrin, & Fathiah, 2008; Demeo, 2005), role of laboratory (Feisel & Rosa, 2005; Fuccia, Witteck, Markic & Eilks, 2012; Tiberghien, Veillard, Jean-Francois, Buty, & Millar, 2001), science process skills (Rohiza, 2008; Rose Amnah et al., 2004) and conceptual development (Domin, 2007). Undoubtedly, the role of laboratory work in maintaining students' interest in science is very crucial.

Laboratory activities have a distinctive and important role in the science learning. Many benefits accrue from engaging students in science laboratory activities (Hofstein & Mamlok-Naaman, 2007; Lunetta et al., 2007). The term 'school laboratory' refers to the experiences in school settings where students interact with materials to observe and understand the natural world. Research by Campbell (2002) on students' perceptions of science at primary and secondary school has shown that primary school students were enthusiastic about science because of its distinctiveness and the exciting experiments. The research also found that students' expectations of science in secondary school were of using specialized facilities and apparatus in the laboratory, and this was what they seemed to look forward to most in order to maintain their positive attitude towards science. Unfortunately, teaching and learning of science at primary level was more on retention of knowledge where student had to involve themselves with too much writing and too little practical work (Campbell, 2002; Galton, 2002; Rohaida Mohd. Saat, 2010). Given the lack of practical work in science, students might have had to deal with problems in obtaining specific skills which required them to perform their psychomotor ability during scientific investigation.

Manipulative skills play an important role in science learning especially in higher level sciences (e.g., biology, chemistry and physics) and these skills can only be obtained from 'hands-on' experiments. Reading about skills and concepts is not sufficient, thus students need to perform the manipulation of scientific apparatus in the laboratory. It is clear that developing these skills is a worthy goal for students to attain. Students who lack exposure to hands-on activities at primary level could lead to deficiency in manipulative skills and science process skills and they will carry this problem to secondary school level and possibly continue on to higher education level.

Research by Delargey (2001) and Buffler, Allei and Lubben (2001) have shown that science laboratory activities at the school level are also vital in preparing students for their higher education level. It is assumed that student progression to the next level of learning depends on their progression in the lower level. Research by Demeo (2005) has shown that students who actually performed manipulations in the laboratory were more successful on evaluations of their skills than students exposed to non-laboratory method such as demonstration or computer simulations.

According to Ferris and Aziz (2005) in their research on students' psychomotor skills at tertiary level institutions, students who performed well in examination did not show competency in laboratory skills. This finding demonstrates that as a science educator, we are not able to evaluate students' manipulative skills in the science laboratory by judging their examination results. Effective approaches have to be applied to ensure that science students have adequate manipulative skills to assist them in conducting laboratory tasks. Thus, it is important for educators to give students a strong foundation on laboratory skills in order to perform efficient manipulative skills in science starting from primary school.

A lot of research has been conducted to understand students' mastery of manipulative skills, for example, on students' competency in manipulative skills of science subject such as in Physics (Ferris & Aziz, 2005), Chemistry (Eglen & Kempa, 1974) and secondary schooling (Braund et al., 2003; Galton et al., 2003; Kirkpatrick, 1992; Mizelle, 1995).

Given the understanding on how students acquire their knowledge, skills and values, as well as life experience at various levels of education, not all student experience a smooth and successful transition. Most of them manage to settle down well but some find it difficult and stressful, hence tend to develop a negative attitude towards their life as secondary school students (Barber & Olsen, 2004; Hawk & Hill, 2004). Smooth transition is essential to ensure students' successful adaptation in secondary school. Negative attitudes developed during this process of transition can be problematic not only for those individuals but also for the future development of our country. This can be associated with low interest in subjects such as science and mathematics, as well as low participation rate in science stream at higher secondary level. If this trend continues, our national aspiration to be a fully developed nation by the year 2020, and the formation of a scientifically-oriented society may be disrupted.

There have been concerns raised regarding how the process of transitioning will impact students. The transition has been recognized as a stumbling point for students especially for those who are considered ‘at-risk’ (Lord, Eccles & McCarthy, 2004). In light of this, making sure students undergo a smooth and successful transition into secondary school is vital yet highly challenging for educators. The most challenging part is whether, schools and teachers could provide various opportunities for students to explore their learning in an encouraging and supportive atmosphere.

Young adolescents inevitably will have different life experiences as they face the transition into secondary school. Two most prominent issues that considerably influence the transition are mainly social and academic in nature. Studies (e.g. Hawk & Hill, 2004; Tilleczek, 2007) have shown that while students are excited and albeit concerned about going to secondary school, they nonetheless admit to being nervous and scared at the same time, particularly about being bullied by older students or making bad grades in their academic performance. The concerns also seem to include the secondary school teachers who might well be stricter than the primary school teachers they are so used to, as well as the increasing workload of secondary school (Cognato, 1999). As teachers and educators, any issue that can lead students to increase their tendency to be negative about schooling should be well acknowledged, particularly if there is evidence of disengagement in school subjects that will somehow affect their academic performance.

STATEMENT OF THE PROBLEM

One of the important goals of science education in Malaysia is to develop the technical and intellectual skills needed to pursue study in science related courses. Therefore, science experiences for the intermediate grades should focus on the use of hands-on experiences with gradual development of the ability to conduct a true experiment (Lawton, 1997; Trowbridge, Bybee & Powell, 2000, Wolfinger, 2000). Conversely, teaching and learning of science is often seen to be more on the retention of knowledge (Campbell, 2002; Galton, 2003; Hawk & Hill, 2004; Rohaida Mohd Saat, 2010). If students lack exposure to hands-on and minds-on activities at the primary level this could lead to lack of acquisition in manipulative skills and science process skills at secondary level. The understanding of science is to be achieved in the first place not only by reading about the theories but also by performing hands-on experiments and deciphering scientific concepts in the laboratory. Science experiments and practical work are what students usually looking forward to most in the science subject in secondary school. Hence, these activities tend to hold the key to maintaining students' positive attitudes to the science subject and science in general (Braund et al., 2003). However based on several previous studies, it show that the emphasis and use of practical work in the science subject is still very limited (Fuccia, Witteck, Markic & Eilks, 2012).

Science education is constantly emphasizing students' mastery of three categories of skills and abilities: (i) the cognitive or intellectual skills and abilities, (ii) the psychomotor or manipulative skills and abilities, and (iii) the affective skills and abilities (Ministry of Education, 2006). The cognitive or intellectual skills are concerned with the development of intellectual abilities which include the science process skills and science contents that are integrated in the Malaysian science curriculum. The second category of skills and abilities of Malaysian science education is the psychomotor or manipulative skills and abilities which include the development of skills in the handling and manipulation of materials and apparatus, and students' proficiency in using tools in the context of scientific investigation. The third is the affective abilities which can be defined as the qualities related to student's attitude and interest in science and the inculcation of science-related values. The psychomotor or manipulative skills are generally given the least attention in the course of academic instruction although important aspects of learning can occur in this area (Anderson, 1970; Ferris & Aziz, 2005; Kempa, 1986; Trowbridge et al., 2000).

A research by Mohd Anuar Ibrahim (2000) on Year Five students showed that one of the problems affecting students' science learning at primary level is their lack of capabilities to conduct experiments. Furthermore, the students are found to be incompetent in handling scientific apparatus when conducting simple scientific experiments. This phenomenon should be taken into consideration by science educators because any difficulties confronted by the student at this stage may affect their progression in science at higher levels of schooling. The acquisition and mastery of the manipulative skills in secondary school are highly dependent on the ability of student to master this skill since primary level. In other words there should be continuity in manipulative skills from primary level to secondary level.

Students' incapability of acquiring science manipulative skills can seriously affect acquisition of other desirable skills in the laboratory, for example, if they struggle to operate a piece of apparatus, this may lead to failure in making important observations and gathering relevant data. Therefore, it is essential for students to acquire the manipulative skills so that they can focus on as well as utilize science process skills such as observation and accurate recording successfully (Anderson, 1970; Johnstone & Al-Shuaili, 2001).

Furthermore, students who are competent in science manipulative skills will have better opportunity concentrating on the development of science process skills which involve skills such as observing, classifying, measuring and using numbers, inferring, predicting, communicating, using space-time relationship, interpreting, defining operationally, controlling variables, making hypotheses and experimenting

(Johnstone & Al-Shuaili, 2001). All of these skills will facilitate them in constructing scientific concepts competently. Thus, the issue in maintaining the progression and continuity in developing students' manipulative skills during the process of transitioning is vital. These scientific skills need to be taught to students progressively from primary to secondary school, and in this situation, teachers are the main instrument who are responsible in developing, inculcating the skills of science learning, as well as transferring the science manipulative skills to their students. Therefore, it is important for teachers themselves to be highly competent and skillful in handling scientific apparatus so that the knowledge and skill transfer during the process of teaching and learning science is maximized.

However, most of the studies (Azizi et al., 2008; Hodson, 1990; Wrutheran Sinnadurai, 2000) conducted both in Malaysia and other countries have found that science teachers and teacher trainees are still somewhat incompetent in handling laboratory apparatus. Hodson (1990) finds that teachers' manipulative skills in the laboratory in United Kingdom are still not satisfying enough. Similarly, the study by Azizi et al. (2008) shows that teacher trainees are still incompetent in the aspect of practical technique in the laboratory. The study by Wrutheran Sinnadurai, Alyas Mohamad, Rohani and Wan Mazlan Wan Muda (2004) states that although there are plenty of laboratory activities suggested in the Malaysian science curriculum, teachers' capability and competency in the basic scientific concepts and the skills of handling laboratory apparatus are still weak and insufficient. These findings are not encouraging as teachers should be proficient in manipulative skills to promote more efficient teaching and learning of science. Examples of manipulative skills that teachers should have mastered include cutting and bending glass tubing, preparing plant and animal specimens for study and making microscope slides.

In Malaysia, research in science manipulative skills is still very limited (Mariam Faridah, 2007; Wrutheran Sinnadurai et al., 2004) and in the scenario that a lot should be done to improve students' laboratory skills, more research in this area should be carried out. The acquisition of student manipulative skills in the context of school transition is one of the settings that have not been given much focus in the field of science education.

According to the Ministry of Education (2006), manipulative skills in scientific investigation are psychomotor skills that enable students to: (a) use and handle science apparatus and laboratory substances correctly, (b) handle specimens correctly and carefully, (c) draw specimens, apparatus and laboratory substances accurately, (d) clean science apparatus correctly, and (e) store science apparatus and laboratory substances correctly and safely. These categories of manipulative skills should be developed in greater detail in order to form precise and complete understanding of this area. From here we will be able to realize the gap which occurs in teaching and learning of these skills in the science classroom and try to come out with more appropriate approach in the acquisition of manipulative skills during the transition from primary to secondary school.

School transition is a challenging process for students whereby they have to adapt with social issues to fit into their new environment (Speering & Rennie, 1996). In this phase of adjustment, students have to deal with anxiety and keep up with new curriculum in regard to their study. Although most of the students experience a smooth and successful transitioning and are able to adapt to their new learning environment, a minority of them find that transition is very difficult and problematic, especially for those considered "at-risk" students. Development factors during adolescence have educational implications. Transition is particularly stressful, often serving to lower self-esteem which in turn lowers school achievement (Hurd, 2000). If this trend is not reversed, it will give a negative impact on students' attitudes and attainment of learning, and may affect the incidence of school drop-outs in our country.

The increased tendency to be negative about school can be noticed not in the first weeks following the transition but will be manifested in the middle of the transition to secondary school. This phenomenon can be exhibited by the decline in achievement and lack of progress in students' learning including science, whereby studies have shown that students' interest in studying science at school can erode in the middle of the schooling year following school transition (Braund et al., 2003; Galton et al., 2003; Kirkpatrick, 1992; Mizelle, 1995). Hence, students' progress in the science subject and their attitudes to school following transition are rarely maintained, let alone progressed (Braund, 2009).

For science education, negative attitudes towards the science subject are not only problematic for the students individually, but can also affect the nation's aspiration for scientific and technological literacy and the development of future scientists. The decline of students' interest at first years of secondary schooling may affect the student enrolment in the science stream at upper secondary level and future career choice in the field of science and technology. In the meantime, the Ministry of Education has to deal with issues which are related to low intake rate in the science stream at upper secondary level, which is far from the targeted ratio of 60 percent students expected to be in the science stream compared to 40 percent in arts (Ministry of Education, 2000).

The findings from the Trends in International Mathematics and Science Study (TIMSS) in 2011 suggest that the declining attitudes toward science education constitute an international phenomenon (IEA, 2012). For Malaysia, the TIMSS science score in 2011 has decreased radically to 426 points which is 45 points lower than the score of TIMSS 2007. Amongst 59 countries taking part in TIMSS 2007, the cumulative score of science achievement for Form 2 Malaysian students (14-year olds) show the most significant decline compared to other countries. The decline in science score may or may not be the impact of poor transition for these Form 2 students but it will definitely give a negative effect on the country's aspiration for future developments in science and technology.

The Relevance of Science Education (ROSE) project in 2005 has shown that Malaysian students are generally interested in learning selected science topics and they are very positive about learning science. The image of school science is much more positive in Malaysia than in some of the developed countries (Yoong & Aminah, 2010). However, Rohaida Mohd Saat's (2010) study finds that students entering secondary school are disillusioned about secondary science learning when they find that the learning of science is similar to the primary school science learning. In other words, while science in primary and secondary school has to be distinctively different, at the same time there is a need in maintaining the continuity of the science curriculum. For example in primary school, science learning emphasize on the cognitive, social, physical and emotional growth of each child. However, in lower secondary school, the commitment changes towards the academic preparation of each student (Trowbridge et al., 2000).

Student in primary school learn science with full of curiosity, interest and enthusiasm that are vital to the development of scientific attitudes and scientific literacy in general. Unfortunately, many student leave primary school with a different attitude and idea that science is a school subject, separated from reality and not particularly useful in their daily lives. If students have had negative science learning experiences before they get to secondary school, they usually take only the required minimum number of courses, thus cutting themselves off from many science-related careers and from the scientific understanding needed by every citizen (Wolfinger, 2000).

The study on transition is not new since it has been documented since the 1970s (Yager, 1996), however, it remains a significant and important issue that needs to be acknowledged, understood and explored by science educators in order to help facilitate a smooth and successful transition in school. The transition period is an important and critical period and there is a crucial need for students to develop their scientific manipulative skills during this period in order to facilitate their learning of science. Various studies have been carried out on many aspects of transition and these positive developments have sparked ideas to initiate research on the same topic in the Malaysian context by looking specifically into the acquisition of science manipulative skills. Appropriate bridging program should be carefully designed in order to assist the students in narrowing the gap in manipulative skills during transition as suggested by numerous researchers in this area (for e.g. Braund, 2009; Campbell, 2002; Diack, 2009).

In Malaysia, the Science curriculum at secondary level is designed to produce students who are scientifically literate, innovative, and able to apply scientific knowledge in decision-making and problem-solving in everyday life (Ministry of Education, 2006). In order to fulfill the science curriculum demand at secondary level, the acquisition of science manipulative skill is fundamental in achieving the holistic goals of science learning which include the acquisition of cognitive, manipulative and affective abilities.

In Malaysia, minimal research attention has been directed towards exploring the progression and continuity in learning science during transition from primary to secondary school and issues relating to it. Previous studies in transition primarily focus on student achievement in science and little has been reported on students' acquisition of psychomotor skills in science. Hence, there is little evidence of past literature which discusses the importance of manipulative skills in science learning and the exploration of the continuity of these skills during school transition. Most of the studies on manipulative skills are being done quantitatively (e.g., Aina, 2006; Azizi et al., 2008; Siti Mariam, 2006) which involve the use of questionnaire and checklist as instruments. Research on assessment of manipulative skills, on the other hand, uses more appropriate technique to understand manipulative skills through observation, where students are observed when exhibiting the skills (Johnstone & Al-Shuaili, 2001; Kempa, 1986; Lunette et al., 1981). Furthermore, most of the studies are conducted at first degree level (e.g., Hamida, 2003; Mohd Anuar, 2000; Rohiza Hussain, 2008, Siti Mariam, 2006), thus it is important for researchers to get an in-depth view of the phenomenon in order to have a better insights of the process of transition in science learning from primary to secondary level of education.

OBJECTIVES OF RESEARCH

The aim of this study is to explore and investigate the acquisition of students' manipulative skills during the transition from primary school (end of Year Six) to secondary school (early Form One) by employing a qualitative approach.

The study examines the differences in students' ability to perform manipulative skills at primary and secondary school level, and to obtain an understanding of these skills during transition by looking at the students' ability in handling four laboratory apparatus namely: Bunsen burner, microscope, thermometer and measuring cylinder. Consequently, the objectives of this study are to:

1. Describe students' manipulative skills during
   (a) early transition,
   (b) mid-transition and
   (c) late transition

2. (a) Identify the differences in manipulative skills among the students during early transition, mid-transition and late transition.

(b) If any, to prepare a form of intervention resource that could assist teachers in narrowing the differences in the manipulative skills during transition.

RESEARCH QUESTIONS

Based on the objectives of this study, there are two questions that need to be answered accordingly:

1. What are students’ manipulative skills during
   (a) early transition,
   (b) mid-transition,
   (c) late transition?

2. (a) What are the differences in the aspect of manipulative skills that could be identified among the students during transition?

   (b) If there is a difference, how can the differences or the gap be narrowed for a smooth transition in manipulative skills?

SIGNIFICANCE OF RESEARCH

From the theoretical perspective, this study provides an understanding on student’s acquisition of the manipulative skills and how these skills progress during the process of transition from primary to secondary school. Bloom (1956) has classified educational objectives into three domains: cognitive domain, affective domain and psychomotor domain. Learning objectives, constantly emphasized by teachers, are in the cognitive domain. They include recognition and recall of information and the development of various problem solving skills. The psychomotor domain is the domain which includes physical, manipulative and motor abilities. It is hopeful that the findings of this study will be contributive towards enriching research on acquisition of psychomotor skills from the perspective of science education, by highlighting the period of transition from primary to secondary school.

From the research findings, it is hoped that educators and the Ministry of Education will give more emphasis on improving the continuity of science curriculum at the primary and lower secondary levels to ensure a better connection between these two different stages of learning. This research may give a clear picture of students' progression in science manipulative skills during the period of transition in order for teachers to take appropriate measures to facilitate students in acquiring sufficient manipulative skills accordingly.

Small scale studies conducted locally have shown that our science teachers and pre-service teachers experienced difficulties in the aspect of practical technique in the laboratory (Azizi et al., 2008; Wrutheran Sinnadurai, 2000). Thus, the findings of this study will hopefully be helpful to higher learning institutions involved in training science teachers by preparing pre-service science teachers with sufficient and adequate laboratory skills before they start teaching formally either in primary or secondary school.

Teachers, either pre-service or in-service, may use the research findings to improve their teaching and learning techniques in science. The findings will also hopefully be valuable to educators in designing curriculum instruction for science education and pedagogy, specifically teaching science manipulative skills. Innovative pedagogical approaches and effective instructional materials are highly needed in order to improve teaching and learning in science education in the attempt to enhance student learning. Furthermore, the research will also potentially give a fruitful insight for administrators and educators to develop a better understanding on the issues arising from transition among students in primary and secondary school, particularly in the continuity and progression in the acquisition of manipulative skills.

LIMITATIONS

Similar to all other researches, this research also has its own limitations. As this research employs a qualitative approach which involves a limited number of participants, the finding is not to be generalized to the intended population. The nature of qualitative study in this research context is to provide an in-depth understanding of the process students undergo in the phase of their transition from primary to secondary school. However, the study may be replicated and useful to a population or sample which has similar characteristics to the present study (Fraenkel & Wallen, 2008).

Transition involves numerous issues such as academic attainment, social adjustment and emotional aspect. I also acknowledge the issue of different learning environment between primary and secondary school for example teachers in primary school have different interpersonal styles compared with secondary school teachers (Fisher, Brok, Waldrip, Dorman, 2011). However, this study only focuses on the students' acquisition of manipulative skills during transition. Thus, other issues beyond the scope of this study are not being discussed or taken into consideration in the research findings. This was a limitation of the study and it is acknowledged that results from the study must be viewed within the confines of this constraint.

OPERATIONAL DEFINITION

The operational definitions in this study are:

Practical work in science laboratory

Practical work in science laboratory refers to planned activities that enable students to interact with scientific apparatus and materials to scientifically solve problems about science phenomenon. It includes activities that have been conducted through demonstration or 'hands-on' approach.

Science Process Skills

Science process skills are a set of skills that enable students to carry out scientific investigation systematically. Science process skills involve skills such as observing, classifying, measuring and using numbers, inferring, predicting, using space-time relationship, communicating, interpreting, defining operationally, controlling variables, making hypotheses and doing experiments.

Manipulative skills

In this study, manipulative skills are psychomotor skills that enable students to use and handle science apparatus and specimens correctly in the approved manner. In school, these skills are interwoven throughout the science curriculum and include diverse activities in laboratory practical work. Manipulative skills enable students to use and handle science apparatus and laboratory substances correctly, handle specimens correctly and carefully, draw specimens, apparatus and laboratory substances accurately, clean science apparatus correctly, and store science apparatus and laboratory substances correctly and safely (MOE, 2006).

In this particular study, emphasis has be given to manipulative skills in using and handling four scientific apparatus commonly and continually used in science learning at primary, secondary and even in tertiary level of education. The capability to master the manipulative skills in handling this scientific apparatus will be advantageous for the students to acquire. It serves as a basis and foundation for the acquisition of higher level manipulative skills in the future. The manipulative skills that have been observed in Year Six and Form One students in this research are:

i. The use of thermometer in measuring temperature of liquid
ii. The use of measuring cylinder in measuring volume of liquid
iii. The skill of using Bunsen burner
iv. The manipulation of microscope and its components

Primary school student

Primary school student in this research are defined as Year 6 (equivalent to Grade 6) students (age 11 to 12) that have gone through five or six years of schooling period which use the syllabus from Ministry of Education.

Secondary school student

Secondary school student in this research are defined as Form 1 (equivalent to Grade 7) students (age 12 to 13) that enter secondary school which use the syllabus from Ministry of Education.

Transition

Transition is a process of moving from the familiar to the unknown learning environment which will be experienced by every student in their educational journey. Transition in this study refers to a period of moving from primary school to secondary school. There are 3 main stages of transition which are the early, during and late transition (refer Figure 1.2). The definition of each term is as follows:

(a) Early transition

In this particular study, transition at primary school is defined as a period before the students end their Year Six journey at primary school (age 11 to 12). This period is always referred to as 'early transition', which occurs about four months before the students end their educational journey at primary school.

(b) Mid-Transition

Transition in this research is defined as a period when students start the first year at secondary school (Form One, age 12-13). Mid-transition refers to the first two months of secondary school where I have conducted the laboratory observation.

(c) Late transition

This period is always referred to as 'late transition', which occurs during the implementation of Manipulative Skills in Transition Tasks (MSTT).

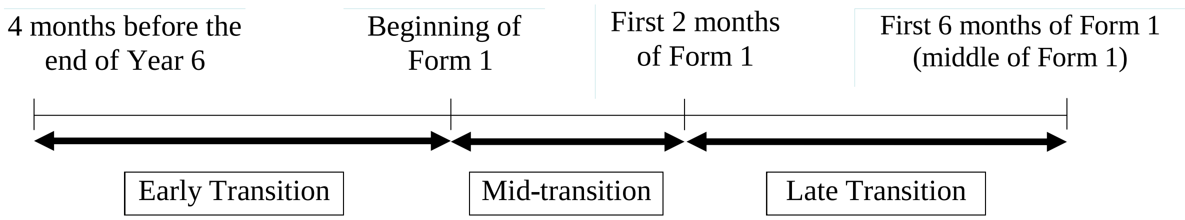


Figure 1.2 Early, mid and late transition

CHAPTER SUMMARY

Practical science emphasizes learning through inquiry-discovery where students are encouraged to learn through discovery of phenomenon that occurs in the environment. Discovery is the main characteristic of inquiry and through scientific experiments, students get an opportunity to investigate a phenomenon, draw conclusions by themselves and at the same time practice the scientific skills in the laboratory.

In Malaysia, research on science manipulative skills is still limited and much needs to be done to improve students' laboratory skills. There seems to be a gap in research on the transition process from primary to secondary school from the perspective of this country. These issues need to be examined further and analyzed in detail. Hence, scientific research needs to be done with an appropriate methodology as an eye-opener to the relevant stakeholder in the local education context.

CHAPTER 2

REVIEW OF LITERATURE

INTRODUCTION

The purpose of this study is to explore and investigate the acquisition of students' manipulative skills during the transition from primary school (Year Six) to secondary school (Form One). This study was guided by the following research questions; (1) What are students' manipulative skills during (a) early transition, (b) mid-transition, and (c) late transition?, 2(a) What are the differences in the aspect of manipulative skills that could be identified among the students during transition?, and (b) If there is a difference, how can the differences or the gap be narrowed for a smooth transition in manipulative skills?. This chapter reviews past research on the manipulative skills and psychomotor learning domain, transition from primary to secondary school and related learning theories. It is divided into sub-topics and the first section gives an overview of science learning and the role of laboratory and practical work in science.

SCIENCE LEARNING AND THE ROLE OF LABORATORY AND PRACTICAL WORK

Advancement in science learning depends on the development of two interrelated areas; conceptual understanding and procedural understanding (Gott & Duggan, 1995) (see Figure 2.1). Conceptual understanding emphasizes the development and understanding of scientific knowledge derived from concepts, theories and models in science, whereas procedural understanding involves knowledge of scientific process and skills or 'thinking behind the doing' (Gott & Duggan, 1995). Understanding and application of conceptual and procedural understanding enables students to construct their fundamental concepts in science. By integrating these cognitive processes students will be able to solve scientific problems through practical activity.

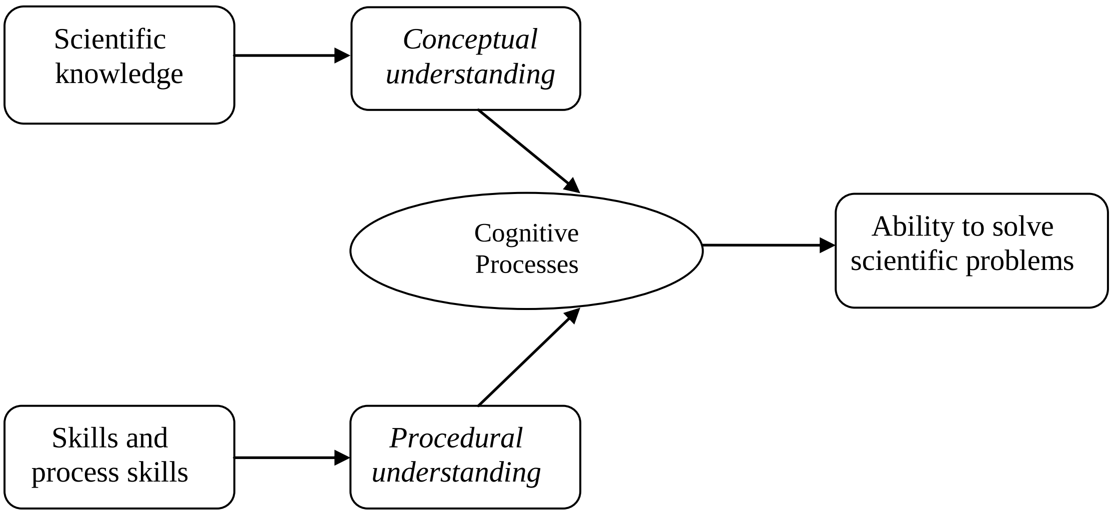


Figure 2.1 Conceptual and Procedural understanding for science (adapted from Gott & Dugan, 1995)

The main purposes of science education in school are generally to develop curiosity, provide sufficient knowledge and understanding of the world, as well as to educate students to make sensible decisions about science issues that affect lives. Thus, science education in primary and secondary schools should offer student with these opportunities. According to Lawton (1997), primary school is a wonderful time for students to build and form their attitude towards education. Positive contacts with science and technology at an early age can have a long-lasting impact. Science learning needs to start early in the school curriculum so that it may become part of the students' life and in the long term, they would feel comfortable studying it. Starting from January 2003, the Malaysian Year One students started to learn science as a subject in primary school. Previously, science was taught as a subject only in Year Four in primary school.

Previous researches show that primary school students have a curiosity for science and technology (Lawton, 1997; Wolfinger, 2000). According to Piaget (1985), primary school students are in concrete operational phase of their development. In order to make the learning more meaningful, invisible things must be represented in a concrete form to enable young students to grasp concepts which tend to be rather abstract, for example the various scientific concepts. At this stage, teachers are encouraged to use teaching tools such as props, diagram, and picture models to enhance the students' understanding in science learning. However, in reality, teaching often focuses on rote learning such as memorizing rather than on understanding. Some teaching techniques such as lecturing and note-taking in science classroom are not meaningful to students (Lawton, 1997). Thus, teaching and learning of science in primary school should focus more on students' understanding of specific scientific concepts and methods rather than focusing only on retaining of information.

Lawton (1997) also emphasizes that science must be taught hands-on to elementary school students in order for them to grasp the scientific concepts. If these students are taught to learn science using hands-on experiments since the early age, they have a better attitude and interest towards the subject, more so than if they are only lectured and assigned a textbook to read (Trowbridge, Bybee & Powell, 2000).

Science experiences for the primary and lower secondary schools should focus on the use of hands-on experiences with gradual development towards the ability to conduct experiments (Wolfinger, 2000). The existence and use of science laboratories in school is a valuable addition to the teaching of science in which students are able to experience and gain insights when conducting their own experiments. Hofstein and Mamlok (2007) define the term 'school laboratory' as experiences in school settings where students interact with materials to observe and understand the natural world. However, it is suggested that in order to achieve meaningful learning in the science laboratory, students should be given opportunities to manipulate apparatus and materials by themselves in order for them to construct their own knowledge of certain phenomena and relate them to various scientific concepts (Tobin, 1990). The ability to perform psychomotor skills or manipulative skills in science is also important and interdependent with students' ability to develop their intellectual and cognitive skills. In this context, the understanding of science is achieved by performing experiments and creating concepts in the laboratory in order to make their own discoveries, and not just by reading the theories.

MANIPULATIVE SKILLS

One of the main aims of laboratory works is to develop skills in manipulating laboratory apparatus (Kempa & Buckley, 1971**;** Tobin, 1990; Trowbridge, Bybee & Powell, 2000). Braund (2008) defines skills as short-term actions or routines that underpin practical work, for example reading the scale of thermometer or the volume of liquid in a measuring cylinder, or setting the right flame on a Bunsen burner to boil a flask of water. Laboratories can be considered as the best place to learn manipulative skills and these skills are learned as part of formal instruction in science. Students can spend much time taking the temperature of liquids, familiarizing themselves to light on the Bunsen burner or observing specimens under the microscope. All of these activities indicate the important role of manipulative skills in the development of science learning (Abu Hassan, 2004; Anderson, 1970; Azizi et al., 2008; Johnstone & Al-Shuaili, 2001; Kempa, 1986; Romiszowski, 1999; Wrutheran Sinnadurai et al., 2004).

According to the Ministry of Education (2006) manipulative skills in scientific investigation are psychomotor skills that enable students to:

- use and handle science apparatus and laboratory substances correctly.
- handle specimens correctly and carefully.
- draw specimens, apparatus and laboratory substances accurately.

- clean science apparatus correctly, and
- store science apparatus and laboratory substances correctly and safely.

Manipulative skills emphasize the usage and handling of scientific apparatus and chemical substances during scientific investigation in the laboratory. In addition, students will also be exposed to the proper and safe technique of using, cleaning and storing scientific equipment (Abu Hassan, 2004). According to Kempa, manipulative skills and abilities comprise the skills of handling and manipulation of materials and apparatus in the context of scientific investigation, as well as the ability to follow instructions and make accurate observation (Kempa, 1986).

Eglen and Kempa (1974) clarify science manipulative skills as one of the most obvious kinds of human capabilities to observe. They propose a breakdown analysis of manipulative skills which consist of four general qualities for assessment of skill competence in evaluating particular practical tasks. Skills competence in manipulative skills includes methodical working, experimental techniques, manual dexterity and orderliness in using apparatus.

Science learning emphasizes the development of three important domains namely; cognitive, psychomotor and affective. According to Trowbridge et al. (2000), psychomotor domain in science education is concerned with learning results that involve physical manipulation of apparatus, skill development and proficiency in using tools such as scientific instrument and devices. This desired behavior in manipulative skills is not an end in itself but are means for cognitive and affective learning in science education. Interrelation between these three domains stresses the importance of total learning by the individual.

Learning and performance of motor skills in science involve the senses and the brain, as well as the muscles. The outcomes of motor skills are reflected in the rapidity, accuracy, force or smoothness of bodily movement. The students' performances are dependent on the basic motor skills learned earlier, and in this situation, the learning of motor skills is best accomplished by repeated practice. Practice is known to bring improvements in learning as well as in accuracy, speed and smoothness of motor skills over long periods of time. The smoothness of action, precision and timing differentiate the performance of novice and expert in the development of manipulative skills (Gagne, 1985).

IMPORTANCE OF MANIPULATIVE SKILLS

In order to acquire experience in manipulating specific scientific apparatus, it is important for students to perform various experiments starting from primary school and later on in secondary school. The progression in students thinking in the late primary years (age 10-13) is more structured and rigorous. Student can relate to more complex phenomena and this stage of learning has significant impact on the scientific activities that teachers can develop appropriately at this time. According to Harlen (2006), student at upper primary stage respond well to the need for measurement in their investigations, and the need for accuracy and precision in observation. They can use measurement and recording as part of a systematic approach in problem solving quite comfortably, as well as carry out activities that include making detailed observation which involves the use of scientific instrument such as microscope or magnifying glass to extend the senses.

According to Piaget (1985), student develops knowledge as a result of a relationship between a student's current cognitive system and the task at hand. When performing experiment, students get mentally and physically involved in the process of learning and their focus will get better as they develop.

Good technique in handling and manipulating scientific apparatus is important because it can reduce, minimize, and control for misinterpretations and may minimize the error in scientific experiments (Yannis, 2001). A common pedagogical method of teaching manipulative skills involved asking students to follow procedures that were detailed, well tested and standardized in order for them to obtain the most precise and accurate result during experiments.

Learning does not only mean the number of increasing scientific facts, concepts and principles that students acquire or master, neither the increasing number of laboratory activities. However, in science education, learning should emphasizes more on the 'minds-on' and 'hands-on'-activities, for example, scientific investigation which is an important component of the science curricula (IEA, 2012). Studies have found that students who learn in school which puts more emphasis on the scientific investigation in the science classrooms have higher achievements in TIMSS 2011 (IEA 2012).

RESEARCH IN MANIPULATIVE SKILLS

This sub-topic reviews research conducted in the area of manipulative skills, by focusing on the Malaysian context. It emphasizes researches done on student ability to apply appropriate skills and techniques in using science laboratory apparatus such as thermometer, measuring cylinders, Bunsen burner and microscope.

Wan Dalila Hanum (2006) uses a quantitative approach in a research on Form Two students which studies the level of manipulative skills in conducting science experiment in three aspects: the use of Bunsen burner, handling of chemical substance and iodine solution. The study shows that there is no significant relation between gender and the ability in mastering manipulative skills. The finding is supported by those of Hofstein, Ben-zvi, and Samuel (1976) and Siti Mariam (2006). Wan Dalila Hanum

(2006) study also reveals that Form Two students' abilities in using and handling apparatus are poor and unsatisfying. In the aspect of handling specimen, the students are categorized to be in the intermediate level. Table 2.1 shows the summary of the students' proficiency in manipulative skills.

Table 2.1
Form Two Students' Proficiency in Manipulative Skills (Wan Dalila Hanum, 2006)

Research Aspect	**Mastery Level of Form Two Students'**
1. Skills in using and handling apparatus	Poor
2. Skills in using and handling specimen	Intermediate
3. Skills in cleaning the apparatus	Good
4. Skills in storing the apparatus	Good
5. Skills in drawing specimen	Poor

A quantitative study by Siti Mariam (2006) on Form Four students indicates that their general acquisition of manipulative skills is at the intermediate level, and this finding is supported by Suzariman (2000). However, 60% of the respondents in this study still have low ability in reading the scale of instruments correctly. The finding indicates that they are not able to give accurate reading for measuring cylinder, burette, thermometer, ammeter and voltmeter, neither can they master the correct method of using thermometer or stir solution using thermometer before taking the temperature measurement. This study (Siti Mariam, 2006) reveals that even at the upper secondary school level, the Form Four students are still struggling to acquire sufficient manipulative skills in using and handling basic scientific apparatus.

Another research by Aina (2006) on Form Four students in the chemistry subject, carried out in an urban district of Johor Bahru finds that students are able to master the correct technique of using thermometer (66%) and Bunsen burner (63%). However, most of them have a strong tendency to stir the solution using the thermometer before measuring the temperature (36%). The students are also able to master the technique of lighting Bunsen burner by closing the air hole of the burner before lighting it and opening the air hole slowly to obtain blue flame (72%). Table 2.2 shows the summary of the aspect of manipulative skills in the research, in which it is observed that among all the manipulative skills studied, the finding for the practical technique levels of the Form four students are categorized as ‘very poor’ (Aina, 2006).

Table 2.2
Percentage of 4 Research Aspects under Study (Aina, 2006)

Aspect of Research	**Percentage (%)**	**Mastery Level**
1. Correct and safe usage and handling of scientific apparatus	71	Good
2. Correct and safe usage and handling of chemical substances	77	Good
3. Technique of using scientific Instrument	57	Satisfying
4. Practical technique	33	Very Poor
Overall performance	60	Satisfying

In addition to the previous studies discussed, Azizi et al. (2008) have also conducted a quantitative study to 92 teacher trainees at Universiti Teknologi Malaysia (UTM) majoring in Chemistry Education. The instrument employed in the study is aimed at ascertaining the participants’ mastery of four aspects of manipulative skills which include handling of scientific apparatus, handling of chemical substances, the technique of using scientific apparatus and practical technique. From the findings, most of the respondents show poor capability of handling a Bunsen burner and this is similar to the research conducted by Hamida (2003), but different from the research by Aina (2006). Azizi et al. (2008) find that teacher trainees are unable to name the different parts of the Bunsen burner and the function of each part. This findings raise concern because students' inability to acquire manipulative skills can be traced back to possibly unskilled science teachers as they are the main medium in constructing the teaching and learning of manipulative skills in science learning. Therefore from Azizi et al. (2008) research, we can conclude that the teacher trainees are not highly proficient in the aspect of practical technique, probably one of many reasons for the student's insufficient acquisition of manipulative skills. In this context, teachers should have mastered all the manipulative skills themselves so they may be able to teach the students to apply the skills adequately. Table 2.3 shows the level of mastery in manipulative skills of the teacher trainees in the research (Azizi et al., 2008).

Table 2.3

Mastery Level of Teacher Trainee in Four Aspects of Manipulative Skills (Azizi, Shahrim & Fathiah, 2008)

Research Aspect	Mastery Level
1. Handling of scientific equipment	High
2. Handling of chemical substances	High
3. Technique of using scientific Apparatus	High
4. Practical technique	Intermediate
Overall performance	High

In another related research, Mariam Faridah (2007) conducts a study to investigate the Form Four students' skills of handling three scientific apparatus; burette, pipette and microscope. Overall, the students' proficiency in handling these apparatus is at the modeling level (based on psychomotor domain taxonomy adapted from Ferris & Aziz, 2005). Students have to refer to the textbook for instruction before using the apparatus even though the technique has been taught since Form 1. In addition, the study finds that students' skill of using microscope is the lowest among all.

Furthermore, the students also have problem in using high magnification power objective lens and only two out of twenty students are at the fundamental level of using microscope. Table 2.4 shows a brief description of the characteristic of each psychomotor domain by Mariam Faridah (2007).

Table 2.4
Psychomotor Domain Taxonomy

Psychomotor Domain	Characteristic of domain
Recognition	The ability to recognize, name and describe the function of apparatus and tools
Modeling	The ability to copy the steps of handling apparatus and tools (try and error) to obtain the appropriate skills.
Fundamental	The ability to handle and arrange tools correctly but with intervention
Manipulation	The ability to use the apparatus with confident and efficient
Comprehensive	The ability to use the tools and apparatus skillfully and effective
Analysis	The ability to plan, design and execute an experiment with the suitable tools and apparatus with skill and effectively
Evaluation	The ability to evaluate the result of an experiment and re-plan it for further improvement

Source. Mariam Faridah (2007) adapted from Ferris & Aziz (2005).

A study by Mohd Anuar (2000) explores Year 5 students' ability in using scientific apparatus and tools during experiments. One of the problems that interfere with students learning of science in primary school is their inability to conduct experiments. From the finding of the study, it indicates that all 72 students cannot answer the items on the use of microscope, 66% are unable to answer items regarding the use of Bunsen burner and 75% fail to answer items on measuring cylinder and beaker. The overall finding of this study indicates that primary students' ability in manipulative skills can be categorized as 'very poor'.

From the research findings discussed, it can be concluded that the Malaysian students either in primary school, secondary school or even in higher learning institutions have shown difficulties in using and handling scientific tools and apparatus proficiently especially when it involves complicated apparatus such as microscope and Bunsen burner. In order to solve this problem, some sort of guide can be developed to assists teachers in enhancing the acquisition of manipulative skills in science classroom.

Most previous researchers in this context use Form Four students as their participants (Aina, 2006; Mariam Faridah, 2007; Siti Mariam, 2006). Research in manipulative skills can start as early as at primary school so it can be possible for science educator to get a clear picture of the students' ability throughout their educational journey. It is important to detect any difficulties in manipulative skills acquisition at the earliest stage of student science learning. Therefore, this particular research focuses on exploring the acquisition of skills at upper primary and lower secondary level of schooling.

Most of the previous studies employ quantitative research methodology (Aina, 2006; Azizi et al., 2008) whereas evaluations of manipulative skills are best made through direct observation (Johnstone & Al-Shuaili, 2001; Kempa, 1986; Lunette et al., 1981) that need the students to exhibit the skills to an assessor. Thus the implementation of qualitative methodology in this research can be considered as more appropriate method as compared to quantitative methodology.

RELATIONSHIP BETWEEN SCIENCE PROCESS SKILLS AND MANIPULATIVE SKILLS

The main objectives of science education in our country are to provide students with knowledge and scientific skills (Ministry of Education, 2006). Scientific skills consist of science process skills, manipulative skills and thinking skills. Science process skills are mental processes that encourage critical, creative, analytical and systematic thinking. In this context, manipulative skills in scientific investigation refer to psychomotor skills that enable students to use and handle science apparatus, laboratory substances and specimens in the approved manner (Ministry of Education, 2006).

The acquisition of manipulative skills has been emphasized since primary school level. For example, in science practical work, children have been taught to measure water temperature using the thermometer using the appropriate technique, and this skill will be further developed gradually in secondary school. Table 2.5 describes the characteristic of science process skills.

Table 2.5

Description of Science Process Skills

Science process skills	**Description**
Observing	Using the sense of hearing, touch, smell, taste and sight to collect information about an object or a phenomenon.
Classifying	Using observations to group objects or events according to similarities or differences.
Measuring and Using Numbers	Making quantitative observations using numbers and tools with standardized units. Measuring makes observation more accurate.
Inferring	Using past experiences or previously collected data to draw conclusions and make explanations of events.

Predicting	Stating the outcome of a future event based on prior knowledge gained through experiences or collected data.
Communicating	Using words or graphic symbols such as tables, graphs, figures or models to describe an action, object or event.
Using space-time relationship	Describing changes in parameters with time. Examples of parameters are location, direction, shape, size, volume, weight and mass.
Interpreting Data	Giving rational explanations about an object, event or pattern derived from collected data.
Defining Operationally	Defining concepts by describing what must be done and what should be observed.
Controlling Variables	Identifying the fixed variable, manipulated variable, and responding variable in an investigation. The manipulated variable is changed to observe its relationship with the responding variable. At the same time, the fixed variable is kept constant.
Hypothesizing	Making a general statement about the relationship between a manipulated variable and a responding variable in order to explain an event or observation. This statement can be tested to determine its validity.
Experimenting	Planning and conducting activities to test a certain hypothesis. These activities include collecting, analyzing and interpreting data and making conclusions.

Source. Science Curriculum Specification, Ministry of Education (2006).

In science education, it is essential for students to determine connection between science process skills and manipulative skills. Science process skills enable students to formulate questions and find out the answers systematically. These skills are strongly related to students' cognitive domain in science learning. Manipulative skills, on the other hand, belong to the psychomotor domain of science learning. Science process skills and science manipulative skills are scientific skills that are related to one another. For example, measuring is one of the components of science process skills whereas

Doran, Fraser and Giddings (1995) categorize "observing, measuring and manipulating" in the same category which is "performing" skills. In Science Practical Work Assessment (PEKA), science manipulative skills and science process skills can be evaluated together (MOE, 2006).

As students learn to manipulate objects and focus their attention on specific tasks, they will increase their science process skills and become more efficient in obtaining meaningful data from their science experiences (Anderson, 1970). Thus, it is essential for students to have robust manipulative skills so they can go on auto-pilot, and free their attention for other tasks in science process skills such as observation and accurate recording (Johnstone & Al-Shuaili, 2001).

Students' ability to integrate theoretical learning (cognitive domain) with laboratory activity (psychomotor domain) is needed for the mastery of scientific skills. A study by Wan Noor Izzah (2006) finds that the integration of scientific knowledge and laboratory activity has a positive impact upon students' attitude towards science. There is also evidence in the study that laboratory activities have successfully increased students' interest in the science subject (affective domain). The integration of cognitive, psychomotor and affective domain in learning is important for holistic learning of an individual (MOE, 2006).

PSYCHOMOTOR DOMAIN TAXONOMIES

This sub-topic briefly discusses four psychomotor domain taxonomies that are expanded from Bloom's psychomotor domain categories of educational objectives: (1) Simpson's 7 levels taxonomy (1972), (2) Dave's psychomotor domain (1970), (3) Harrow's psychomotor domain taxonomy (1972) and (4) Ferris and Aziz psychomotor domain taxonomy (2005).

A) Bloom's Taxonomy of Educational Objectives (1956)

Blooms taxonomy of educational objectives (Table 2.6) has been a general tool for analyzing and evaluating the goals of educational activities. Bloom's places educational objectives in three categories of domains namely, the cognitive domain, the affective domain and the psychomotor domain.

Bloom and his team have completed a detailed work on taxonomy which mainly focuses on the cognitive and affective domains but fail to do much on the psychomotor domain (Bloom, 1956). They have made a claim that the psychomotor domain is not very useful and not much research has been done about it at the secondary and higher level of education (Bloom, 1956). While the psychomotor domain is generally given the least amount of attention in the course of academic instruction, important process of learning can occur in this area as a result of science learning (Abu Hassan, 2004; 86 Anderson, 1970; Azizi et al., 2008; Johnstone & Al-Shuaili, 2001; Kempa, 1986; Romiszowski, 1999; Wrutheran Sinnadurai et al., 2004).

Table 2.6

Categories of Domains in Bloom's Educational Objectives

Domain	Characteristics
Cognitive domain	This includes the largest proportion of educational objectives and goals that require the student to remember something and concerned with the development of intellectual abilities employed in the recall of knowledge.
Affective domain	This includes goals describing changes in interest, attitudes, values and the development of appreciation.
Psychomotor domain	**This includes goals that focus upon the development of manipulative or motor skills.**

B) Simpson's Psychomotor Domain (1972)

Simpson (1972) has constructed a seven (7) level taxonomy for educational objectives in the psychomotor domain based on the complexity of physical movement and their order of occurrence. Table 2.7 displays the seven categories of educational objectives in psychomotor domain as constructed by Simpson (1972).

Table 2.7
Simpson's Seven Levels Structure of Educational Objectives in Psychomotor Domain

Level	**Definition**
1. Perception	The ability to use sensory cues to guide motor activity. It ranges from sensory stimulation, through cue selection, to translation
2. Set	Readiness to act includes mental, physical and emotional sets. These sets are dispositions that predetermine a person's response to different situations (mindsets)
3. Guided response	The early stages in learning a complex skill that includes imitation and trial and error. Adequacy is achieved by practicing
4. Mechanism	The intermediate stage in learning complex skill. Learned responses have become habitual
5. Complex or overt Response	The skillful performance of motor acts that involve complex movement patterns. Proficiency is indicated by a quick, accurate and highly coordinated performance, requiring a minimum of energy. It includes performing without hesitation and automatic performance
6. Adaptation	Skills are well developed and the individual can modify movement patterns to fit special requirements
7. Origination	Creating new movement patterns to fit a particular situation or specific problem. Emphasize creativity in the learning outcome

The learner's capability of learning physical behaviours is established on the accuracy, quickness, distance and performance of technique (Clark, 1999; Wu, Yang, & Chuang, 2007). The classification of the educational objectives in Simpson psychomotor domain follows these five (5) principles:

(1) Simpler skills involved more reflex in the movement.

(2) As the skills become more complex, higher cognitive skills are involved.

(3) The achievement of educational objectives in the higher level skills depends on the achievement of the lower skills level. Thus the ability to obtain higher skills level was only made possible by achievement of lower skills.

(4) Higher achievement of the educational objectives involves more complex cognitive abilities.

(5) Three domains of educational objectives (cognitive, affective and psychomotor domain) are interrelated with each other.

C) Harrow's Psychomotor Domain (1976)

Harrow model of taxonomy for psychomotor domain is more applicable to the development for teaching and learning adolescence's bodily movement (Seels & Glasgow, 1990). It is organized according to degree of coordination which begins from simple reflexes to complex neuromuscular coordination. Tables 2.8 shows Harrow's model of psychomotor domain.

Table 2.8

Harrow's Psychomotor Domain Taxonomy

Level	Definition
1. Reflex movement	Segmental, intersegmental and super segmental reflexes
2. Basic-fundamental movements	Locomotor movements, nonlocomotor movements, manipulative movements
3. Perceptual abilities	Kinesthetic, visual, auditory and tactile discrimination and coordinated abilities
4. Physical abilities	Endurance, strength, flexibility and agility
5. Skilled movements	Simple, compound, and complex adaptive skills
Nondiscursive communication	Expressive and interpretive movement

The six (6) levels are from simple reflex movement to non-discursive communication. Harrow psychomotor domain is the only taxonomy that specifically denotes feeling and emotional influence on others, which make it more distinctive.

D) Dave's Psychomotor Domain (1970)

Dave's psychomotor domain taxonomy consists of five (5) categories of domain that are significant in skill learning. Table 2.9 explains each level of the taxonomy domains briefly, from the first level of imitation to the fifth level of naturalization. Dave's psychomotor domain is the simplest domain among the four taxonomies and it is significant and appropriate in the assessment of student manipulative skill.

Table 2.9
Dave's Psychomotor Domain Taxonomy

Level	Definition
1. Imitate	Student observes a skill and tries to repeat it. Student may also attempt to replicate a finished product by referring at an exemplar.
2. Manipulate	Perform the skill in a recognizable fashion by following general instruction. Student did not depend on observation to conduct the task.
3. Precision	At this level, the skills can be performed independently with accuracy, proportion and exactness.
4. Articulation	The ability to modify the skill in a new situation. At this level student can combine more than one skill in sequence consistently.
5. Naturalization	Mastery of skills and the application of skill are automatic.

E) Ferris and Aziz Psychomotor Domain (2005)

Ferris and Aziz are educators with engineering background who have been involved in the supervision of engineering practical classes for numerous years. Ferris and Aziz (2005) make observations of students' competency related to the execution of laboratory tasks. The main reflection from the observations is that student competence in the laboratory skills was not correlated with their performance in examination and assignment work. As a result of their study, Ferris and Aziz have come out with a psychomotor skills domain extension to Bloom's taxonomy that consist of seven levels taxonomy that is useful for laboratory work in higher education. Table 2.10 shows a brief explanation of the Ferris and Aziz model of psychomotor domain.

Table 2.10

Ferris and Aziz Psychomotor Domain Taxonomy

Psychomotor Domain	Explanation
1. Recognition of tools and materials	Involves the ability of recognizing tools and materials. Recognition of tools and materials are vital for effectiveness and safety.
2. Handling of tools and materials	Every tool and material in the laboratory has the appropriate technique of handling in order to avoid damage to the object or other objects at the surrounding area, or hazard to any person.
3. Basic operation of tools	Concerns the student's ability to hold the tools, set the tools in action and perform elementary tasks in their most basic form.
4. Competent operation of Tools	Students are able to perform a task by using the tools fluently, for which the tools were designed.
5. Expert operation of tools	Concern with the student ability to perform work tasks on a regular basis efficiently and effectively.
6. Planning of work operations	Student is able to take specification of work output and perform transformation of the description into a sequence of tasks.
7. Evaluation of outputs and planning means for improvement	Student is able to view the output product and assess the quality of the particular product for any deficiencies.

The Ferris and Aziz taxonomy assumed that student advancement to the next level of learning is dependent on the mastery in the lower level. This model of psychomotor domain is more appropriate in addressing and imparting manipulative skills in science education either at higher school level or higher learning institutions. However it will be the main guidance that provides direction for me in constructing a psychomotor domain model that is pertinent for students in the process of transition from primary to secondary school.

From the analysis of the psychomotor domain taxonomies discussed in this sub topic, I refer to three taxonomies as guidance for the study of transition from primary school to secondary school. Dave's (1970), Simpson's (1972) and Ferris and Aziz (2005) taxonomies of psychomotor domain have been analyzed in order to suit the capability of young adolescents in the process of transition. These taxonomies serve as a guide in analyzing the students' skills and abilities in the manipulative domain in order to explore and acquire deeper understanding of this phenomenon during the transition from primary school to secondary school.

The next sub-topic discusses the context of this study which is school transition. Although the discussion involves the aspects of academic, emotional, discipline and social aspects of transition, the interest of this current study is to understand the students' manipulative skills during this period of transition. The aspects, which are beyond the scope of the study, are presented in this thesis in order for the reader to get sufficient information on the issue of transition.

TRANSITION FROM PRIMARY TO SECONDARY SCHOOL

Transition is a process of moving from the familiar to the unknown (Green, 1997) which will be experienced by everyone in their educational and life journey. The phase of transition can be either from kindergarten to primary school (Aunola, Leskinen, & Nurmi, 2006), from primary school to secondary school (Eccles, Midgley & Lord, 1991), transition to the tertiary level institution (Berzonsky & Kuk, 2000; Kantanis, 2000) and transition to work (Biggeri, Bini, & Grilli, 2002; Ryan, 2001).

In this research transition refers to the period of moving from primary school to secondary school. This process occurs during the adolescence stage of students' development; the phase of changing from childhood to adulthood. They are shifting in the physical, intellectual, social and emotional aspects in their adolescent life and this is not only a period of growth but also a period of instability and vulnerability. At this stage students are vulnerable and easily influenced by the changes in their environment (Hurd, 2000).

Transition is viewed as an on-going process which requires time for students to adjust. Most students can adapt quickly at secondary school but transition is not an 'event', it is an on-going 'process' in which students need time for adjustment. Transition can also be conceptualized as a journey along a path across momentary gaps & shifts in schools (Tilleczek & Ferguson, 2007). Additionally, Hargreaves and Galton (2002) view transfer as 'status passage' where the move from childhood to adolescence will involve individuals with their new roles in society.

Previous studies show that the 'danger period' in terms of increased tendency to be negative about school is in the second half of the transitioning or the second semester of the first year at secondary school, and not in the first few weeks following the transition. Transition has different effects on different individuals. For a significant minority, there is a negative impact on attainment and attitudes toward learning during transition (Hurd, 2000; Tilleczek, 2007). According to Hurd (2000), 20% of the students have difficulty in handling the stresses and challenges during the adjustment period.

Kirkpatrick (2004) has reported that students naturally look forward to a fresh start but they are either able or not able to cope with a lot of experiences and influences during the process of transition. Some students claim a sense of relief because things are not too difficult as expected but for others transition can get very stressful. A study by Graham and Hill (2003) find that many young people at the threshold of secondary school are hopeful about the potential of their new status, school, friends and education. They view transition as a fresh start that brings greater challenges and more opportunities. At the same time, emotional contradiction exists where students express anxiety and stress about the transition they go through (Tilleczek, 2007). They feel anxious about coping with academic demands in the new school and making new friends. Good students will probably have a smooth and successful transition but at-risk students and low achievers may confront problems and difficulties (Hawk & Hill, 2004). Vulnerable students need more personalized help before and after transition (Hawk & Hill, 2004).

Transition in this research context refers to the adjustment phase children have to experience in their education journey from primary to secondary school. From a global perspective, it is found that substantive progress is achieved by students in developed countries especially the USA (Eccles et al., 1991), UK (Schnepf, 2002), New Zealand (Hawk & Hill, 2004; Ward, 2000), Australia (Speering & Rennie, 1996) and Canada (Tilleczek, 2007; Tilleczek & Ferguson, 2007) in formulating and implementing specific programs for transition from primary to secondary level, in which it focuses on the importance of ensuring a smooth progression during the transition period. One of the initiatives in bridging the gap between transition is by establishing inductions programs and teaching materials to prepare students to be ready in the new environment (Braund, 2009).

Transition in the United States

Research conducted by Mizelle and Irvin (2000) in the United States aim at exploring appropriate articulation practices for students making the transition from middle school into high school. The research has come out with numerous programs that specifically address to support a successful transition during the transition period including the activities that support young adolescents, activities that provide students and parents with information and activities that bring middle and high school education together. Liu and Lesniak (2005) and Campbell (2002) on the other hand, focus on progression in science learning during the transition from elementary to high school. Liu and Lesniak's (2005) qualitative research explore the development of students' understanding of the major concepts in science from elementary to high schools and develop an understanding on how school context and maturation by age contribute to the progression in students' understanding of scientific concepts. Campbell (2002) explores the perception and expectation of science through interviews and questionnaires collected from students during their final term in primary school and their first term in secondary school. Research shows that after moving to secondary school, students reflected less positively on their school science experiences. He argues that expectations of continuing to learn science through a predominately practical approach were not fulfilled.

Transition in the United Kingdom

In the United Kingdom, numerous research studies have been conducted to facilitate a smooth and successful transition between key stages in order to sustain student progress and motivation toward learning. Galton et al. (2003) explore the impact of school transitions and transfer on student progress and attainment by measuring students' motivation, anxiety and attitude to school. The decline in work rate and the generally reported erosion of interest in subjects such as science and technology may stem from the high expectation students have on these subjects prior to transfer. Braund, Crompton, Driver, and Parvin's (2003) research was focused on finding factors that can narrow the gap in science learning during transition. Among the issues known to affect students' progress and performance in the process of transition are social factors, curriculum factors and assessment factors.

Transition in New Zealand

In New Zealand, the issue of transition has been viewed substantively by the government whereby a particular research has been conducted by the New Zealand Ministry of Education Research Division in 2008. One hundred students were interviewed for eighteen months to study the effect of transition from primary to secondary schooling. Transition gives a serious implication on New Zealand students that make two transitions within two years. Hawk and Hill (2004) and Ward (2000) in their study to understand the implication of transition in the context of New Zealand students and how the students cope with this process both found that students react differently to transition. Some report a sense of relief that things are not as difficult as they expected; for others it is very stressful and for some it gets slowly worse. McGee (1987) recommends a few strategies for managing the transition to secondary school that are still relevant which involve ideas for principals on how linkages could be established between the principals of transition schools; primary and secondary teachers should meet for curriculum co-ordination; and research projects should look at perceptions of students and school communities about transition to secondary school.

Transition in Australia

Howard and Johnson (2000) in their interview with final year primary school and first year high school students in Australia concluded that social issues are the main transition challenges for the students. These issues include making new friends, fitting in and dealing with bullying. Commitment from parents, teachers and school leaders is crucial in maintaining a smooth transition for the student.

From the global review, we can conclude that much research has been carried out globally in recent years to get a better understanding of today's adolescents and the implication of transition to teaching and learning. Each country has their own experience of transition and the impact of transition depends on systems in place in the country's educational system. For example, New Zealand students have to face two school transitions within two years; thus it will bring more serious implication to their students. Research on transition has also come out with numerous programs that specifically addressed to support a successful transition. Nevertheless, not much progress has been done particularly in the field of science education. Table 2.11 shows a summary of research conducted in each country and the context of their study.

Table 2.11

The Summary of Research Context

Country	Author	Context
US	Lesnak and Liu (2005)	Explore the development of student understanding in science and how maturation affect students progression in understanding scientific concept
	Mizelle and Irvin (2000)	Explore appropriate articulation practices for students in transition including activities that bring middle school and high school together
	Campbell (2000)	Explore student perception and expectation of science during transition
UK	Braund et al. (2009)	Focusing on the factors that may narrow the gap in science learning during transition
	Galton, Gray and Ruddock (2003)	Explore impact of transition on students' progress by using their motivation, anxiety and attitude toward school as indicator
New Zealand	Hawk and Hill (2004)	Understand the implication of transition and how the students cope with two transitions within two years
	Ward (2000)	
	McGee (1987)	Recommended a few strategies for the management of transition to secondary school
Australia	Howard and Johnson (2000)	Investigate the challenges students have to deal with during transition.
	Cocklin (1999)	Investigate the nature of the teacher and the type of teaching style during transition to secondary school.

Research in transition is a relatively new issue in Malaysia. Noraini Zainal Abidin (2009) conducts a study on transition at secondary school for students with special education needs. The study involves issues of transition particularly preparation during the transition stage in order to discover the perception and understanding of students and parents related to the transition program. Interestingly, students and parents did not really understand what 'transition' was. It can be concluded that transition in Malaysia did not receive enough attention from educational authorities in term of the preparation for the adaptation from one stage to another.

TRANSITION AND INTEREST IN SCIENCE LEARNING

By the time adolescents get to secondary school, specialization of interest and abilities has often occurred resulting in the selection of some courses of study and avoidance of others. Some of them will prefer subjects such as languages, mathematics, history or science. If students had negative science experiences before they get to secondary school and during transition, they will cut themselves off from many science-related careers (Braund, 2008). According to Howe and Jones (1993) the low interest in science may also lead to poor scientific understanding needed by every citizen. Thus, poor opinions about school may lead to negative educational experiences.

The Relevance of Science Education (ROSE) project (Sjoberg, 2005) is a cross-cultural project which surveyed students' attitude and interest to science and technology has found that in many industrialized countries, science is not as popular as other subjects especially amongst girls. However, in Malaysia, students were generally interested in learning selected science topics and they were very positive about science learning (Yoong & Aminah, 2010). However, Rohaida Mohd Saat (2010) in her study found that students entering secondary school were disillusioned with secondary science learning. Primary school students were enthusiastic about science because of its distinctiveness and the exciting experiments. However, after moving to secondary school, expectations of continuing to learn science through a mainly practical approach were not fulfilled. The teaching and learning at secondary school were similar to primary school approaches.

Galton et al. (2003) have also discussed the curriculum discontinuity in science during transition. This is a factor causing erosion of students' interest in studying science (Delamont & Galton, 1986). Continuity of curriculum suffers during transition due to the gaps in knowledge that make students lose confidence in their ability. Greater emphasis on ensuring better curriculum continuity between upper primary and lower secondary levels will improve support for implementing curriculum change.

THEORETICAL FRAMEWORK

This sub-topic clarifies the theories underpinning the study of manipulative skills during transition from primary to secondary school. Teaching and learning of science involve important components such as the mastery of scientific concepts, scientific skills and inculcation of scientific attitudes and values. This particular research focuses on student acquisition of manipulative skills during their process of transitioning from primary to secondary school. Although this research is related to student psychomotor abilities, the skills cannot be separated from student cognitive development. The processes of learning psychomotor skills depend on the development of cognitive abilities. Theories in this framework explain how skills are generated and acquired.

The theoretical frameworks underpinning this study are based on two theories: (1) Anderson theory of skill acquisition which also known as ACT-R theory (Adaptive Control of Thought-Rational), (Anderson, 1970) and (2) Bandura observational learning theory (1977). ACT-R theory emphasizes the acquisition of cognitive skill and is appropriate for this current study because the theory involves stages on the development of cognitive skills and skills performing. The ability to perform manipulative skills in science certainly will depend on student cognitive ability. In this research, Bandura's observational learning theory explains the relationship between learners, the classroom environment and the outcome of learning, which is the manipulative skill students should acquire.

ACT-R Theory

According to Anderson's (1982) framework of skill acquisition, there are two major stages involve in the development of cognitive skills known as declarative stage and procedural stage. These stages are based on long-term memory stores: a declarative memory and a procedural memory (Taatgen, 1999). When the learner receives instruction and information about particular skills, the instruction will be encoded as a set of facts about the skills. These sets of facts will be interpreted further to generate desired behavior. Figure 2.2 represents the basic framework of skills acquisition by Anderson (1982).

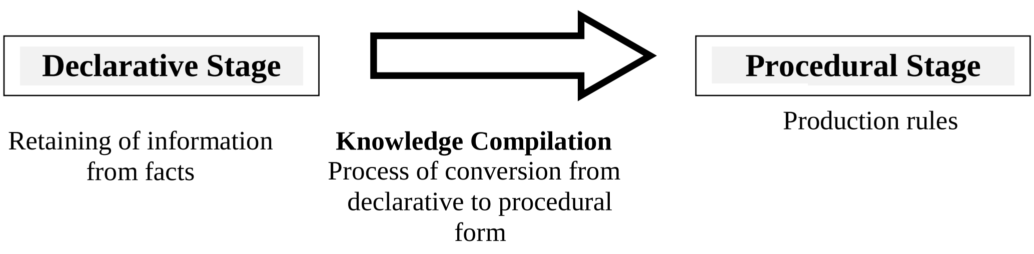


Figure 2.2 Basic framework of skills acquisition (Anderson, 1982)

In the science curriculum, students will be taught the basic operation of handling scientific apparatus theoretically. For example in Year 5, students learn about the application of thermometer in determining the temperature of liquids. Learning of the procedure of using thermometer is considered as a process in the declarative stage. The declarative stage involves the process of interpretation of facts from the particular knowledge or information. It is a cognitive stage where processing of information is deliberate, slow and requires complete attention. At this stage, the facts have to be recall and rehearsed to make them available and active in working memory so that they can be used for the next stage.

ACT-R theory focuses on the acquisition of the product from the procedural stage (Anderson, 1982). The procedural stage involves skill performing and generation of particular behavior that reflects knowledge from the declarative stage. In this research, students' ability to perform the manipulative skills of handling scientific apparatus will be manifested in the procedural stage. At this stage the knowledge of scientific theory that has been rehearsed in working memory at declarative stage will be interpreted and the outcome can be represented as a production. Students at this stage should have the ability to apply the skills of using thermometer appropriately based on the theoretical knowledge of using thermometer constructed in the earlier stage. Knowledge about the skill has to be used interpretatively in order to generate behavior. With further tuning of facts, performance of the skill will gradually be more appropriate and can be speeded-up.

Anderson (1988) emphasizes the importance of practice as a medium for converting knowledge into procedural form. Procedural stage memory contains production rules and these rules can act as outcomes of learning. Production rules have to be interpreted from declarative knowledge and this explains why the processing of information in the cognitive stage takes time (Taatgen, 1999). As a rule is repeated, it will increase the strength value and decrease the time it takes to perform the skills (Anderson & Lebierre, 1998).

Knowledge or fact will be gradually converted from the declarative stage to procedural stage and this process of transition is known as ‘knowledge compilation’. ACT-R performance theory is concerned with the use and development of facts in declarative form and procedural form, and the knowledge compilation process by which the skills transit from declarative form to procedural form. Knowledge compilation and processing of information from the declarative stage takes time and does not occur spontaneously. In knowledge compilation, all the factual knowledge and information on the using and handling of scientific apparatus will be processed gradually and execution of manipulative skills will progressively speed up.

The factual knowledge and theory on manipulative skills from declarative stage will be compiled and retrieved back in procedural stage where the skills will be performed. At this stage students should regain the knowledge that have been interpreted and analyzed from the process of knowledge compilation. In this research, I have included another stage of learning in the framework, which is known as the self-governing stage. In this stage, students are expected to perform the skills automatically. Automation of manipulative skills may occur over a long period with continuous practice during the transition from primary to secondary school.

In order to achieve this stage of automation, repetition of handling the equipment is crucial because manipulative skills learning can only improve through practices. Students may have a hard time when they first using scientific apparatus (for example: thermometer, Bunsen burner and microscope) but with repetition and practices, this task can be performed automatically and requires very little attention as they have already acquired the skills proficiently. In other word, when all the knowledge in declarative stage is completely compiled, self-governing stage of manipulative skills performance is reached. Figure 2.3 shows the framework of acquisition of manipulative skills adapted from Anderson theory of skills acquisition.

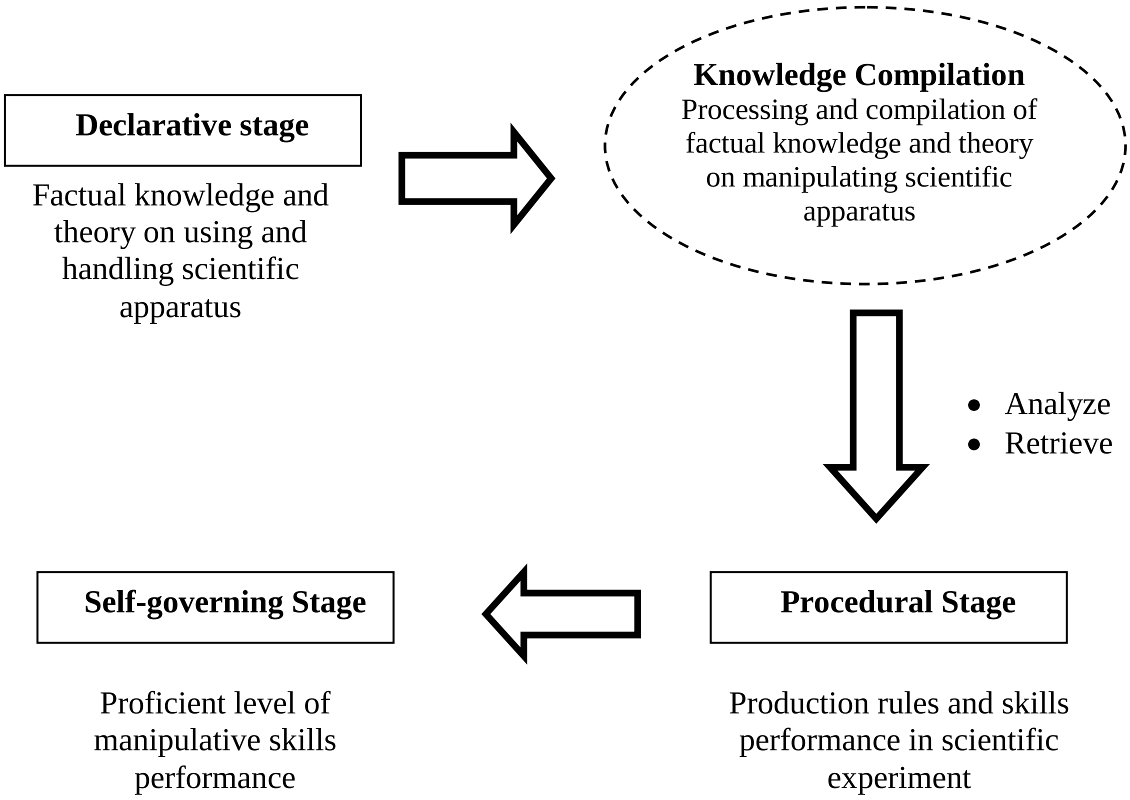


Figure 2.3 Manipulative skills acquisition (adapted from Anderson ACT-R theory of skills acquisition, 1970)

Bandura's Observational Learning

Social cognitive learning theory is a theory which concerns the relationship between the learner, the environment and the outcome of learning (Bandura, 1977). The primary mechanism in this theory is that each individual learns from their observation of others' behaviors and the social consequences of those actions (Bany & Johnson, 1975). Each individual in science classroom function together. Even though each student works individually, they are embedded in the same school environment. The communication either verbal or non-verbal will affect their behavior. In performing manipulative skills, observation of the skills or models is an essential component of learning. Among the factors that influence student learning are the students' ability to process the observed events (Bany & Johnson, 1975). Thus the concept of 'self-regulated learning' is always being related to social cognitive theory. Self-regulated learning can be referred to students' proactive efforts to mobilize emotional, cognitive and environmental resources during learning (Gredler & Schwartz, 1997).

During the transition from primary to secondary school, students should have progressed to self-regulated learning due to the development of their cognitive ability. Figure 2.4 on the next page explains the interaction between students' internal and external conditions of learning. Students' capabilities and behavior are acquired actively from the environment and cognitive processes undertaken by them. The outcome of learning in this research is the manipulative skills performed by the students in handling of Bunsen burner, thermometer, measuring cylinder and microscope.

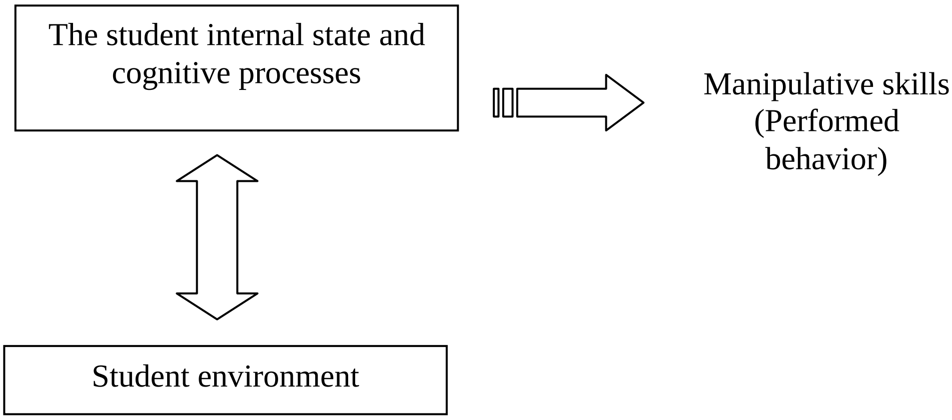


Figure 2.4 Components of manipulative skills learning in social-cognitive theory

Bandura (1977) introduces four component processes that are responsible for learning and performance of skills: (1) attention, (2) retention, (3) motor production, and (4) motivational process. These learning processes are worthy to be used in this research because imitative or observational learning play an important and significant role in the acquisition of manipulative skills. Figure 2.5 explains each process in the context of the acquisition of manipulative skills.

In social cognitive learning theory, students learn from behavior enacted by the model. 'Model' in the context of this research is the manipulative skills enacted by the science teacher. Teachers play their essential role as a 'live model' that should be able to demonstrate suitable technique in manipulation of apparatus during experiments and a 'verbal instructional model' that explains and describes the appropriate manipulative skills students should acquire (learning outcomes). The behavior enacted by the teacher will be coded and retained by the students. During the modeling of behavior, reinforcement to the model is important in motivating the students to perform the observed behavior.

Students' cognitive processes play a central role in observational learning. The cognitive processing of events will guide learner behavior and performance in manipulative skills. Recurrence and repetition of this learning process during transition from primary school to secondary school may assist the students' progression on manipulative skills acquisition. The relationship between behavioral model, the students' cognitive processes and performance is shown in Figure 2.6.

(1) Attention Processes

- In the learning of manipulative skills, new behaviour can be acquired from students' attention process during demonstration of skills by the teacher.
- Students' observational skills and sensory capabilities will influence the accuracy of the information processing
- Attended skills will be coded by the observer and cognitive process will take place

(2) Retention Processes

- Accountable for coding of the manipulative skills and the storage of the codes in the students memory (verbal and visual codes)
- Mental and process rehearsal serves as important memory support.
- Students' cognitive development during transition to secondary school will influence the process of retention
- When information was cognitively stored, it can be retrieved, rehearsed and strengthened long after the observational learning has taken place.
- Student's will have the ability to utilize information long after it has been observed

(3) Behavior or Motor Reproduction Processes

- Determine to what extent the learned behavior (cognitively) is translated into performance (behavior)
- At this stage, performance of the manipulative skills in using and handling scientific apparatus depends on students motor reproduction process
- According to Bandura (1977), this process includes the selection and organization of responses cognitively, followed by the execution of the acquired skills

(4) Motivational Processes

- This process is important in encouraging the students to perform the acquired skills
- Reinforcement will affect students' capability in executing manipulative skills

Figure 2.5 Processes in manipulative skills observational learning

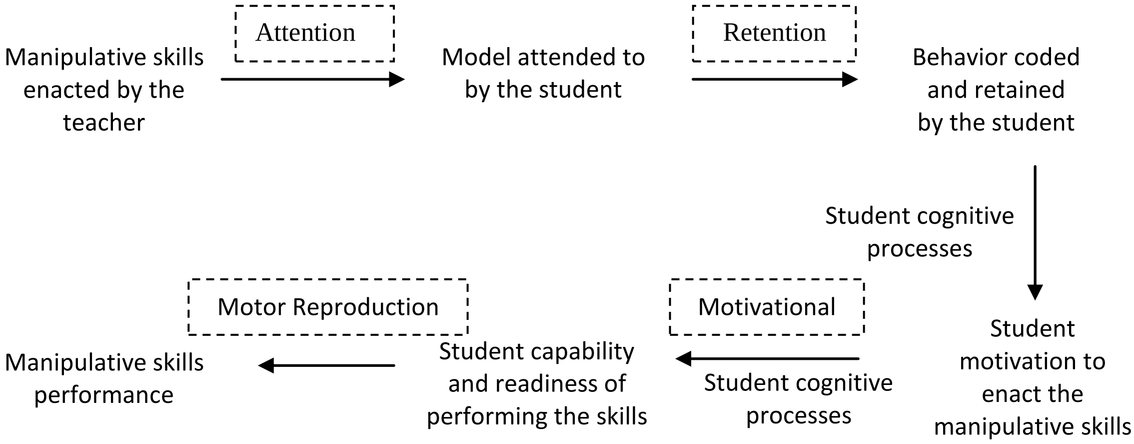


Figure 2.6 Sequence of steps in observational learning according to social-cognitive theory (adapted from Gredler, 1997)

SUMMARY

At the beginning of this chapter, I clarified the definition of the term science manipulative skills and the importance of these skills in the process of science teaching and learning. It is followed by the discussion of previous studies conducted in the field of manipulative skills and most of the reviewed researches are done in local context. The analysis of previous study showed an inadequate performance of students' ability to master the appropriate technique in handling scientific apparatus and this trend can be viewed as very upsetting to science educator. The insufficient skills in this area not only occur to primary and secondary school students but also involved our science teacher trainee.

I have also explained the relationship between manipulative skills and science process skills in the acquisition of scientific skills. The next sub topic briefly discussed the four (4) main psychomotor domain taxonomies that developed from Bloom's psychomotor domain categories of educational objectives: (1) Simpson's 7 levels taxonomy (1972), (2) Dave's psychomotor domain (1970), (3) Harrow's psychomotor domain taxonomy (1972), and (4) Ferris and Aziz psychomotor domain taxonomy (2005).

Then I described the studies conducted in the topic of transition from primary to secondary school from the global perspectives. Countries such as United Kingdom, USA, New Zealand and Australia have done numerous researches on the effect of school transition to their students but in Malaysia, these issues are relatively new and need to be further explored.

The theory underpinning the study of manipulative skills during transition from primary to secondary school was discussed in the final sub-topic of this chapter. I have chosen two learning theories to guide the research; (1) Anderson's ACT-R theory and, (2) Bandura's theory of observational learning. The application of both learning theories in this research has been discussed thoroughly and the theoretical framework is presented in Figure 2.7. Figure 2.8 shows the literature map for this study.

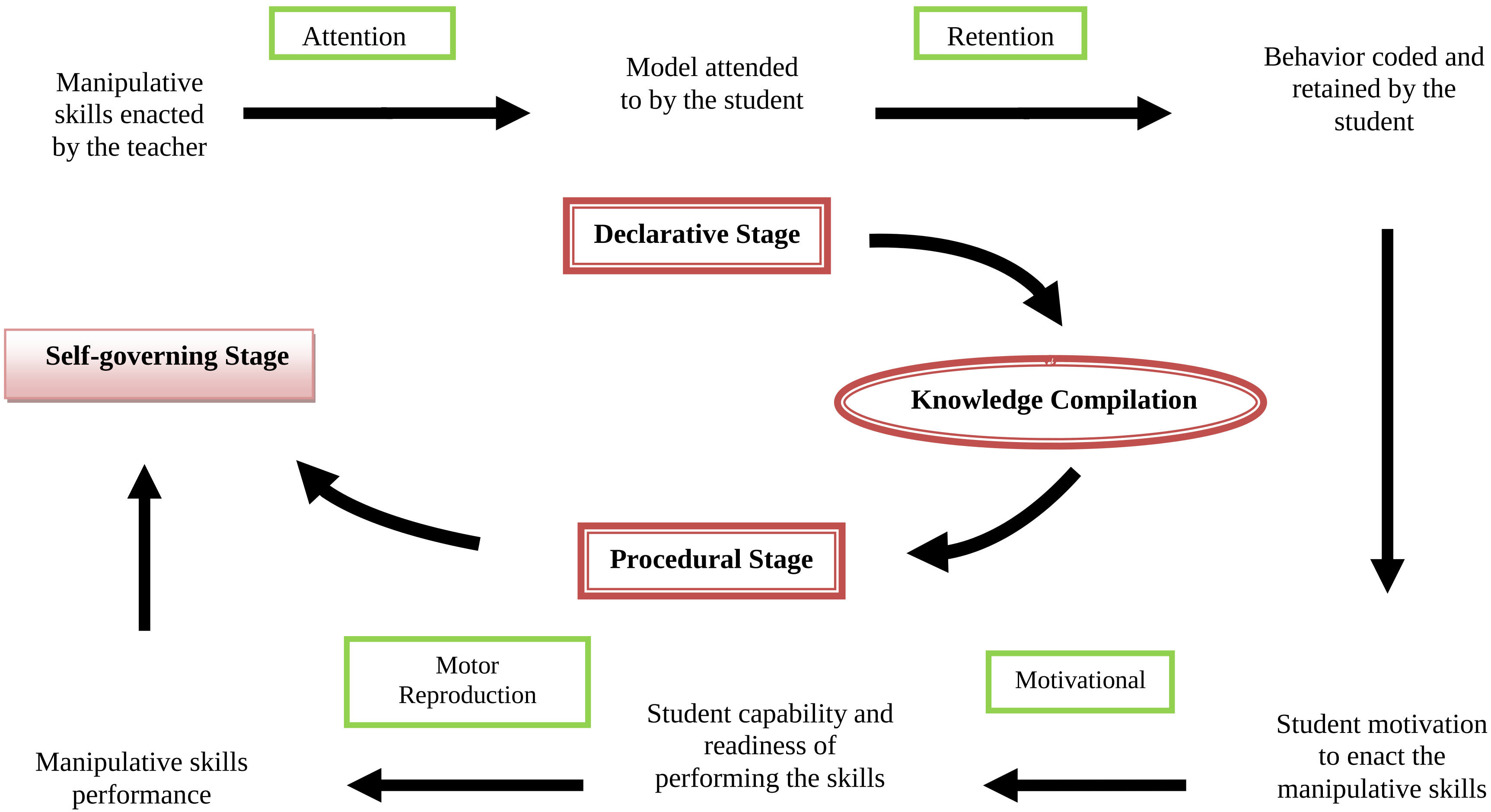


Figure 2.7 Theoretical framework of the acquisition of manipulative skill

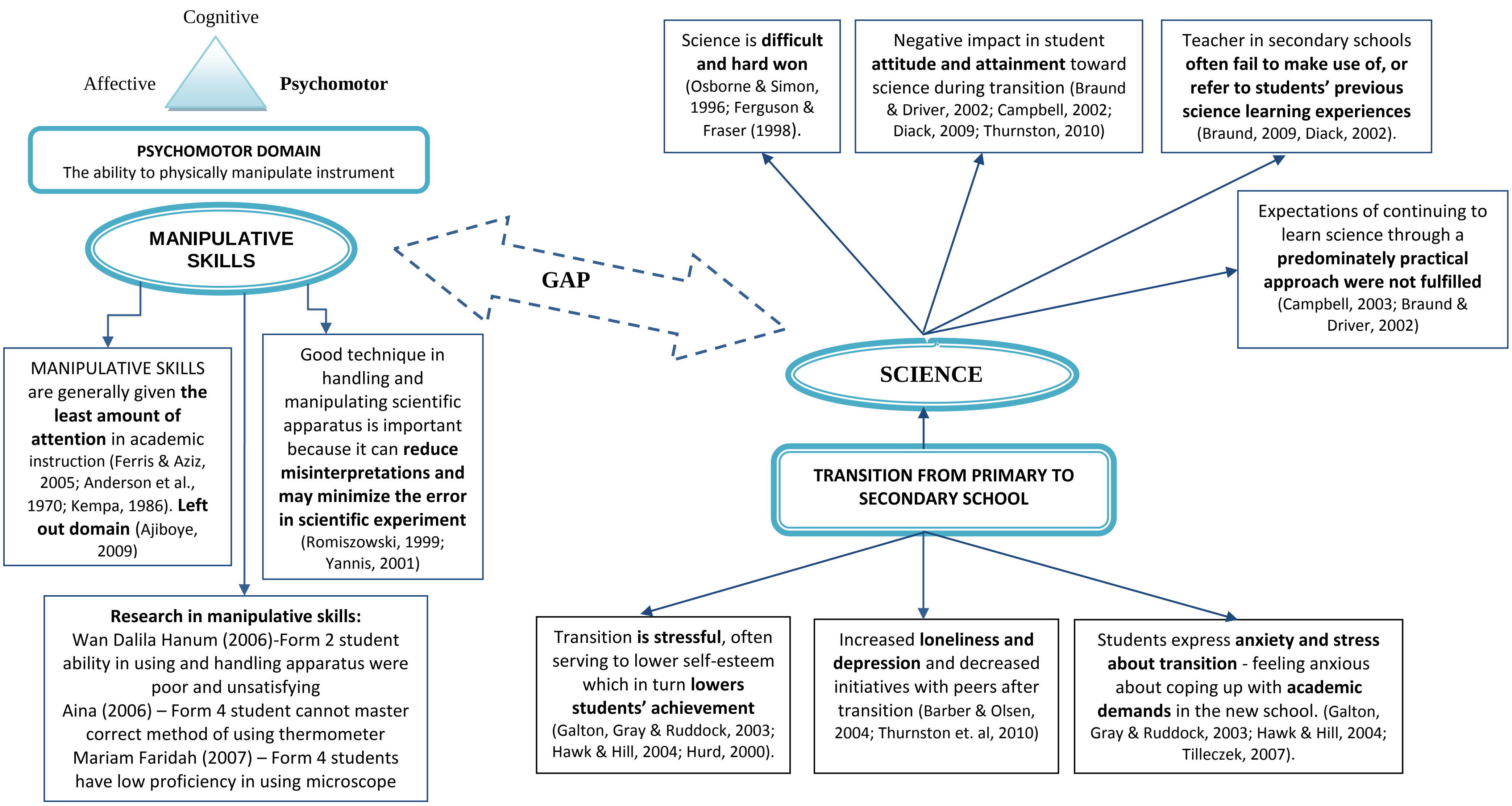


Figure 2.8 Literature map

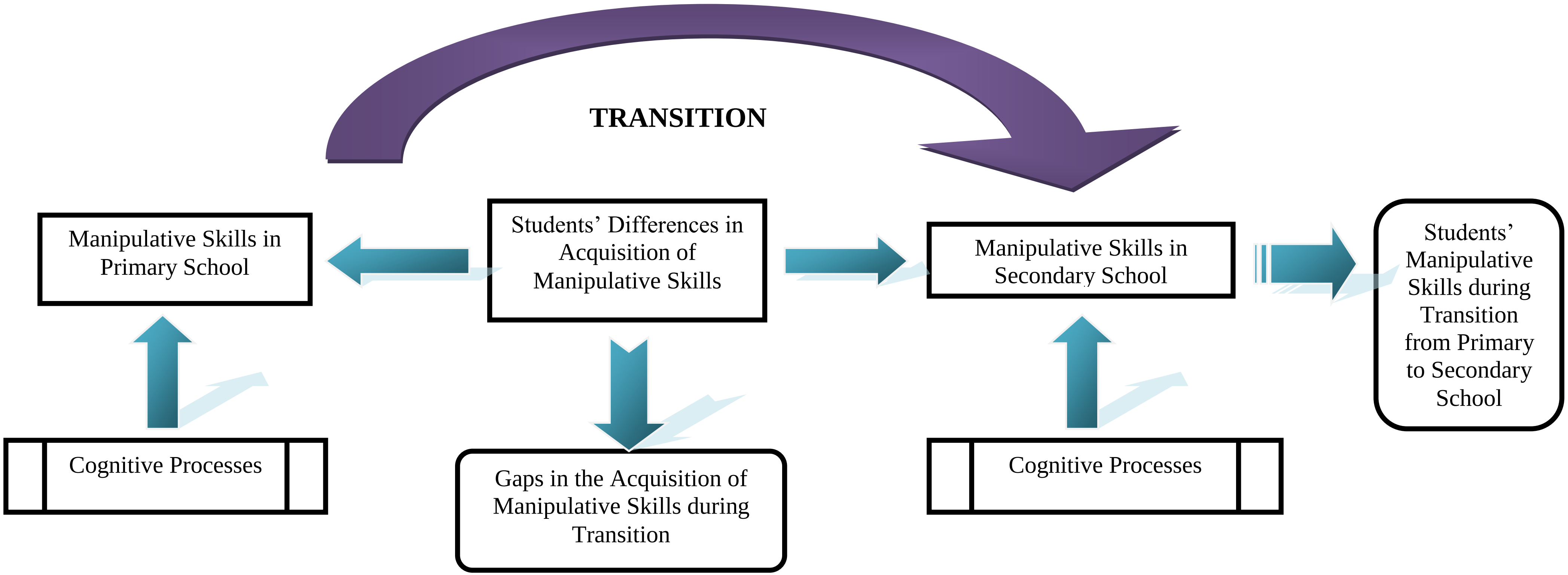


Figure 2.9 Framework of manipulative skills during transition from primary school to secondary school

CHAPTER 3

METHODOLOGY

INTRODUCTION

This chapter focuses on the topic pertaining to research methodology. The first sub-topic discusses the rationale of utilizing qualitative research paradigm for this study in order to answer the research questions. A qualitative paradigm of research design has been chosen due to its distinctive features and suitability with the research objectives. The second sub-topic describes the selection of site and subjects.

The study utilizes purposive sampling in order to obtain samples that are suited to the intent of the study in the attempt to gain maximum understanding of the phenomenon. The discussion then leads to the number of participants involved in this study which will be justified and further discussed in the chapter. Further on, the discussion elaborates on the research procedure in determining students' science manipulative skills during transition from primary to secondary school which is divided into three phases.

The first phase is the pre-research phase, followed by preliminary study and the actual research. The pre-research phase concentrates on the analysis of numerous documents for designing the tasks and the construction of the tasks itself. A structured task has been designed to achieve the objectives of understanding students' manipulative skills during transition from primary school to secondary school.

Data collection in this study involves document analysis, laboratory observations and interviews. These techniques of data collection are discussed further in the subsequent sub topic, followed by discussion on data analysis for this study. The final sub topic will discuss the validity and reliability of the research.

RESEARCH DESIGN

Research design reflects the objectives of the study and provides guidance in data collection and strategies for analyzing data. This study of transition from primary to secondary school adapts the qualitative research paradigm in order to obtain deeper understanding of this particular phenomenon The characteristics of qualitative research design have guided me in order to answer the research questions of the study. One of the major characteristics of qualitative research is the application of holistic perspective which conserves the complexities of human behavior (Creswell, 2008; Denzin & Lincoln, 2005; Merriam, 1998). The phenomenon under study has to be understood as a 'whole', not the sum of its parts. This research is conducted in order to get an in-depth understanding of students' ability in science manipulative skills during school transition. The transition that concerns with this study involves three stages: early, mid and late transition. Thus, I have to interpret and explore the interconnectivity and interrelationships of these three stages of transition.

In the search for understanding, qualitative researchers are not only concerned with product but also the process involved. In other words, qualitative researchers are especially interested in 'how' things occur in its natural phenomena (Bogdan & Biklen, 2007). In this study, for example, my aim is to get a comprehensive understanding of how students engage themselves in using the scientific apparatus during individual experiment. As the outcome of this process of 'doing', I have come out with specific categories which can describe the students' manipulative skills in science.

One of the features of qualitative research is the use of natural setting as a direct source in obtaining data (Bogdan & Biklen, 2007; Denzin & Lincoln, 2005). The natural setting is paramount for researchers to get an in-depth view of the phenomenon from the participants' perspective. In this study, the observation of students' manipulative skills is conducted in the science laboratory during science experiments to get the understanding of the actual settings in which the process of learning occurs. Studying real-world situation will lead to the openness to whatever emerges during data collection. Figure 3.1 characterizes the relationship between the population of the study and the central phenomenon.

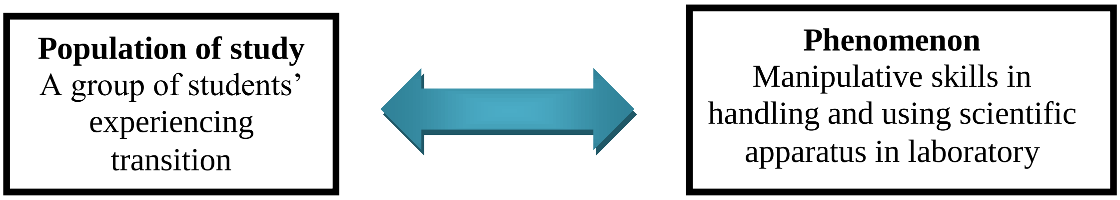


Figure 3.1 Relationship between population subject of the study and central phenomenon

SELECTION OF SITES AND SUBJECTS

The selection of sites and subjects is done carefully in order to gain in-depth understanding of the central phenomenon. This study is conducted to understand students' manipulative skills in science from primary to secondary school during early, mid and late transition. The research is administered to final year primary school students (Year Six) and first year secondary school students (Form One) from two primary and two secondary schools in Gombak District in the state of Selangor. I began the field work at primary school for Year Six students and followed them as they progressed to Form One at secondary school.

Data collected from primary school were analyzed before I continued with the data collection at secondary school. This was followed by the reflection of the data from the primary school and secondary school. Most researchers in studying transition adapt the same technique of choosing participants, which is the use of participants in the second semester of their final year of primary school and the first semester of their first year of secondary school (e.g., Campbell, 2002; Howard & Johnson, 2000; Thurnston, 2010; Ward, 2000).

In choosing research participants, I used the techniques of purposive sampling in order to obtain suitable participants for the study who would give me their comprehensive views and insights that will enable me to obtain maximum understanding of the phenomenon (Creswell, 2008; Fraenkel & Wallen, 2008; Merriam, 1998). The important concern for selecting the right research participants is to obtain rich data. Participants were purposively selected with the help of primary science teachers from both schools. The main criteria in selecting participants in this study were they should be articulate and have the ability to express their opinion since verbal data during the interviews was one of the main data source. It was important for me that the participants were consisted of students who were willing to talk about what they were doing comprehensively instead of being shy or rather quiet as I wanted to explore their understanding of the phenomena.

After identifying the participants, I needed to get their permission to cooperate in this study. The students gave their affirmative agreement to participate in the study orally. According to Ungar, Joffe and Kodish (2006), there is no requirement for formal written form (omission of signature) for students assent. However, informed consent has to be obtained from the parents and guardian in order to protect the privacy and confidentiality of the students. Hence, I prepared the formal letters to be given to the participants (please refer to Appendix A). Each letter included the main purpose of the study, the institution which I represented, the time required for the participants and the benefits for the participant. I distributed the consent form to the potential students who agreed to participate in the study and only students whose parent signed the consent form were selected as participants.

Data collection in this study was tedious and time consuming. This research took 11 months of data collection where I had to come to the school two or three times every week except during the school holidays and examination week. I administered this research at two primary schools and two secondary schools in Gombak district. The selection of schools was based on ‘typical case sampling’, simply because these schools were not unusual in any way and it reflected the average phenomenon of interest (Merriam, 2009; Patton, 2002).

When clarifying about the typical sampling, Patton (2002, p. 236) explained that “the site is specifically selected because it is not in any major way atypical, extreme, deviant or intensely unusual”. The schools were typical in the aspect of laboratory facilities, the use of the same science syllabus and each participant from the schools experienced transition. Moreover, the schools were situated near to each another. There was a limited number of primary and secondary schools in this area where most of the students from primary schools A and B would enter either secondary schools C or D. This was done in order to minimize the chance of losing the participants in this study.

A total of 13 students were selected as research participants from primary school and I followed them to their secondary school during the phase of transition. This ‘manageable number’ of participants provided sufficient information for me to understand the complexity of the phenomenon. According to Patton (2002), there are no rules for sample size in qualitative inquiry. The sample size and data analysis is a continuous process until it comes to a saturation point where no other new information can be found (Creswell, 2008; Denzin & Lincoln, 2005). Furthermore, the number of participants is not the main issue in qualitative research; instead the phenomenon under research is the main concern (Creswell, 2008).

In qualitative research, the number of participants may vary from one research to another. For example, Reid and Petocz (2002) use 20 participants to study students’ conception and understanding of statistics. Boon, Johnston, and Webber (2007) interview 80 participants throughout the United Kingdom in their study of conceptions of information literacy, and Domin (2007) use 17 participants in his research on exploring perceptions of conceptual development during laboratory instruction. Trigwell (2000) suggests that a sample size of 10 to 15 participants is feasible in a qualitative study. However, Bowden (2005) suggests that in any qualitative research there needs to be enough participants for sufficient information, but not too many that makes it difficult to manage the data.

Figure 3.2 displays the relationship between participants and the research site involved in the study of understanding students' manipulative skills during transition from primary to secondary school.

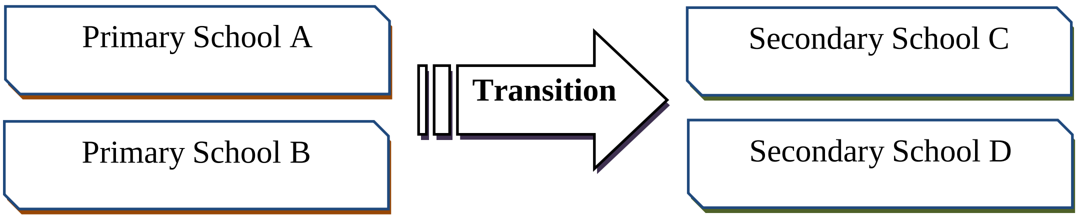


Figure 3.2 Research site and participant

RESEARCH PROCEDURE

The technique in determining students' acquisition of science manipulative skills during transition from primary to secondary school is divided into three stages. The first stage is the pre-research stage, followed by preliminary study and the actual research. The research procedures of this study are discussed in this sequence.

A) Pre-research

Pre-research stage is the stage where I analyzed the related documents for this study and constructed the instruments in order to answer the research question. At the initial stage, Year Four, Year Five, Year Six and Form One Science Practical Text Books had been examined to analyze all the experiments conducted in each level. Manipulative skills from each themes of science syllabus for Year Four, Year Five, Year Six and Form One were appraised to determine the continuity and progression in the learning of science manipulative skills during transition which involved the handling and using of scientific apparatus.

For example in Year Five, students were introduced to the use of microscope to observe the movement of microorganism under the theme 'Investigating Living Things'. Again in Form One, the students were required to handle the microscope to understand that organisms are built from the basic units of life. During the transition to secondary school, student were expected to familiarize themselves with the appropriate skills of using glass slides and glass slide covers, the manipulation of microscope and the correct technique of drawing specimens. The Curriculum Specification had also been reviewed analytically in order to get a deeper comprehension of the science syllabus for Year Four, Year Five, Year Six and Form One. Based on the analysis, I was able to grasp a deeper understanding of what and how the skills should be taught in accordance to the science syllabus.

From the document analysis, I had chosen four scientific apparatus that had been continually used in science learning at primary, secondary and even in tertiary level of education. The capability to obtain the manipulative skills in handling this scientific apparatus would be advantageous for the students to acquire. It served as a basis and foundation for the acquisition of higher level manipulative skills. For example the use of measuring cylinder served as the basis of using other specialized apparatus such as burette, pipette and volumetric flask where the fundamental skills and techniques were not much different. The manipulative skills that had been observed in Year Six and Form One students' in this research were:

i. The use of thermometer in measuring temperature of liquid
ii. The use of measuring cylinder in measuring volume of liquid
iii. The skills of using Bunsen burner
iv. The manipulation of microscope and it components

These skills had been chosen based on the analysis of science practical textbook for students in Year Four, Five, Six (primary school) and Form One (secondary school). They were introduced to students at primary level science and played an important role in secondary school science. For instance, at Year Four, students were introduced to the proper technique of using thermometer which included specific technique such as;

i) Holding the thermometer upright at the upper stem and not at the bulb,
ii) Immerse the bulb of the thermometer in the liquid and make sure the bulb did not touch the bottom of the beaker,
iii) Ensuring that the position of the eye is at the same level as the top of the meniscus of mercury to prevent errors.
iv) Not taking out the thermometer from the liquid when reading the temperature,
v) Taking the reading of the temperature when the temperature is not rising or falling
vi) Ensuring that the position of the eye is at the same level as the top of the meniscus of mercury to prevent errors and
vii) Washing the thermometer and wipe it before placing it back in its casing

From past studies, it had been found that most of the primary and secondary school students had difficulties in handling these apparatus during science practical, for example the research by Wan Dalila Hanum (2006) revealed that Form Two students' ability in using and handling apparatus especially Bunsen burner was poor and unsatisfying.

The assessment guide for Science Practical Work Assessment (PEKA) for UPSR examination (Malaysia Examination Board, 2008) had also been analyzed to get an overview of the characteristics of practical assessment in school (Appendix B). Among the objectives in conducting UPSR PEKA was to enable students to master the Scientific Skills which consisted of (a) science process skills and (b) manipulative skills. According to this guideline, one of the characteristics of UPSR PEKA was student-centered where students themselves should carry out all activities in a conducive environment and teacher would serve as a guide. Element Two of this PEKA assessment guide set focus on the student science manipulative skills. It contained five 'constructs' to assess the student science manipulative skills. The summary of the construct is shown in Table 3.1.

Table 3.1

Summary of Constructs in Manipulative Skills (Ministry of Education, 2008)

Science Manipulative Skills	**Criteria**
<u>Construct 1</u> Use and handle science apparatus and substances	C1 – Use at least 5 apparatus correctly and carefully C2 – Handle apparatus and substances correctly and carefully C3 – Set up the apparatus or prepare the substances in an orderly manner C4 – Carry out the experiment following the correct procedures

Construct 2 Handle living and non-living Specimens	C1 – Handle living specimens correctly and carefully C2 – Handle non-living specimens correctly and carefully C3 – Caring for living specimens C4 – Use non-living specimens without waste
Construct 3 Draw specimen, apparatus and Substances	C1 - Draw neatly C2 – Label drawings correctly C3 – Draw what is observed C4 – Draw using correct scales
Construct 4 Clean apparatus	C1 – Clean apparatus using the correct method C2 – Dispose waste using the correct method C3 – Clean apparatus (frequently)
Construct 5 Store apparatus and substances	C1 – Store apparatus and substances correctly and safely C2 – Store apparatus and substances correctly and safely (frequently)

From the understanding of document analysis and literature reviews, I developed a set of instrument called 'Manipulative Skills in Transition Tasks' (MSTT) which served as a tool to understand the students' manipulative skills and to observe as to what extent these skills were highlighted in the school science curriculum. Students should be able to reflect the manipulative skills which they had been acquired, by conducting the tasks at early and late transition. The analysis of documents was important in the pre-research stage where it served as sources of pertinent information in this particular research.

Manipulative Skills in Transition Tasks (MSTT)

The Manipulative Skills in Transition Tasks (MSTT) is a set of tasks constructed to understand students' manipulative skills during the transition from primary to secondary school (Appendix C, D, E and F). It is developed based on my analysis of the related documents, for example the science practical text books, science curriculum specification, science text books and science teaching and learning materials in primary and secondary level from the pre-research stage.

I had to come up with these tasks because the main objective of this practical activity was to comprehend the students' ability in using the scientific apparatus rather than focusing on the result of the practical activity. The procedures of the experiments in MSTT had to be simplified, as compared to the procedures from the text book. For example in the text book, students were given detail instructions such as 'measure 100ml of water by using measuring cylinder' and 'stir the solution by using glass rod'. However in MSTT, the instructions given were 'measure 100ml of water' and 'stir the solution from time to time'. These were done to avoid cookbook type of instructions and to see the students' true ability in using the apparatus during the execution of the tasks. Therefore the use of practical activity from the text book was not suitable for this study.

The MSTT tasks served as a tool to understand students' manipulative skills in handling four scientific instruments: scientific thermometer, measuring cylinder, Bunsen burner and light microscope. MSTT were created in accordance to the Year Four, Five, Six and Form One science syllabus. The MSTT consisted of two sets of instruments. The first set of instrument was developed for primary school students (Year Six) and the second instrument was for secondary school students (Form One). The laboratory tasks were written in both English and Malay language to assist students' comprehension and understanding in completing the tasks. In this research, language played its role as a medium to convey information. Thus, the use of English and Malay language was acceptable.

The tasks in MSTT had been created in order to understand students' ability in manipulating four (4) scientific apparatus; thermometer, measuring cylinder, Bunsen burner and light microscope. The first task in phase one (primary school) was conducted by Year Six students. The students' capability and skills in handling thermometer, Bunsen burner and measuring cylinders were observed. The experiment was adapted from Year Five learning theme, 'Investigating force and energy'. The second task involved the handling of microscope and this was also adapted from the Year Five learning theme, 'Investigating living things'.

In the second phase (secondary school), the students were again observed. The students conducted the third task which required them to demonstrate their manipulative skills in using Bunsen burner, thermometer and measuring cylinders. The fourth task was under the learning theme 'Matter in nature' and again, the students were required to prepare a slide for onion cells under the learning theme 'Man and the variety of living things'. The differences between the tasks at primary school and secondary school were the complexity of the tasks and materials used in these different stages. The content of these tasks is based on the curriculum specification for the respective grade. The tasks were not created to evaluate students' knowledge on the science concept but specifically prepared to understand their manipulative skills in using and handling of the apparatus. Table 3.2 summarizes the tasks and learning themes.

Table 3.2

Tasks and its learning theme

Tasks and Learning Theme	**Learning Outcome**	**Specific scientific apparatus to be observed**
TASK 1 - Year Six Theme: Investigating Force and Energy	To measure the temperature of water when it is heated	Thermometer Bunsen burner Measuring cylinder
TASK 2 – Year Six Theme: Investigating Living Thing	To observe the movement of microorganisms	Microscope Glass slide and glass slide cover
TASK 1 – Form One Theme: Matter In Nature	To understand how the presence of salts affects the boiling point of water	Thermometer Bunsen burner Measuring cylinder
TASK 2 – Form One Theme: Man and the Variety of Living Things	To understand that organisms are built from the basic units of live	Microscope Glass slide and glass slide cover

B) Preliminary study

According to Saldana (2003) a pilot study or preliminary study is worthwhile as a preparatory stage before the actual research begins in order to assess the effectiveness of data collection. The preliminary study is important in order to find the most efficient method of data gathering and to refine the data analyzing technique used in the study. The data collection of this study involves laboratory observations and interviews. The purpose of this preliminary study is to refine the instruments (Manipulative Skills in Transition Tasks) before the implementation of the instruments in the actual research and to test the MSTT for its appropriateness and usability. Furthermore, as a novice researcher, I needed to acquire and familiarize myself with the appropriate and effective process of data collection.

Two primary schools and two secondary schools were chosen as research sites in this preliminary study. Through preliminary study, I sharpened the skills and technique in observing the students during experiments in order to get the maximum input of data. The instrument was also revised and added with new instruction as a result of the feedback from teachers and students in this preliminary study. Based on the preliminary study the interview protocol was also refined. I also had the opportunity to familiarize myself with the proper technique of interviewing. As a result, interview protocols for Year Six and Form One students were reconstructed and organized systematically.

It can be concluded that in this study, the preliminary study is significant to ensure the usability of MSTT and interview protocols. It also served as a phase of familiarization for the novice researcher to assist me in obtaining sufficient skills for collecting qualitative data. The flowchart of the construction of instrument in pre-research and preliminary study is shown in Figure 3.3.

Findings of Preliminary Study

As discussed earlier, the main aim of preliminary study is for me to familiarize with the technique of collecting data. As a novice researcher, the preliminary study was important in order to assist me in getting maximum input from the observation and interview. It was also conducted to enhance the instruments used in this study. For example, the MSTT and research protocol had been slightly modified after the accomplishment of Preliminary Study 1, based on the feedback from the students and teachers.

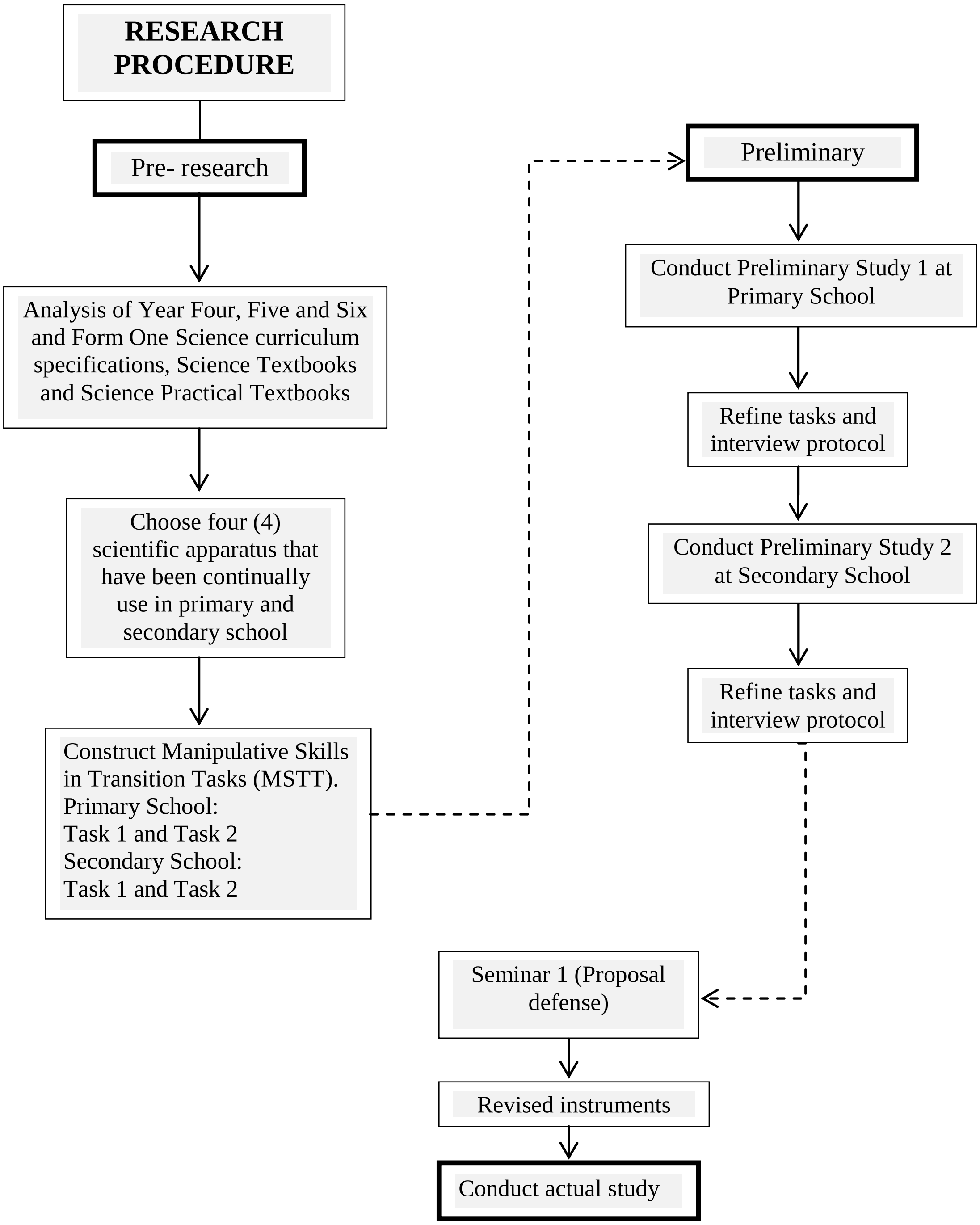


Figure 3.3 Flowchart of construction of instrument

The Preliminary Study 1 was conducted in October 2010 at two primary schools in Selangor. The main activity during this stage was piloting the tasks of the MSTT and familiarizing with the observation work, in terms of what was to be observed before conducting the actual study. Six students were selected from each school and three students were selected for each session.

The first task in MSTT needed the students to measure the temperature of water when it was heated. From the feedback, the students did not find any difficulty in understanding the procedure for this task and the MSTT instrument was comprehensible for them. The experiment went very well at both schools and it took around 30 – 35 minutes to be completed.

Initially, the task was conducted in pairs. Two students executed the experiment together. However, it was rather challenging for me to observe students' individual skills. Thus, in the actual study, participants conducted the task individually instead, in order for me to get maximum input on each student's competency. Four experienced science teachers from this phase verified the tasks for primary and secondary school by giving their opinion regarding the appropriateness of the procedure conducted in MSTT.

In the first session of the interview, focus group technique was conducted in order to assess the appropriateness of the interview questions and also to sharpen my interviewing skill. The main purpose of the interview was to explore students' perception on the issue of transition in science learning from primary to secondary school especially on their progression of manipulative skills. The interview was also conducted in order to get students' clarification on their technique of using and handling scientific apparatus. From the first session of this preliminary study, I found that sufficient data could be gathered through a group interview. However, in order to get utmost input from the participants, a one-on-one interview technique was more appropriate and this was employed in the actual research.

As the result of the preliminary study, the interview questions were further refined, basically in terms of wording. The numbers of questions were also reduced. The sentence structures were altered to cater to the students' capability in understanding the given questions. For example, the Year Six interview protocol initially consisted of 25 questions. During the first phase of preliminary study, the number of questions was reduced to only 20 questions. The sentence structure and word usage were also simplified for more meaningful understanding, for example, the words ‘transition’, ‘apparatus’ and ‘manipulative skills’ were considered as a jargon to the participants; instead of “Can you give an example of science apparatus that you have used at primary school?” was reworded to “Can you name some scientific equipment that you have used at primary school?” From the interview, I noticed the change in students’ responses when the different wordings were used.

C) Actual research

Research in school transition from primary to secondary school was implemented using qualitative research paradigm. The research was conducted in two phases; in primary school (Year Six) and secondary school (Form One). In this phase, the MSTT was utilized in the data collection.

Research Procedure

This study involves two phases. The first phase is conducted at primary school and the second phase at secondary school. The approval from the Educational Planning, Research and Development Division (EPRD) and permission from the schools’ authority was given a month before the research started (Appendix G). At the early transition, the first week of the study involved the phase of familiarization to establish a rapport with the research participants. The research was conducted at the schools’ science laboratory. I also acted as the instrument of this study; I was the instructor and facilitator for all the MSTT conducted in this study. Hence, I was able to observe every action in the laboratory, recorded every question raised and noticed all the difficulties the students encountered. Preparing and writing field notes allowed me to record and reflect what the participants had been observing, especially when I conducted the laboratory observation at mid transition and the teacher did not give permission to record the teaching and learning session.

During the early transition at primary schools, I did not encounter much difficulty in data collection because the students had already finished their national examination. This study did not affect their learning session at school. I went to Primary School A three times a week and it took approximately five weeks to be completed. This was then followed by the data collection at Primary School B which took about six weeks.

Initially 13 students participated in this study. Seven of them were from Primary School A and the rest were from Primary School B. Three (3) of the students had to go to boarding school in Kedah, Pulau Pinang and Johor and due to the time and financial constrain they had to be withdrawn from the study. The students were Student 2, Student 3 and Student 11. Table 3.3 shows the number of students from each school who participated in this study.

Table 3.3
Participants of the Study

Schools	**Number of Students as Participants**
Primary School A	7 (2 students went to boarding school)
Primary School B	6 (1 student went to boarding school)
Secondary School C	5
Secondary School D	5

In optimizing the communications with my research participants, as well as between the participants themselves who were studying in different schools during the early transition, a ‘closed group’ was designed in the social networking site, using the ‘Facebook’. The group was named the 'Transition Learning in Science Group’. It consisted of 13 active members and I acted as the moderator. In this group, participants could interact with each other, as well as discuss and share their experiences in the respective schools during the transition process. This group was helpful for me especially to track down the participants at secondary schools, for example, to determine their schools, classes and science teachers.

During the school break at the end of the primary school, I kept in touch with the participants through this group, for example by asking them about their preparation to secondary school, their feeling about entering secondary school and their perception and expectation of learning science at secondary school. From this interaction, the continuity of the familiarization process was assured and the participants did not feel disconnected throughout this research process.

The second phase (secondary school) started in January where I met the school authorities to ask for their permission to continue this study. The bigger challenges started here. The students dispersed into four different classes at two secondary schools. During the mid-transition, laboratory observations were conducted in order to observe how the students acquired the manipulative skills through the demonstration enacted by the teacher, in accordance to Bandura’s observational learning theory.

I understood my responsibility which was not to interfere with the students’ school session which started from 1.10pm to 6.30pm. In order to do that, I had to work closely with the laboratory assistants to make a schedule of non-occupied science laboratory, one hour before the evening school session started. The data collection process started simultaneously for both secondary schools at the late transition. I went to each school twice a week, and was only given one hour for each session to conduct individual tasks. Each student took approximately 30-35 minutes to complete one task. That means I could only conduct one task with one student in each session. The interview sessions were conducted immediately after the students had finished their task. The data collection took about three months to complete. Table 3.4 displays the duration of fieldwork in this study.

Table 3.4

Research Fieldwork Schedule

PHASE	MONTH	SITE	ACTIVITY
Preliminary study 1	October 2010	Two primary schools in Selangor	*Preliminary study (Primary School):* Piloting the questions and interview technique, becoming familiar with the observation work in terms of what to observe before conducting actual study
Preliminary study 2	March – June 2011	Two secondary schools in Selangor	*Preliminary study (Secondary School):* Piloting the questions and interview technique, becoming familiar with the observation work in terms of what to observe before conducting actual study
Phase 1	August - December 2011	Primary School: Primary School A Primary School B	*Interviews, observation and document collection (Primary school):* Carry out interviews and observation session at laboratory
Phase 2	January - June 2012	Secondary School: Secondary School C Secondary School D	*Interviews, observation and document collection (Secondary school):* Carry out interviews and observation session at laboratory

DATA COLLECTION

A number of techniques can be used as tools to collect data in qualitative research. These include interviews, diaries, observation, field notes, diaries and document analysis (Creswell, 2008; Denzin & Lincoln, 2005; Fraenkel & Wallen, 2008). In this study, the following instruments were used: (a) observations, (b) interviews and (c) document analysis.

Observation

According to Morris (1973), observation can be defined as the act of noting a phenomenon and recording it for specific purposes. It involves engaging all senses; seeing, hearing, touching, smelling and tasting. In other words, observation includes gathering impressions of the surrounding world through all relevant human capabilities. The research questions on exploring students' manipulative skills during transition can be answered appropriately by observing the students' skills and ability in using and handling the scientific apparatus in the laboratory. From literature review on assessing science manipulative skills, direct observation technique is the most appropriate instrument to understand manipulative skills, where the students are needed to exhibit the skills to an assessor (Johnstone & Al-Shuaili, 2001; Kempa, 1986; Lunette et al., 1981).

In this study, observations were conducted in order to understand the students' manipulative skills during transition. Two types of observation had been carried out: (1) individual observation of tasks from MSTT during early and late transition and (2) laboratory observation during mid-transition.

The individual observation of tasks from MSTT began at the end of students' primary school session or 'early transition', after the UPSR examination. At this stage, students were expected to know, and to be able to perform the manipulative skills in handling scientific instruments that they had acquired in the upper primary school level (Year Four, Year Five and Year Six). At the primary school, I did not get the approval to conduct laboratory observations from the Educational Planning, Research and Development Division (EPRD) because it might have interfered with the existing teaching and learning session. This was because at this stage, the students were busy preparing for the UPSR national examination. Thus, the acquisition of manipulative skills in the laboratory during early transition could not be observed.

The second phase was conducted from January 2012 until the end of the first semester at the secondary school (June 2012). At this stage, students were expected to have familiarized and adjusted themselves with the secondary school. I visited two (2) secondary schools in order to track the participants from the primary schools. Observations during laboratory sessions were carried out twice for each student during the mid-transition, respectively, with verbal consent from the science teachers as a secondary participant for this research. During the laboratory observation, I observed the acquisition of skills from students' 'attention process' (Bandura, 1977) during the demonstration by the teacher.

At the late transition, I conducted the individual tasks with the participants. Each of them was given two individual tasks from the MSTT in order to explore how far their skills over the past three months were manifested. These tasks were conducted at the science laboratory twice a week, an hour before the students started their school session. This was done to minimize any interference with their school session.

Observational role in qualitative research may vary considerably. In this research, I implemented the technique of 'participant observation' and played the role as an instructor. I participated in the experiments of the group being studied in order to get the opportunities to observe students' experiences and collect their views (Creswell, 2008; Fraenkel & Wallen, 2008).

Qualitative researchers always use the natural setting to get an in-depth view of the phenomenon from the participants' perspective. In this study, the observations of students' manipulative skills were conducted in the science laboratory during the science experiment in order to get better understanding of the actual settings in which learning occurred. Studying the real-world situation might lead to the openness to whatever emerges during data collection.

During the task performance, I did not interfere with the students' work. I observed the students' skills individually to get the understanding of the different ways in which they manipulated the instruments in conducting the experiment without any intervention. However, if the situation got out of control, I had to intervene in order to avoid any unwanted incident, for instance, in using thermometer during the early transition, students tended to hold it roughly and tapped the thermometer to the surface of the table.

In order to avoid the observer effect, I had interacted with the students frequently for a certain period of time. This made the students become familiar with my presence so that they carried out their activities in the usual manner. In addition to the video recording during laboratory observation, I also had to use field notes to describe my experiences during the field work especially during laboratory observation. All the observation field notes were transcribed and analyzed accordingly.

Interview

Interviewing is the most common and powerful ways to understand human beings. In social science, interview is among the most generic methods of collecting data (Atkinson & Silverman, 1997). It serves as a tool to provide insights into participants' constructed world and beneficial in generating significant data. Booth (1997) and Reid (1997) explicate the use of open, deep interview as the main instrument in qualitative research in order to discover students' understanding and conception of particular phenomenon. 'Deep' indicates that the process of interviewing will reach an exhausted stage or saturation point, where the participant and researcher will come to a mutual understanding about the meaning of the experiences. Dortins (2002) characterizes an interview as a productive conversation that needs collaborative endeavors in which produced through understanding between interviewer and interviewee.

In this research, an interview protocol had also been constructed in order to find out students' experiences and acquisition of manipulative skills during the process of transition in school (Appendix H and I). By utilizing semi structured interviews in collecting information, I were able to determine issues experienced by students during the transition period, their perception about the process of transition which might also serve as a check prior to the laboratory observation. The interview sessions were conducted after the students had completed each task from MSTT. I ensured that the time laps between the observation of students completing MSTT tasks and the interview session were not too long so that the students were able to recall the skills which they had shown earlier.

Morse (1998) defines several general criteria for a 'good informant' or interviewee. They should have a necessary knowledge and experience of the issue or object at their disposal for answering the questions in the interview or in observational studies for performing the action of interest. In this research, the participants should have had the capability to reflect and articulate the issues of transition and manipulative skills in science learning. They should have had ample time to ask questions, and should be ready to participate in the study.

The one-on-one interview (Creswell, 2008) was conducted in this study in order to gain insights from the students' true ability in using and handling the scientific apparatus during transition from primary to secondary school. This individual interview was conducted after the observations of laboratory task. Students were expected to rationalize and justify their act of handling scientific instruments during the execution of the tasks. From the interview, I was able to explore the students' method of handling the apparatus at primary and secondary school.

As in observations, interviews were conducted in two phases. Phase one was conducted at the end of primary school for Year Six students, after their UPSR examination. This interview focused on students' expectation of transition to the secondary school and questions related to the teaching and learning of science and manipulative skills in primary school as well as their expectation of science at the secondary school. The second phase was conducted at the end of the first semester of secondary school (late transition). The total duration of each interview was between 25 to 35 minutes.

I began each interview with an ice-breaking session in order to establish rapport with the students. I introduced myself as a researcher who was interested to find out about the students' experience in handling scientific apparatus at primary and secondary school. In the interview, participants were given several chances to express themselves and my role was to assist the participants in exploring and expressing their ideas on the central phenomenon, which were the process of transition to secondary school and their perception on the learning of manipulative skills during transition. Interviewer must obtain sufficient responses from the participants to ensure the fullest coverage of the topic by encouraging the participants to talk (Creswell, 2008; Merton, Fiske, & Kendall, 1956). At the same time, I should be simultaneously concerned about the script of the questions, as suggested by Marton (1996). Discussions were always followed with probing questions in order to get an in-depth meaning of the students' experiences, for example, "What do you mean by…", "Can you give me the example of…" and "Could you tell me more about…". All the interviews were audio-recorded and transcribed verbatim for data analysis.

Document Analysis

Document is a valuable source of information in qualitative research (Creswell, 2008). They can include textbooks, essays, magazine articles, newspapers and any form of written contents that provide information that help to enhance a researcher's understanding of the central phenomena in qualitative research. In this study, the documents that were used as sources of data were the students' drawing of specimen. The drawing was obtained from two tasks: Task 2 at primary school and Task 2 at secondary school. In primary school, the students' had to draw the microorganism which they observed using a microscope. In the secondary school, the students' drew the onion cells to understand that organisms were built from the basic units of live.

The ability to draw specimen was one of the aspects in manipulative skills. Construct three of the assessment of science practical work (PEKA), specifically focuses on the student ability to draw specimen and apparatus. These criteria served as one of the guideline for me to understand the students' drawing in this study. Four criteria in assessing the drawing in PEKA are shown in Table 3.5.

Table 3.5

Criteria of assessing student drawing in PEKA

Construct	Criteria
<u>Construct 3</u>	C1 - Draw neatly
Draw specimen, apparatus and	C2 – Label drawings correctly
Substances	C3 – Draw what is observed
	C4 – Draw using correct scales

Table 3.6 is a summarization of the technique used in the data collection in order to achieve the research objectives. Figure 3.4 shows the phases of data collection in this study.

Table 3.6

Data Collection Techniques

	Research Objective	**Technique for collecting data**
1.	Describe students' manipulative skills during (a) early transition, (b) mid-transition and (c) late transition	Tasks observation from MSTT, laboratory observation, interview and document analysis.
2.	(a) Identify the differences in manipulative skills among the students during early transition, mid-transition and late transition.	Task observation from MSTT, laboratory observation, interview and document analysis.
2.	(b) If any, to prepare a form of intervention resource that could assist teachers in narrowing the differences in the manipulative skills during transition.	Emerging findings from data analysis and feedback from observation and interview with experts.

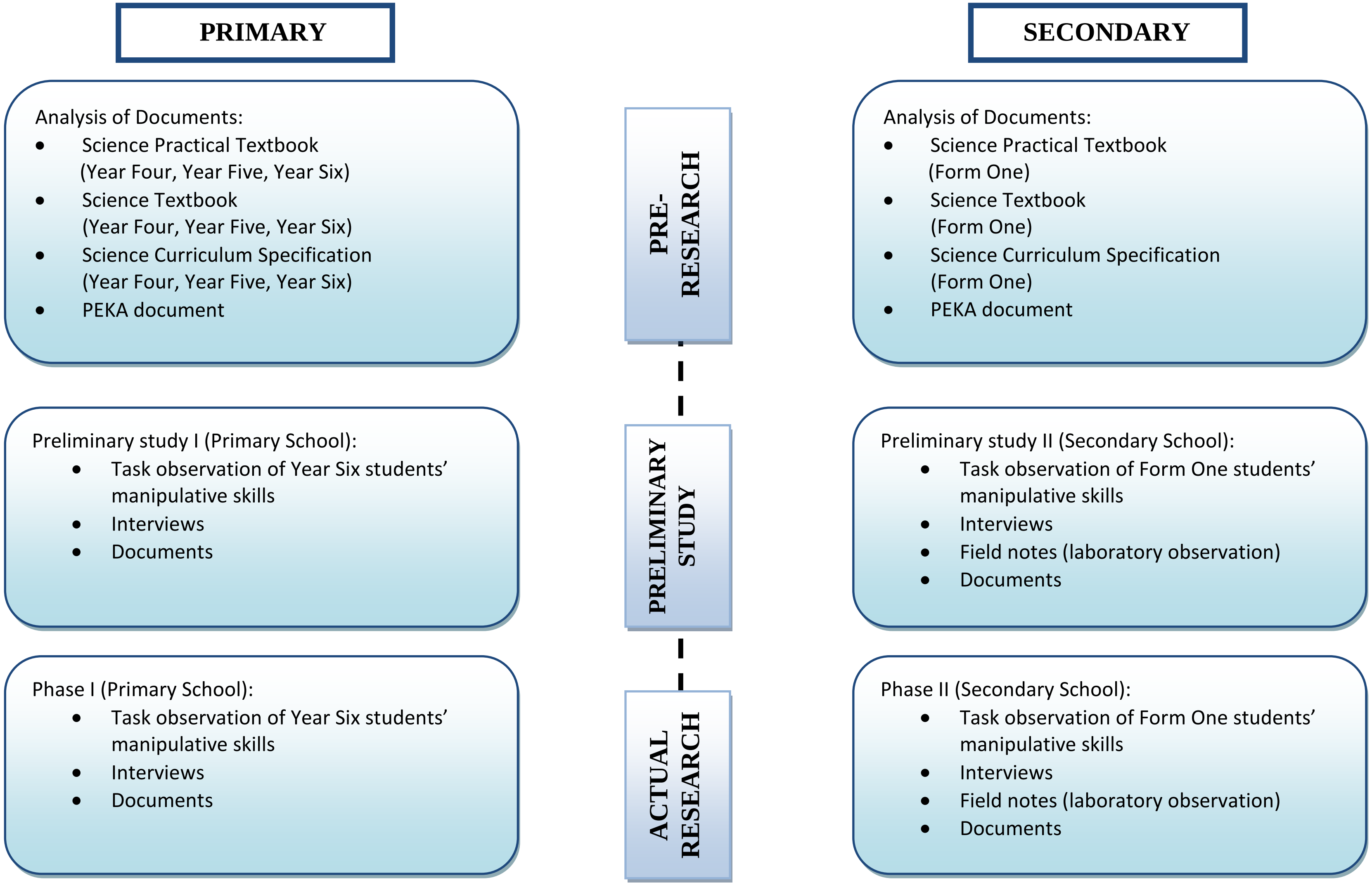


Figure 3.4 Phases of data collection in primary and secondary school

DATA ANALYSIS

Data analysis is the process of making meaning out of the raw data gathered during the field work in order to develop conceptions of the phenomenon under study. In qualitative research, the process of analyzing data occurs simultaneously with the data collection and perhaps the writing of the research report (Creswell, 2008; Merriam, 1998). It is an iterative process where the repetition of the process of data collection and analysis is done back and forth until the saturation point has been reached (Creswell, 2008). The initial planning of the data analysis involves a systematic process of organizing a considerably large amount of data from the related documents, audio-taped interviews and videotaped observations. The summary of the data gathered in the present study is listed in Table 3.7.

Analysis of raw data from the fieldwork begins with the verbatim transcription of recorded materials into text data. In preliminary exploratory data analysis, the transcriptions of interviews, observations, documents and fieldnotes are explored and analyzed thoroughly in order to obtain a general sense of the data (Creswell, 2008). In this research, students were observed individually during the execution of each laboratory task. Each individual had his or her own technique in handling the scientific apparatus and hence, there were the dissimilarity and variations in manipulative skills. The different ways of performing manipulative skills were scrutinized and the inability in using and handling the apparatus were the main phenomenon to be understood.

Table 3.7

Summary of Data Sources for the Study

Sources of data	Summary	Phase of data collection
1) Observation (Main source of data)	Observation of individual performing the tasks from MSTT: Primary School - Task 1 and Task 2 Secondary school – Task 1 and Task 2	Phase 1 – Early transition Phase 2 – Late transition
2) Laboratory observation	Minimum of one observation for each student. Observation involves four science classrooms with four different teachers.	Phase 2 – Mid-transition
3) Interview	Conducted individually in two phases: Primary school and secondary school. Each session lasted approximately 25- 30 minutes.	Phase 1 – Early transition Phase 2 – Late transition
4) Student's drawing	Scientific drawing from Task 2 at primary school and secondary school	Phase 1 – Early transition Phase 2 – Late transition

Before analyzing, the process of familiarization was conducted in order to get an overview of the richness and diversity of the gathered materials and to get immersed in the data collected. During this stage, I read through the transcripts, watched the recorded observation, studied the field notes and listed the main ideas and recurrent themes, as suggested by Ritchie and Spencer (1994). This was the foundation of the abstraction and conceptualization process which led me to identifying the key issues, concepts and themes of this research. Abstraction in this context was the process of formulating generalized concepts by extracting common qualities from the pool of data. This process was conducted in two main phases which involved the data collected during primary school and secondary school.

Further method of analyzing involved a more rigorous and detailed data analysis. Constant comparative data analysis technique (Glaser & Strauss, 1967) was used to answer the research questions for this study. It involved the process of coding, categorizing and developing themes from information that emerged from the collected data, which can best describe the ways students experience transition in science learning. This is in line with the view that refining the thematic framework involves a logical and intuitive thinking in making sure that the research objectives are being addressed appropriately (Ritchie & Spencer, 1994).

Constant Comparative Method of Data Analysis

Constant comparison is the data analytic process whereby each interpretation and finding is compared with the existing findings as they emerge from the data analysis (Strauss & Corbin, 1998). It is normally associated with the grounded theory data analysis method, which Glaser and Strauss (1967) refer to as the "constant comparative method of qualitative analysis". This comparative analysis is also the main principle of analysis process in other design of qualitative research and due to the compatibility of constant comparative method, it has been adopted by many qualitative researchers without the necessity of building a grounded theory (Boeije, 2002; Merriam, 2009; Silverman, 2001; Strauss & Corbin, 2008.)

The main strategy of the method is to constantly compare. According to Glaser and Strauss (1967), constant comparative method involves simply inspecting and comparing all the data fragments that arise from the data. It begins with the identification of particular incident from an interview, field notes, or document and compares it with another incident in the same set of data or in another set.

The method of comparing and contrasting is used for practically all intellectual tasks during analysis including forming categories and to discovering patterns (Tesch, 1990). The comparisons lead to tentative categories that are then compared to each other (Merriam, 2009). By comparing, a researcher is able to do what is necessary to develop a theory inductively as suggested by Boeije (2002) and Merriam (2009). The data in hand are analyzed again and compared with the new data and the cycle of comparison and reflections on old and new material are iterative. Strauss and Corbin (1998) emphasize on the art of comparison which relates to the creative processes and the interplay between data and the researcher when gathering and analyzing data. The saturation point occurs only when new information does not bring any new perspective to enhance that category (Boeije, 2002).

In this research, unit of data from observation and interview transcripts during transition was analyzed and systematically compared with previously collected and analyzed data. During the initial stage of the research, comparison was conducted within a single observation. The main aim of this analysis was to come out with appropriate categories and label them with different codes. The detailed line-by-line analysis (microanalysis) started with the process of open coding where every transcribed observation was studied and coded to generate initial categories and to suggest relationships among categories. This was done in order to determine the students' technique in manipulative skills during the execution of experiment. The consistency of the observation was examined as a whole. I began the analysis on a small part of the data at first in order to generate a set of initial categories.

For instance, if one excerpt was given the label 'accuracy', I examined the observation for other relevant excerpts that should be given the similar code. If reference was made to the same category again, the excerpt relating to the 'accuracy' was compared and contrast in order to find out what the commonalities, differences, and the dimension of the highlighted code. During this stage, I had to keep in mind on the issue of suitability of the codes used in the observation. There were also important questions that needed to be addressed which include: What are the characteristics of each excerpt in the same categories? What characteristics do excerpts with the same code have in common? How are all the excerpts related? (Boeije, 2002). This task became more complicated due to the nature of this research which involved two phases of data collection, at primary school and secondary school.

Altogether, there were 46 electronic files from task, each approximately 25 minutes in length. Other 23 audio tapes came from students' interviews. A total of 19 of students' observations during the tasks and nine hours of interviews were recorded. All were transcribed verbatim into electronic files. Through axial coding, the categories were further refined by relating, combining and comparing the categories to each other. The sample of initial coding is illustrated in Appendix J. The coded transcripts were transferred to the matrix (Appendix K). The process got tedious when the number of codes increased. Initially they were 162 open codes emerged from the data (primary and secondary school). The codes were then collapsed into 27 different categories. The further method of analyzing was to compare between observations and interviews categories at primary school and secondary school. Categories were then related and compared to form more precise and complete explanations about the observed phenomena (Strauss & Corbin, 2008).

In this study, the process of comparing was necessary in order to identify the categories and to further develop these categories. From this step, a form of pattern or theme was developed in order to further define the concept and conceptualization of the subject. The categories were then sorted out, refined and condensed into categories and sub-categories which came from various sources of data. Miles and Huberman (1994) term this process as data reduction. Data reduction refers to the process of condensing the findings, in order to make meaning out of the gathered data. During this stage, serendipitous findings help me to get beyond initial conceptions.

The condensed data from the coding and categorizing process were displayed in an organized and structured form, in order to assist me in evaluating and drawing conclusion from the emerging findings. This analytical process is referred to as ‘data display’ process (Miles & Huberman, 1994) which involves the analysis of matrixes and charts from numerous sources of data.

The first draft of categories emerged two months after I finished my data collection. Initially, seven categories and 18 sub-categories arose from the first draft. After much discussion with my supervisor and fellow colleagues in the same field, the second draft was constructed. The second draft comprised five categories and 11 sub-categories which were further refined. The emerging categories and sub-categories were compared and refined until they were mutually exclusive.

Then the second draft of categories was presented to my supervisor and colleagues in the same field who have had training in qualitative research. For example the category ‘confidence/interest’ was eliminated in the second draft due to its unsuitability with the conception of manipulative skills. However, it will still be discussed in the findings. The first and second drafts of the categories and sub-categories are illustrated in Figure 3.5 and Figure 3.6.

Systematic theoretical comparison technique (Strauss & Corbin, 2008) has also been utilized to bring out possible properties and dimensions from the data. This is conducted through comparison of concepts from the research with one recalls from the literature. In this research, the category is considered saturated when no new categories or sub-categories seems to emerge during analyzing. Figure 3.5 displays the process of data analysis in this study as adapted from Creswell (2008).

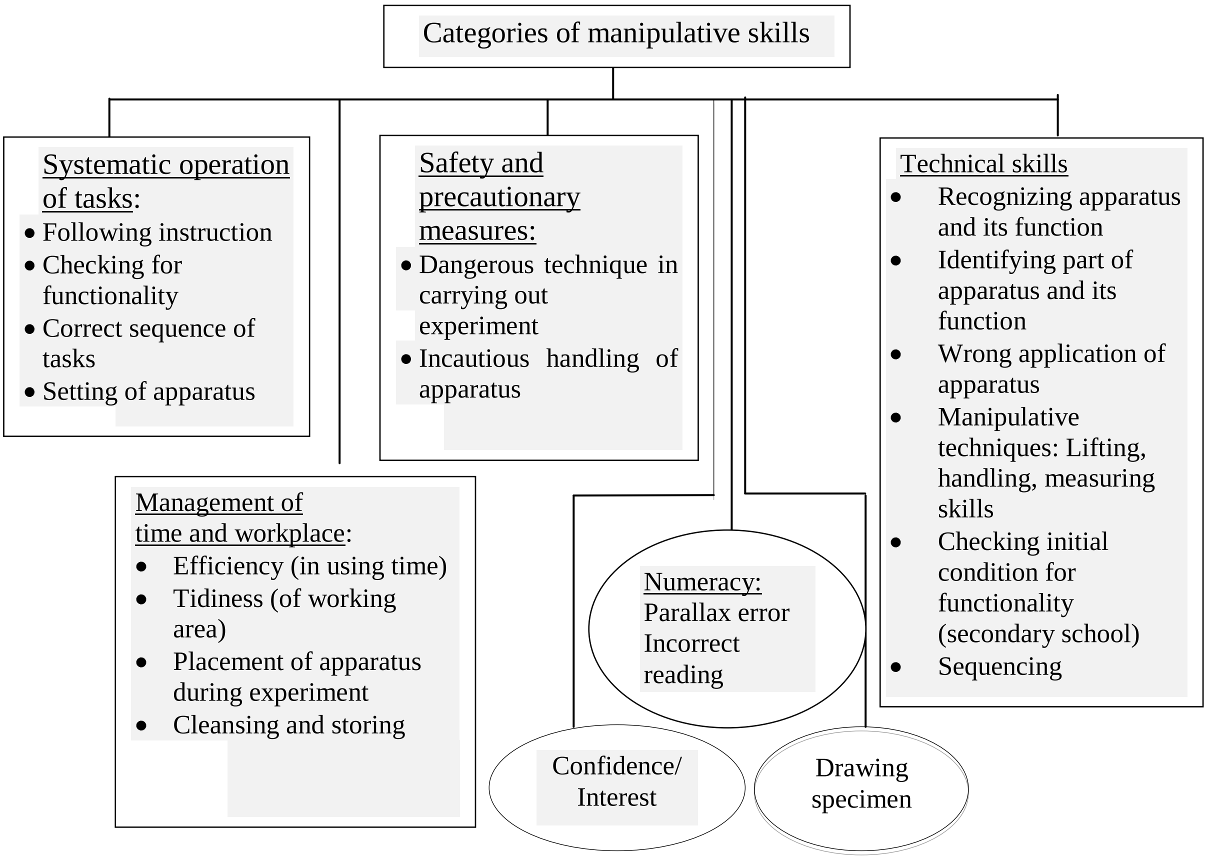


Figure 3.5 First drafts of categories and sub-categories

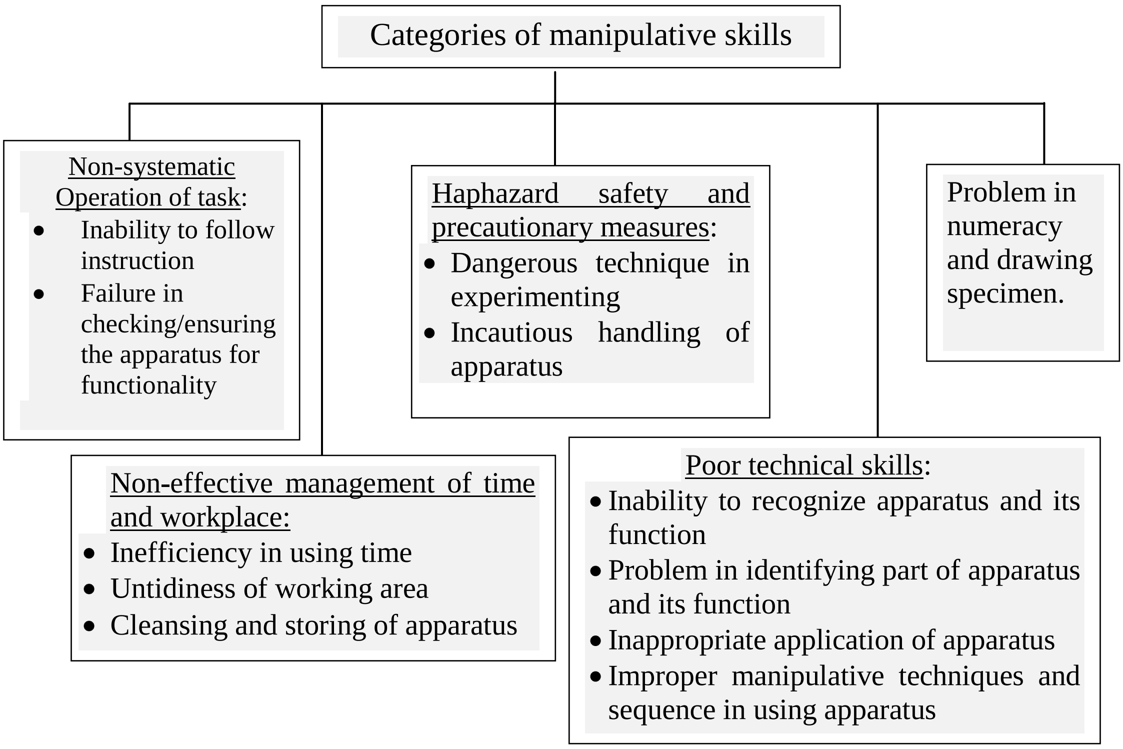


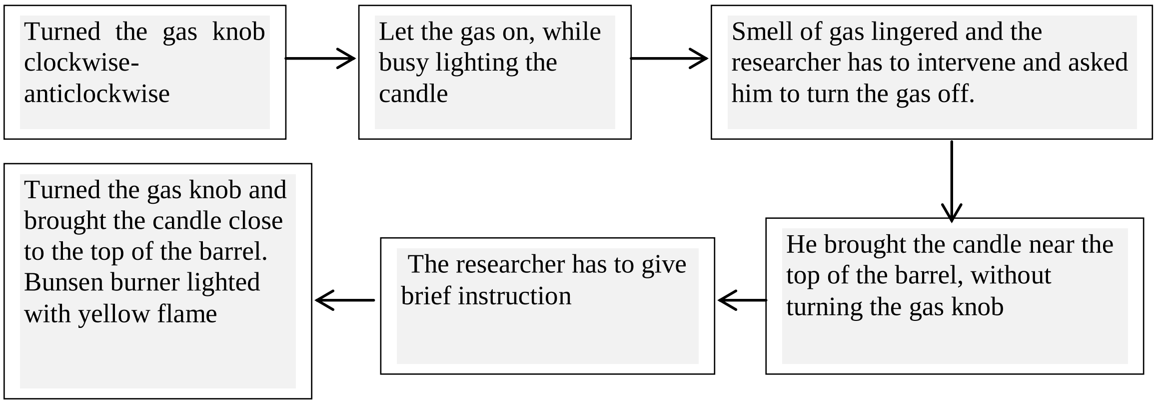
Figure 3.6 Second drafts of categories and sub-categories

Refinement of the second draft was done again. The category ‘Technical Skills’ has been polished where I had to analyze the data once more. I needed to come out with the categorization technique in order to analyze the students’ skills effectively. The categorization was based on four apparatus used in the study; the measuring cylinder, thermometer, Bunsen burner and microscope. The apparatus were divided into two main categories according to its features; the graduated apparatus and sequential apparatus. The data from each student for each apparatus were then arranged in sequence, in order to assist me in analyzing and coding the data. An example of how students’ data were compared according to the apparatus is shown in Figure 3.7.

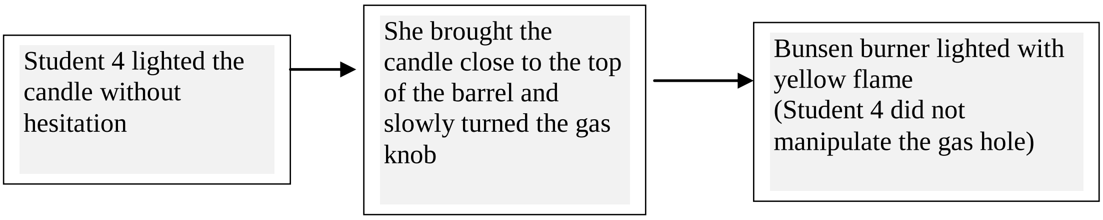
Subsequently, the sequencing for each apparatus was compared and contrasted across students (primary and secondary school) to get a general trend of technical skills required for each apparatus. After separating the transcribed data according to the apparatus (measuring cylinder, Bunsen burner, thermometer and microscope) the coding of the students’ technical skills of using each apparatus began. Again, I compared and contrasted the general trend for each apparatus to come out with the sub-categories under the categories of ‘Technical Skills’, which were suitable for the students during transition from primary to secondary school. The findings of this study will be discussed further in the next chapter.

Bunsen burner, Primary School

Student 1

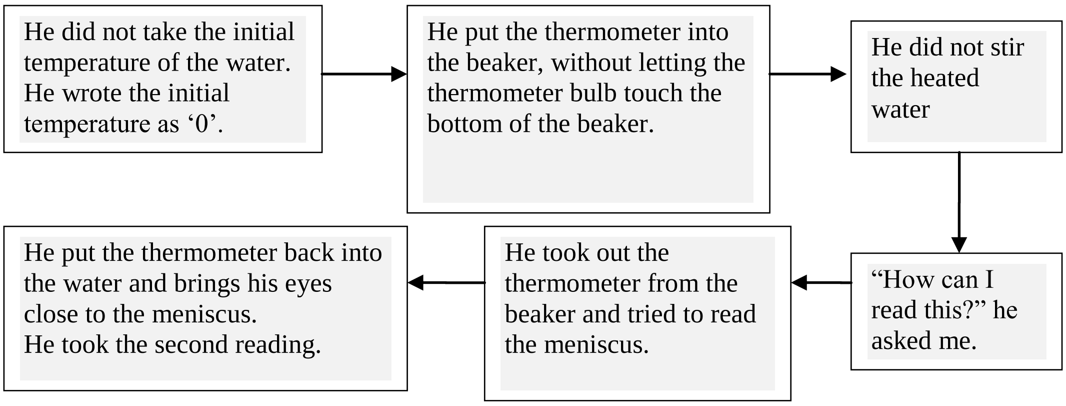


Student 4



(Thermometer, Primary School)

Student 1



Student 6

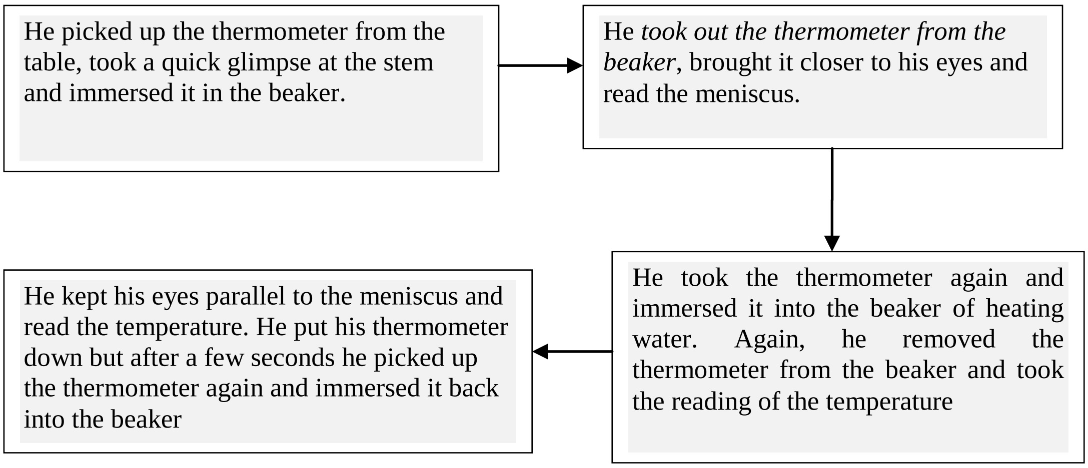


Figure 3.7 Example of the sequence of diagram according to apparatus for primary school

Scientific Drawing

One of the most important skills of a science student is the ability to construct a proper scientific drawing. This skill is considered as basic scientific skill and serves as an essential part of manipulative skills. Drawing specimens, apparatus and laboratory substances accurately is one of the criteria of manipulative skills in Malaysia (MOE, 2006). The skill also serves as an excellent way for students to exhibit their science process skills of observing and communicating in order to collect information from what they have seen. The ability to draw and label the drawing is considered as one of the ways for the students to demonstrate their knowledge in scientific content.

Scientific drawing requires student to give full attention to every detail and important features of the specimen observed. It helps the student to develop ideas and share their ideas and observation with others (Holt, 2002). All the information received from the observation needs to be interpreted and converted into scientific drawing through the control of muscle of the hands (Hoese & Casem, 2007). This process is considered as a very challenging process especially for primary school students. Students need to process the new information that they receive from observation and relate it with the schemata that they already place in their mind. Thus, the ability to interpret and construct accurate drawings requires much practice. However, drawing skill has not received enough attention in teaching and learning of science and this can be supported by the lack of explicit literature on the appropriate instruction on how drawings are made (Wekesa, 2013).

There is a standard as to what constitutes an acceptable scientific drawing, in which all drawings should adhere to this specific standard. However, from the analysis of related documents during the pre-research stage and the interview conducted with students' and their teacher in this research, this standard had not been put forward and presented specifically in the syllabus.

Line drawing is always used in scientific drawing at school level. It consists of distinct single lines, without gradations in shade or hue to represent the specimen (Sayre, 2010). Some of the important components or principles of scientific drawings includes the presence of drawing title, magnification, annotation, labels and the drawing should be neat and clear (Johnson, 1992). Based on literature reviewed (e.g., Holt, 2002), I have developed an appropriate framework to assist in analyzing the students' scientific drawing during transition (refer Table 3.8).

This framework is based on a few principles of scientific drawing and supported by the criteria in PEKA (Assessment of Laboratory Work) by the Ministry of Education (2010). Initially, the framework was reviewed by a lecturer from a teacher training institute who has a lot of experiences as an inspectorate for Science PEKA at primary and secondary school.

From this framework, a rubric for assessing students' manipulative skills which include scientific drawing was constructed. The constructed rubric was validated by 39 primary school and secondary school science teachers from 39 different primary and secondary schools who teach Year Six and Form One students at the district of Kota Bahru, Kelantan. The amended criteria from the rubric were used as a guideline to analyze the students' scientific drawings for this particular study. Table 3.8 presents the initial framework for analyzing scientific drawing.

Table 3.8

Framework for Analyzing Students' Scientific Drawing

No.	Criteria	Explanation
1.	Use of pencil	Student may only use pencil to draw the specimen. The pencil should be appropriate and be able to produce thin outline with uniform thickness.
2.	Use of line drawing	Student did not shade in any area of the drawing and the outline should be drawn continuously
3.	Neat drawing	Student's drawing should be positioned at the center of the page and fill the space provided. Drawings must be large and clear so that every structure can be distinguished easily. Student show their competency by avoiding unnecessary erasing which may lead to untidiness of drawing
4.	Appropriate title of the drawing	Student should be able to give a clear and concise title that explains what is being illustrated.
5.	Magnification of drawing is indicated	Student should be able to draw using correct scale and label their drawing with magnification used.
6.	Correct label of scientific drawings	Student should be able to give correct label(s) to the drawing. Each label line must be straight and should not overlap with other label lines in order to make it clear.
7.	Authentic drawing	Student draws what they actually observe, as opposed to what they think they should be seeing.

TRUSTWORTHINESS (VALIDITY AND RELIABILITY OF STUDY)

While designing a qualitative study, validity and reliability are two issues that a researcher should be concerned about (Golafshani, 2003; Lincoln & Guba, 1985; Patton, 2002). Qualitative researchers need alternative models that can ensure the rigor without sacrificing the relevance of the qualitative data. Lincoln and Guba (1985) proposes such model for assessing the trustworthiness of qualitative data based on identification of four main aspects.

Trustworthiness in qualitative study involves establishing: (a) Credibility/internal validity; (b) transferability/external validity; (c); dependability/reliability; and (d) conformability/objectivity. In ensuring the trustworthiness of the data especially during data collection and analysis, I always kept in mind some of the useful questions, as suggested by Miles and Huberman (1994). Among the relevant queries that need to be acknowledged are:

(1) Are the research question congruent with the method of the study?
(2) Are the general methods and procedures described explicitly and in detail?
(3) Is there a detail record of the study's method and procedures to be followed?
(4) Is the researcher's role and status explicitly described?
(5) Are the findings internally coherent and systematically related?
(6) Were the coding checks made, and did they show appropriate agreement?
(7) How thick and meaningful are the descriptions? Can the reader assess the potential transferability and appropriateness for their own settings?
(8) Did triangulation used in this study produce converging conclusion and if not, is there a coherent explanation for it?
(9) Are the presented data well linked to the underpinning theories? Are the findings congruent with or confirmatory of prior theory?
(10) Is there a coherent explanation for the conclusion?
(11) Do the actions taken actually help solve the local problem?

Among the approaches implemented in this study is triangulation. Triangulation is one of the strategies for improving and enhancing the internal validity of research in order to control bias. According to Bryman (2006), triangulation refers to the use of more than one approach to the investigation of a research question in order to enhance confidence in the ensuing findings. Triangulation is defined as a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study (Creswell & Miller, 2000). Triangulation should support the findings by showing corroboration or a confidence interval, as claimed by Greene, Caracelli and Graham (1989). Engaging multiple methods such as interview, observation and analysis of document will lead us to more reliable, accurate and trustworthy findings and may reduce uncertainty of interpretation.

Denzin (1978) has distinguished four categories of triangulation; data triangulation (e.g., a student and a teacher), investigator triangulation (e.g., the use of more than one researcher in fieldwork), theoretical triangulation (e.g., the use of more than one theoretical perspective in data interpretation) and methodological triangulation (e.g., document and interview). According to Creswell (2008), the use of multiple sources of information, individuals or processes will ensure the accuracy and credibility of the study.

With reference to Figure 3.8, this study adopts the triangulation of data and methodology. The input came from several sampling strategies so that data at different times and from a variety of sources were gathered. Students were interviewed and observed at a few phases during field work of this study. The data were collected through various techniques which were observation, interview, field notes, video and audio recording.

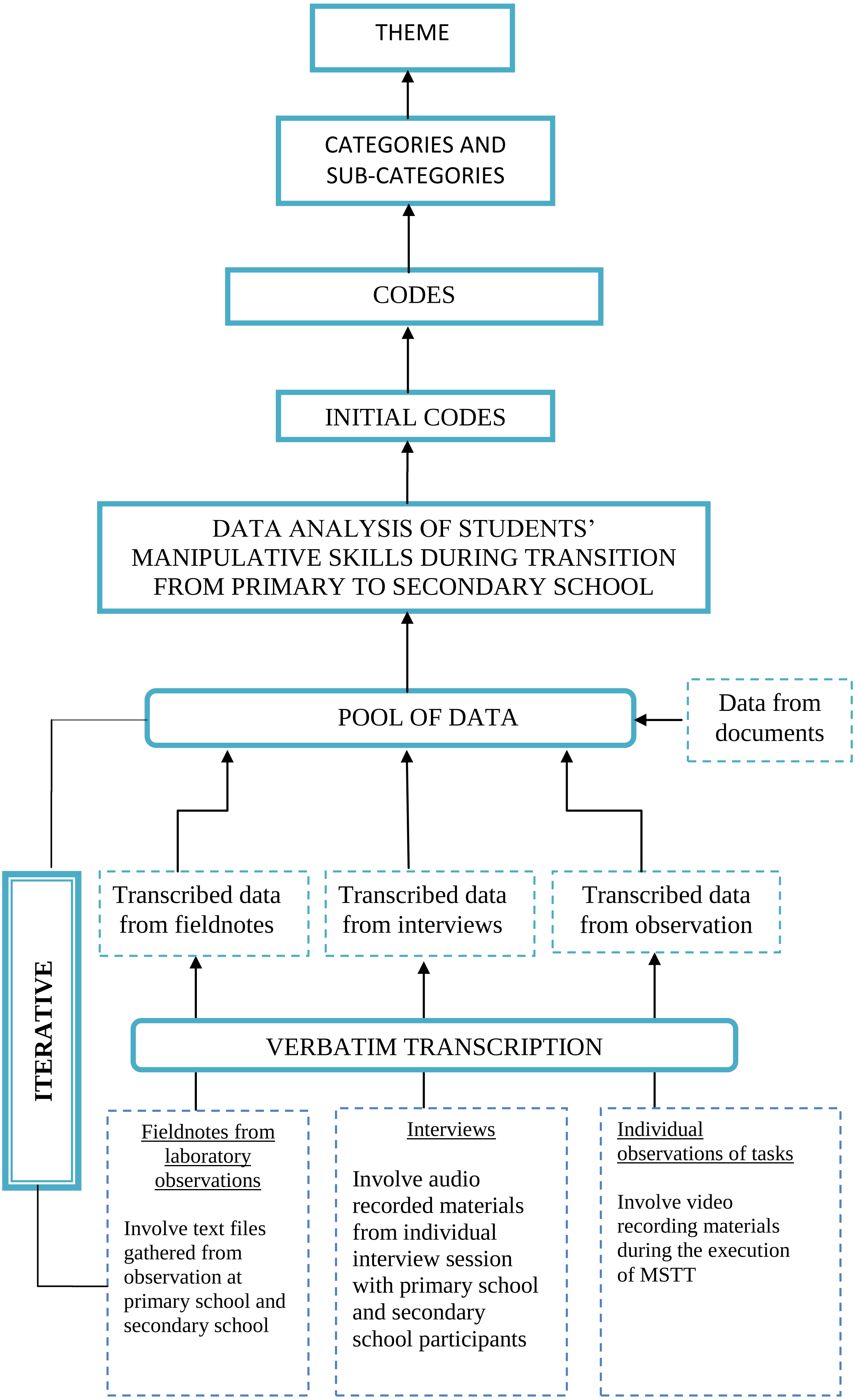


Figure 3.8 Framework for data analysis

Prolonged and persistent field work was carried out in this particular research in order to enhance the internal validity and reliability in qualitative research (Fraenkel & Wallen, 2008). Consistency over time with regard to what researchers are seeing or hearing is a strong indication of reliability or dependability. There is much about a group that does not even emerge until some time has passed and the members of the group become familiar with and are willing to trust me. This research took 11 months for data collection and within that time I had tried to establish a good connection with the sample in order to ensure the stability of observations over time.

The reliability of the tasks (MSTT) and interview protocols was determined by peer review and through multiple processes during preliminary research (as explained in research procedure). Themes and categories identified during data analysis were also evaluated through peer review. Peer review is regarded as one of techniques used to enhance the credibility and trustworthiness of qualitative research through the use of external peers.

A detailed audit trail was also constructed (Appendix L) which explained the procedures and methods conducted in this study as a way to enhance the reliability of research. Furthermore, the use of constant comparative approach for data analysis itself may contribute to the trustworthiness of a research (Boeije, 2002; Strauss & Corbin, 2008). Comparisons will increase the accuracy or internal validity of the findings. When the sampling has been conducted well in homogenous sample, there is a solid basis for generalizing the findings which connected with the external validity (Boeije, 2002; Miles & Huberman, 1994).

Communicative Validity

Communicative validity focuses on the ability to argue persuasively on the findings that have been proposed. It can be done by ensuring that the interpretations are regarded as suitable or appropriate by the research community especially from the relevant research area. This can be done by sharing the interpretations during research seminars, conference presentation and peer reviewed journals as proposed by Akerlind (2005). I have defended my interpretations through debriefing sessions with my research supervisor and PhD colleagues, proposal defense and candidature defense with Faculty Defense Committee and at research conferences and seminars in order to fulfill the communicative validity of my research.

Communicative validity is also significant in minimizing the issue of biasness in establishing the categories of the findings. This approach is important to minimize the distortion of evidence during the analysis of data (Bowden, 2005). Among the critical issues raised during the conferences was the suitability of 'measuring' to be categorized as one of the sub-elements in manipulative skills and the suitability of the elements in the 'five levels hierarchy of learning technical skills'. The issues have been justified accordingly in the writing of my thesis. The details of the conferences I have attended related to my research were listed at the 'list of publications and papers presented' at the end of this thesis.

CHAPTER SUMMARY

I conclude this chapter by revisiting the justification of choosing the qualitative paradigm as the backbone of this research. In order to get better understanding of this phenomenon, I have selected the basic qualitative research design. The methodology of this research is guided and supported from the analysis of the previous researches in the field of school transition and in manipulative skills. A preliminary study has been administered before conducting the actual study to get an insight of the phenomenon and to familiarize with the research technique in collecting data.

Manipulative skills are capabilities that underlie performances in science which outcomes are reflected in the rapidity, accuracy, force or smoothness of bodily movement (Gagne & Briggs 1992). The application of Manipulative Skills in Transition Tasks (MSTT) in this research is to recognize the students' skills and capability in handling four scientific apparatus: thermometer, Bunsen burner, measuring cylinders and microscope. Data were collected through documents analysis, interviews and observations with the utilization of MSTT. Collected data were analyzed comparatively using constant comparative data analysis technique in order to obtain understanding of this central phenomenon.

Further method of analyzing involves the process of coding, categorizing and development of themes from information that emerges from the collected data, which can best describe the ways students experienced transition in science learning. I had to find general patterns out of the analyzed data, in order to make robust conclusion of the findings. Refining the thematic framework involves logical and intuitive thinking in ensuring that the research objectives are being addressed appropriately (Ritchie & Spencer, 1994).

Trustworthiness of this research was established through the application of triangulation of data and methodology, member check and prolonged and persistent field work. The use of constant comparative approach itself may contribute to the trustworthiness of research.

CHAPTER 4
FINDINGS

INTRODUCTION

This chapter reports on the main findings of the research and cites evidence from collected data to show the students' understanding of manipulative skills during this research. Generally data were analyzed using the constant-comparative data analysis method. Qualitative data are 'sexy' in the sense of the richness of the gathered description in particular phenomenon (Miles & Huberman, 1994). Methodically, the analysis began with a microanalysis of the students' manipulative skills and their experiences during transition, as suggested by Strauss and Corbin (2008). Microanalysis is a detailed type of open coding most likely to be used at the beginning of analysis to generate ideas and explore all the possibilities one can acquire from the data.

Late stage of analysis tends to be more general. The data were analyzed from a broader perspective. At the macro level, interpretations were developed fully and validated. Findings are substantiated by excerpts which are transcribed verbatim from the audio and video recordings.

The amount of data collected throughout the study was enormous. Analyzing the data was a tedious process and to present the findings in the most thought-provoking way was another challenge for me. Several different ways to present the findings were used since the data collection involved early, mid and late transition at primary and secondary schools.

Initially, it was intended that student understanding of manipulative skills were explored by the presenting of the overall findings in primary schools, followed by the overall findings in secondary schools. However, upon discussion with supervisor and peers, a decision was made to change the technique of presenting the data.

The data were presented in a form of dimensions, where each dimension describes the different ways of practicing manipulative skills as experienced by a group of students during transition from primary to secondary school. This improvement was done to make it easier for the reader to understand and comprehend this phenomenon in a more appropriate context.

The rationale of answering research questions 1(a), 1(b) and 1(c) simultaneously is for the reader to be able to experience transition as a continuous process (early, mid and late transitional stage), throughout discussion of the emerging dimensions and elements. This was done to make it easier for the reader to understand and comprehend this phenomenon in a more appropriate context, which is, as a whole.

This chapter is divided into four main sections. The first section is an overview of the dimensions. The second section presented an in-depth description of each dimension, its elements and sub-elements, at primary school and secondary school during early, mid and late transition, in order to answer the first and second research question. For instance, the first element 'Operation of tasks during practical work' will be discussed thoroughly from the contexts of early, mid and late transition at primary school and secondary school. As discussed in Chapter 1, primary school in this study refers to the phase of early transition, which occurs four month before the students end their Year Six at primary school. Secondary school on the other hand, refers to the phase of mid and late transition, which occurs in the first six months of Form One. In the second section, the differences of each element in primary and secondary school will be discussed to answer research question 2(a). The third section discusses the application of the emerging findings which are the preparation of manipulative skills "Meniti Peralihan" resource guide.

The overall findings were summed up in the chapter summary in the final section of this chapter. The findings are supported by excerpts from various sources of data such as the observation and interview transcripts of the students. In the excerpts from the transcripts, abbreviation will be used to denote the sources of the data. The transcripts follow the conventions below:

S	Represents ‘student’. For example ‘S1’ referred to ‘Student One’
a	Early transition at primary school. For example ‘S13a’ referred to excerpt from Student 13 at primary school
b	Late transition at secondary school. For example ‘S13b’ referred to excerpt from Student 13 at secondary school
Int.	Interview
Obs.	Observation
ST	Science teacher
LObs.	Laboratory observation
SD	Student’s drawing

OVERVIEW OF THE FINDINGS

The findings emerged from the study represented the students’ manipulative skills during the period of transition. The findings reflected the students’ understanding of the phenomenon whereby each characteristic signified the central meaning of conceptions. The findings focused on the content-oriented categories (Marton, 1982) which focus on the meaning of the phenomenon being studied, based on the experience of the students. Different ways of performing manipulative skills amongst the students have been explored during the stage of data analysis. Students’ collective experiences in manipulative skills have been distributed across all the dimensions in order to develop a structured element that underlies a reflection of reality. For each of the element, excerpts taken from the interview and observation transcript were used as evidence to support the findings. Figure 4.1 represents the overview of the findings.

Two (2) main dimensions emerged from the analysis of the finding: (a) technical skills and (b) functional aspects of performing laboratory task. Technical skills comprised two main categories of apparatus used in the tasks, which are graduated apparatus and sequential apparatus. Functional aspects include four elements of manipulative skills, (a) operation of tasks during practical work, (b) management of time and workplace, (c) safety and precautionary measures, and (d) numeracy and technique in scientific drawing. The characteristics of the manipulative skills can be represented in Figure 4.2.

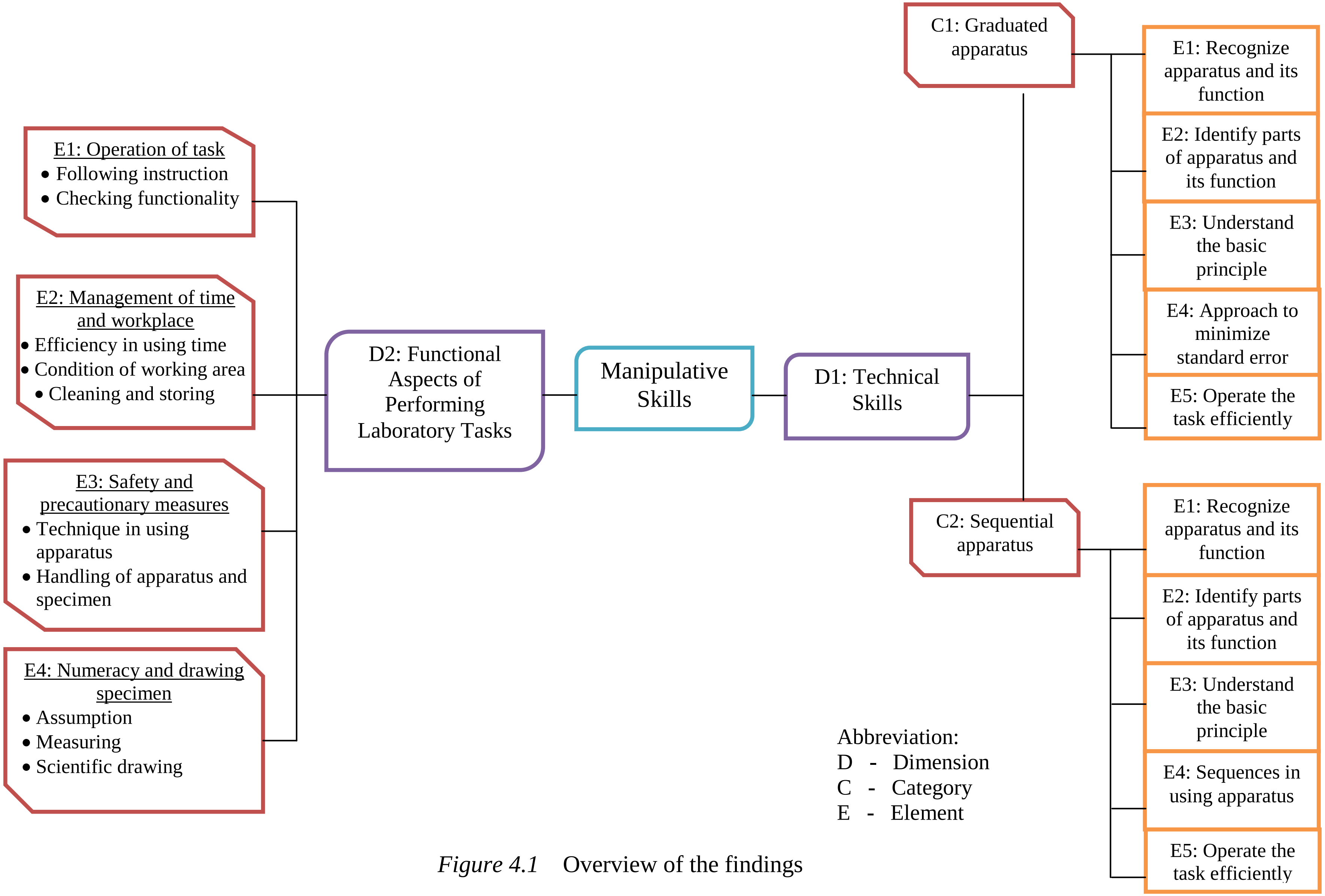


Figure 4.1 Overview of the findings

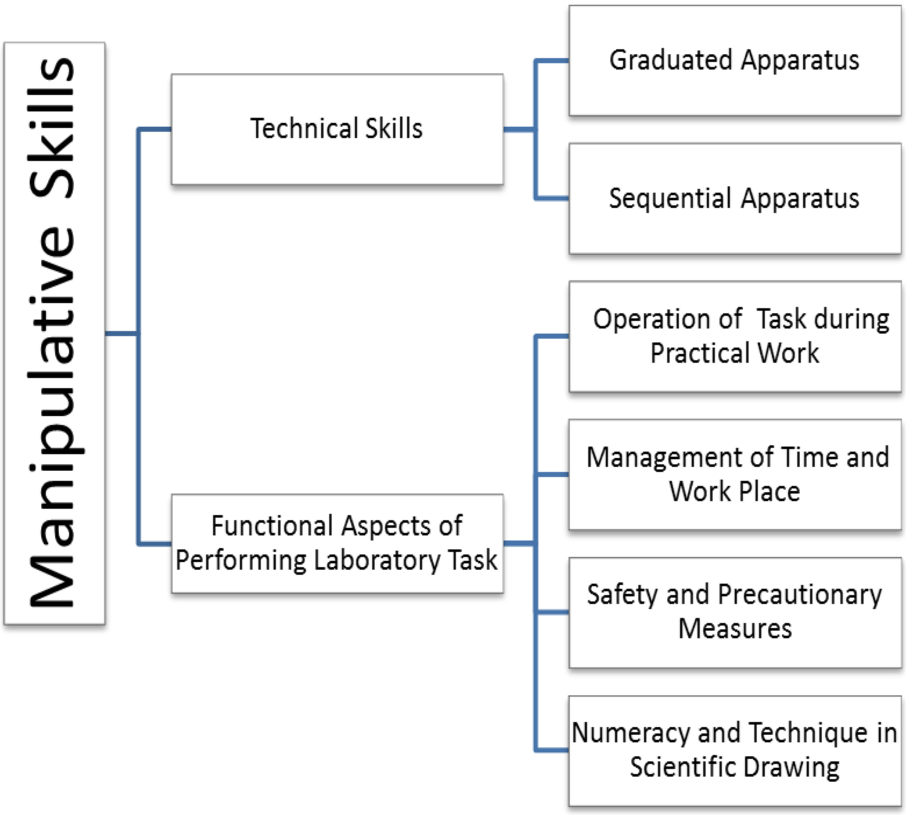


Figure 4.2 Dimensions and elements of manipulative skills

UNDERSTANDING STUDENTS' MANIPULATIVE SKILLS DURING TRANSITION FROM PRIMARY TO SECONDARY SCHOOL

The second section of this chapter will discuss an in-depth description of findings at primary and secondary schools, in order to answer the first research question of this study. The differences of each element in primary and secondary school will also be discussed. Overall findings from the study revealed that the students have limited basic understanding of manipulative skills during primary school. When they entered secondary school, some of the students showed some improvement in the skills, some exhibited no changes or in some cases, a decline in the skills.

Data from this study came primarily from tasks observation and interviews. This section will present in detail, the two (2) dimensions that emerged from the analysis of data; technical skills in handling apparatus and functional aspects of performing laboratory tasks. Table 4.1 summarizes the definition of technical skills and the functional aspects of performing laboratory tasks.

Table 4.1

Definition of Technical Skills and Functional Aspects of Performing Laboratory Task

Dimension	Definition
Technical Skills	Skill, abilities and knowledge required for the accomplishment of a specific task. The skills include knowledge and skills needed to properly manipulate and operate scientific apparatus during the execution of scientific task.
Functional Aspects of Performing Laboratory Task	Specific procedures (apart from the technical skills) which are related to the operation of manipulative skills.

Technical skills in handling apparatus

This dimension has been divided into two main categories based on four apparatus used in the study; the measuring cylinder, the thermometer, the Bunsen burner and the microscope. The explanations for both categories are given in Table 4.2.

Table 4.2

Categories in technical skills

Category	Explanation
Graduated Apparatus	Specifically for apparatus with lines or markings to indicate the measurement The Measuring cylinder The Thermometer.
Sequential Apparatus	Involves apparatus that need the user to understand and acquire the knowledge about sequence of using it, in order to use it appropriately The Microscope The Bunsen Burner

Graduated Apparatus

The measuring cylinder and the thermometer are graduated apparatus which involve an ordered or graduated scale. Graduated is a mark on an instrument that indicates degrees or quantity. Based on analysis, the students underwent a series of steps in handling the graduated apparatus and they are as follows (Figure 4.3),

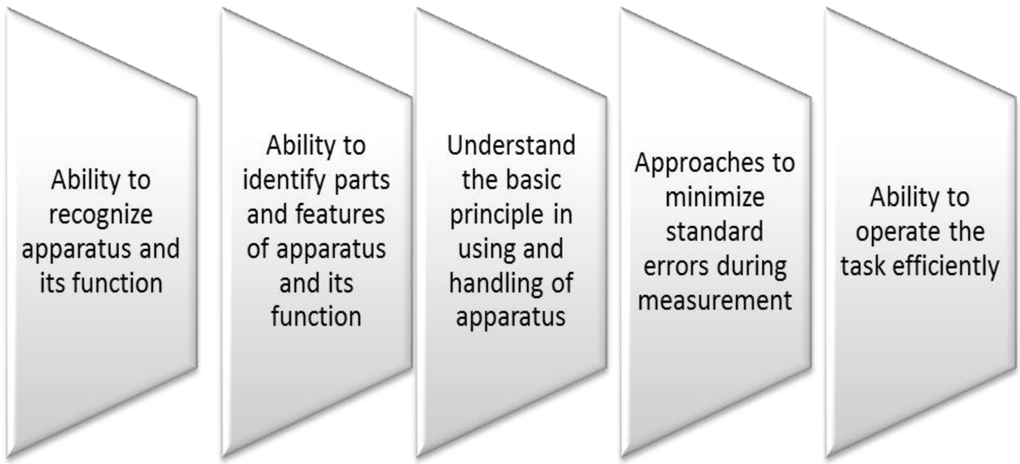


Figure 4.3 Elements of using graduated apparatus

Ability to recognize apparatus and its function

The ability to recognize scientific apparatus is the most basic skill in manipulation of graduated apparatus. During the interview at early transition, the students have shown good ability in recognizing the apparatus. From the introduction session conducted during the individual task, almost all of them could give the correct name of the graduated apparatus. The following excerpts were extracted from the interview session at early transition,

Researcher : Can you please tell me the name of this apparatus (showing a measuring cylinder to the student)?
Student 4 : Erm…Measuring cylinder.
Researcher : Do you know what is the function of this apparatus?
Student 4 : To measure the volume of water.

(Int. 1, S4a, Ln. 65-68)

Researcher : Can you please name this apparatus (showing a thermometer to the student)?
Student 5 : It is a thermometer.
Researcher : Do you know what the function of this apparatus is?
Student 5 : Yes, we use thermometer to…measure the temperature.

(Int. 2, S5a, Ln. 81-82)

The quotes indicated that the students did not have any difficulties recognizing the apparatus and its function. The excerpts from the following observation transcript at early and late transition, on the contrary, exhibit a different facet of this element,

> He poured the water from beaker into the measuring cylinder. However he did not stop when the water reached 100 ml marker. He continued emptying the beaker.
> He poured the water from the measuring cylinder back into the empty beaker. He used the beaker as a measurement tool.
>
> (Obs.1, Ep.1, S10a)

> She examined the volume of water in the beaker, walked to the sink and poured some of the water into the sink. She lifted the beaker to her eye level to make sure the volume was 100ml.
>
> (Obs.3, Ep.1, S13b)

During the interview at early and late transition, all students were able to recognize the apparatus and know their functions. However observation shows that some of the students were not using the correct apparatus according to its specific function. This was certainly conflicting from their theoretical knowledge shown during the interview session. Students should be able to differentiate the function of a beaker with a measuring cylinder. The measuring cylinder is use to make accurate measurements of liquid volumes. On the other hand, the volume graduations on beakers should only be used for ball park estimations.

Ability to identify parts and features of apparatus and its function

The measuring cylinder is a simple apparatus which consists of 2 main parts: (1) the main cylinder part of the long tube (usually made from glass and Pyrex) and (2) the base of the cylinder, which helps to hold the cylinder in place while placed on a flat surface. The measuring cylinder also consists of markings on it to allow for measurements of liquids. Usually these markers are displayed as printed-on lines on the main cylinder. Measuring cylinders have a small spout like lip on the top opening of the cylinder which helps in pouring liquid out of the cylinder without spilling.

The findings show that none of the students at early, mid and late transition were aware of the different parts and features of the measuring cylinder. The observation at mid transition indicated that teachers just emphasized on the skill of reading the meniscus at eye level.

Another apparatus that was used in this study was the thermometer. The thermometer is a graduated apparatus which consists of:

(i) Stem - sealed glass capillary tube containing mercury

(ii) Bulb - the part that touches the material being measured which is located at one of the end of the stem.

(iii) Mercury - The important feature of the thermometer is a column of mercury, that moves up or down in response to the temperature of the material.

(iv) Markings on the stem to allow for measurements of temperature - The mercury thermometer is usually marked in degrees of Celsius.

At early transition, findings revealed that the students were unable to identify parts and features of the thermometer and its function at early, mid and late transition, as illustrated in the following interview excerpts,

> Researcher: Can you name me this part of thermometer (showing the thermometer bulb to the student)?
> Student 8: I do not know. But it contains mercury.
> (Int. 1, S8a, Ln.80-81)

> Researcher: Ok, can you please tell me the name of this part of thermometer (showing the thermometer bulb)?
> Student 5: Erm…Nose of the thermometer? (giggle)
> (Int. 1, S5a, Ln. 65-66)

The same situation also occurred during late transition at secondary school. From laboratory observation at mid-transition and interviews at early and late transition, students' can only acknowledge that the thermometer contains mercury.

Understanding the basic principle in using and handling of apparatus

Based on the analysis of science textbooks (Year Four, Year Five, Year Six and Form One) at pre-research phase, the learning of correct techniques in using graduated apparatus is introduced since Year Four at primary school. For instance the use of the measuring cylinder to measure the volume of liquid and the use of thermometer to measure the temperature of a substance. Once introduced, the apparatus are the common ones in most experiments in primary and secondary science.

Despite this fact, during the study, students exhibited inappropriate techniques in using and handling of apparatus, especially in handling the thermometer, as shown in the following observation excerpt and Figure 4.4 at early transition;

> She cautiously took out the thermometer from the plastic casing. She held the thermometer upright, at the tip of its upper stem and started to check the thermometer condition. She immersed it in the beaker to take the initial temperature of the water until the bulb touched the bottom of the beaker. (Obs.1, Eps.2, S9a)

Figure 4.4 Holding the thermometer at the tip of the stem

Similar to Student 9, most of students at early, mid and late transition showed the same common mistake of holding the thermometer at the tip of the upper stem, or even by holding it with both hands, as portrayed in the following excerpt and Figure 4.5 at late transition. Handling the thermometer this way lacks stability, since it just might slip from the student's hand.

> He took the thermometer and immersed it into the boiling water. He held the thermometer with both hands, right in the middle of the stem.
> (Obs.3, Eps.2, S1b)

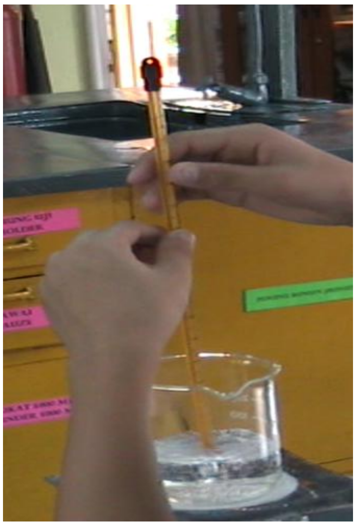


Figure 4.5 Holding the thermometer with both hands

Some of the primary school students at early transition immersed the wrong end of thermometer when taking the temperature (refer to Figure 4.6). However no such mistake was observed among the secondary school students at mid and late transition.

> "It was upside-down", he talked to himself and laughed. He immersed the wrong end of the thermometer. "No wonder there was no change in the temperature," he told the researcher.
>
> (Obs.1, Eps.2, S12a)

Figure 4.6 Holding the thermometer upside-down

Another common mistake exhibited by most of the students at early transition was that they tend to let the thermometer bulb touch the base of the beaker while taking the temperature of the solution, as illustrated in the following excerpt and Figure 4.7;

> She held the thermometer carefully and immersed it into the heated water, letting the bulb touch the base of the beaker.
>
> (Obs.1, Eps.2, S9a)

Figure 4.7 Letting the thermometer bulb touch the floor of the beaker

During late transition at secondary school, the students have shown progression in this particular element. This can be noticed from observation fieldnotes and interview with Student 9,

> She immersed the thermometer again and read it parallel to her eye level without letting the bulb touch the beaker floor.
>
> (Obs.3, Eps.4, S9b)

Researcher	:	I have noticed some changes in your technique when taking the temperature. Are you aware of the changes?
Student 9	:	I think I always tend to let the thermometer touch the bottom of the beaker. Now I know that I should not do that.

(Int.3, S9b, Ln. 50-52)

Observation of tasks during early transition also indicated that students have a strong tendency to stir the solutions using thermometer even though they have been given a glass rod;

> She stirred the water from time to time by using the thermometer (even though the glass rod was provided).
>
> (Obs.1, Eps.2, S9a)

Various incorrect techniques of handling the thermometer were observed during tasks observation at early and late transition. However, despite all the inappropriate techniques displayed, most of the students were able to explain the proper handling of the thermometer during the interview session;

> Researcher: What are the basic rules of using the thermometer?
>
> Student 9 : First we have to place the ‘curve end’ of the thermometer to the place you want to measure its temperature. After a while we examine the temperature strip and make sure your eyes are parallel to it.
>
> (Int. 1, S9a, Ln.95-99)

In using measuring cylinder, most of the students were able to use the apparatus correctly, as illustrated in the following excerpt at early transition:

> She brought the measuring cylinder close to her sight, trying to find the 100ml mark at the cylinder and put her thumb as an indicator to the volume needed. She placed the measuring cylinder on the table. Cautiously, she poured water from the beaker, gradually, while simultaneously checking the volume on the measuring cylinder.
>
> (Obs.1, Eps.1, S13a)

However, at early transition, some of the students still found it difficult to handle the measuring cylinder using the appropriate technique. Most of the students were unaware of this basic principle of using the measuring cylinder, for example, they should place the measuring cylinder on a flat surface in order to get an accurate measurement of the volume of liquid. It was observed that they tended to raise the measuring cylinder and brought it closer to their sight, as illustrated in the following excerpt and Figure 4.8;

> He went to the sink, turned on the faucet and filled the measuring cylinder with the tap water. He lifted the measuring cylinder and brought it to his eye level. He poured some of the water back into the sink and walked back to his work station.
>
> (Obs.1, Eps.1, S6a)

Figure 4.8 Taking the volume while holding up the measuring cylinder

At late transition, the students' skills in this aspect did not develop much. They repeated the same error in using the graduated apparatus. Observation during transition period at primary and secondary schools also indicated that one of the distinct problems which occurred during the using of measuring cylinder was the inappropriate technique in reading the volume of water, which will be discussed later in the element known as 'numeracy'.

Approaches to minimize standard errors during measurement

From the observations at early, mid and late transition, most of the students were aware of the appropriate technique they have to follow in using graduation apparatus. The awareness was also manifested during the interviews. They ensured that their eyes were parallel to the meniscus of the measuring cylinder and the thermometer while taking the measurement, as manifested in the following quotes of Student 13 at early transition;

She lifted the measuring cylinder to her eye-level, trying to hold it as straight as possible to ensure it was parallel with her eyes. She poured some more water into the measuring cylinder and checked the marker again.

(Obs.1, Ep. 1, S13a)

The previous excerpt indicated that Student 13 was aware of the needs to ensure her eyes were parallel to the meniscus. However, the approach that she has displayed in order to accomplish the criteria was considered as inappropriate. She lifted the measuring cylinder and overlooked the basic principle of using the measuring cylinder which is to place the cylinder on a flat surface. This episode can still be observed during observation at mid and late transition.

In other cases, students' displayed inappropriate techniques in avoiding parallax error, for instance, by tilting their heads while taking the measurement, instead of lowering their heads to get the accurate reading. This technique can still be observed at secondary school. The following excerpt and figure demonstrated one of the student's approaches in avoiding parallax error at late transition;

He carefully poured the water into the 100ml measuring cylinder. He tilted his head to observe the marker. He stopped when the upper meniscus reached the 100ml line.

(Obs.3, Ep. 1, S7b)

Figure 4.9 Tilting heads during measurement

Some of the students at early transition chose a different option to simplify the task. For instance Student 9, she *"checked on the volume of water by placing the measuring cylinder on the tripod stand"* (Obs.1, Eps.2, S9a). By doing this the meniscus was parallel to her eye level so she did not have to lower her eye-sight.

In some cases, the students were not even concerned about avoiding parallax error while measuring the volume of water, for example Student 8 at early transition "*poured all the water from the beaker into the measuring cylinder until it reached 100ml. He did not make his eyes parallel to the meniscus*", (Obs1, Eps1, S8a). However from the interview, he mentioned the need to ensure that the meniscus to be parallel with eye-level (Int.1, S8a, Ln. 93-94).

What is noticeable during observation at early, mid and late transition was that almost all of the students ensured that they have their eyes in the correct position when reading the marker of the thermometer in order to prevent parallax error. However most of the approaches displayed by them were inappropriate.

In using the thermometer, observation indicated that the students have the tendency to take out the thermometer from the beaker in order to take the reading of the temperature, as illustrated in the following observation transcript;

> Student 1 took out the thermometer from the beaker and brought it closer to his sight. His eyes narrowed. He put the thermometer back into the water.
>
> (Obs 1, Eps4, S1a)

The quote again indicates that the student encountered difficulties in measuring the temperature at early transition. From the interview, he admitted that he struggled to take the reading of temperature because he could not identify the thin mercury thread in the capillary. The same problem was observed at late transition where some of the students were still struggling to acquire the appropriate technique.

The findings of this study indicated that the students did not realize that they were practicing inappropriate techniques while taking measurements of the temperature. The observation contradicted with the information gathered from the interviews. Individual interviews conducted with the students at early and late transition have shown that their theoretical knowledge in using the thermometer were acceptable and the notion is evident in the following interview quote at early transition;

> Researcher: How do you use thermometer to take the temperature of any solution?
>
> Student 7 : Your eyes have to be parallel to the mercury line… Examine the temperature carefully to get the correct reading…and the thermometer should not be handled roughly. Humm…the part with mercury (showing the bulb to the researcher) has to be immersed into the solution.
>
> (Int. 1, S7a, Ln. 65-70)

This study has revealed that 'hands-on' activity in practical work is a vital component of science learning. In this particular case, students were able to explain how to handle apparatus theoretically during the interview session. However from the observation of tasks, the students have shown numerous techniques which were considered as inappropriate. Thus findings clearly supported the statement that direct observation is the most appropriate approach to understand the students' ability in manipulative skills, as explained by Johnstone and Al-Shuaili (2001), Kempa (1986) and Lunette et al. (1981).

Ability to operate the task efficiently

The element refers to the method in operating the graduated apparatus during the execution of tasks. It can be recognized by the students' ability to use the thermometer and measuring cylinder efficiently and confidently in the science laboratory. Some of the students have shown an awkward and choppy movement when handling the thermometer to measure the temperature of boiling water. In another instance, some of them were able to operate the thermometer in a smooth and appropriate manner. This approach in operating the apparatus has been used as one of the indicators to understand the students' competency in technical skills.

From the students' mode of action, the level of guidance in performing technical skills can be determined. This element deals with the supervision necessity in order to enhance the students' technical skills in using and handling graduated apparatus. It emphasizes the teacher's role as a facilitator and instructor in the laboratory. Laboratory observation at mid-transition indicated that the teacher is responsible in transferring the technical skills to the students and to further enhance the appropriate technique during transition to secondary school.

The following excerpts illustrated examples of student performance in using graduated apparatus at early transition which require much supervision from the teacher,

> Student 4 grabbed the measuring cylinder and went straight to the sink (without checking thoroughly what has been provided to her). She filled the measuring cylinder with tap water (she did not notice a beaker of unmeasured water at her work station). She turned the tap water off when she assumed the water has reached 100ml meniscus (she did not place the measuring cylinder on a flat surface and did not comply with the correct procedure in reading meniscus).
>
> (Obs.1, Ep.1, S4a)

> "How should I read this?" he mumbled to himself while holding the thermometer. He took out the thermometer from the beaker and tried to read the meniscus.
>
> (Obs.1, Ep.3, S1a)

Observation at mid-transition indicated that the Students 1 and 4 play a passive role during group experiment and act as mere passengers in the group, allowing other members to actively conduct the experiment.

Sequential Apparatus

In this study, the Bunsen burner and the microscope have been categorized under the same category of "sequential apparatus." These apparatus require the user to understand their appropriate manipulation sequence. It is technically more complex and requires constant repetition and practice for competent handling. Figure 4.10 lists the five (5) elements emerged from analysis of data regarding the use of the sequential apparatus.

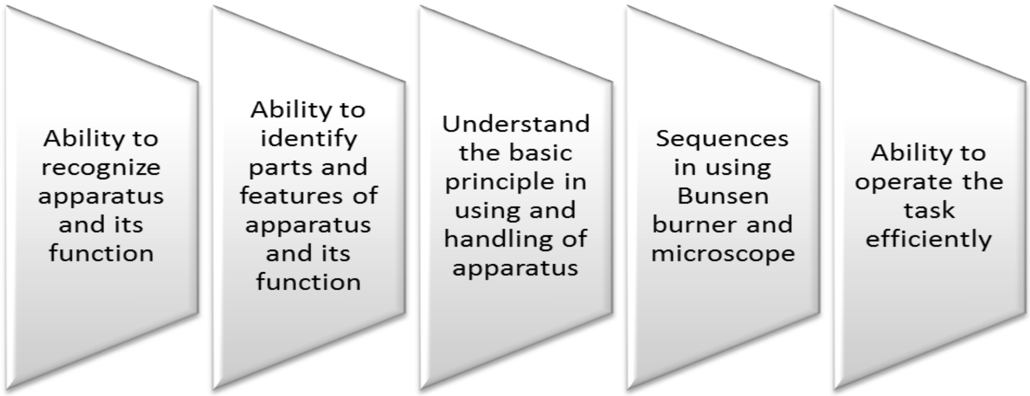


Figure 4.10 Elements of using sequential apparatus

Ability to recognize apparatus and its function

Recognizing apparatus and their functions is the essential aspect of learning manipulative skills. The study showed that most of the students can easily recognize any given apparatus and its function, as proven by the following transcripts from interview at early and late transition,

Researcher:	Can you name me the function of this apparatus? (showing Bunsen burner to Student 8)
Student 8 :	We use this apparatus for heating.
	(S8b, Ln. 32-34)

Researcher :	Do you know what this apparatus is? (showing microscope to Student 6)
Student 6 :	A microscope
Researcher :	Do you have any opportunities to use this apparatus in primary school?

Student 6 : My teacher has shown a microscope and the method to use it. I have also learnt about it from textbook. I recognize its function, which is to observe microorganisms.

(Int. 1, S6a, Ln. 89-90)

However a number of students were unable to give the exact function of the Bunsen burner, as shown in the following transcripts of Student 7 at early and late transition;

Researcher: Can you name me the scientific apparatus that you used at primary school?
Student 7 : Beaker, measuring cylinder, Bunsen burner, litmus paper…and thermometer.
Researcher: So can you tell me what the function of this apparatus is? (The Bunsen burner)
Student 7 : It has gas…If we light the burner, the flame will last longer.
Researcher: What do you mean by 'it will last longer'?
Student 7 : The flame will stay until we turn the burner off.

(S7a, Ln 81-87)

Researcher: Can you tell me the function of Bunsen burner?
Student 7: To 'burn' thing. (S7b, Ln 29-30)

The above mentioned quotes from Student 7 indicated that the student's skills did not progress and he had a hard time explaining the function of the Bunsen burner, at both primary and secondary school.

Ability to identify parts and features of apparatus and its function

Unlike the graduated apparatus which are technically simpler, the sequential apparatus come with complicated parts that need to be distinguished in order for the user to master the technical skills necessary to use them. The ability to identify the different parts of apparatus will help the students in using the apparatus sequentially. If a student encounters difficulties in identifying parts of the apparatus, it may impede their abilities in understanding the appropriate technical skills in the laboratory. For example, during the laboratory observation conducted at mid-transition, the teacher asked the students to manipulate the coarse adjustment knob in order to examine the onion cell closer. A number of students were not be able to recognize that particular part of microscope and used the fine adjustment knob instead (S7b, LObs.1, Ln. 25-26). From the observation I realized that it is important for the students to be able to distinguish the different parts of apparatus before they were able to operate the apparatus efficiently.

The portable Bunsen burner is commonly used in our school science laboratories instead of burners with gas outlet facilities. The portable Bunsen burner is the most convenient type of Bunsen burner which offers an excellent and quick heating capacity and requires no unnecessary gas piping. The portable Bunsen burner consists of a number of parts: (1) the gas tank and the barrel, (2) the collar which is located around the air hole on the bottom of the barrel, (3) the gas knob to control the amount of gas, and (4) the air hole to increase or decrease the amount of air going into the barrel.

Another sequencing apparatus that was used in the study is the microscope. The microscope consists of 12 main parts that need to be identified: (1) the eyepiece (2) the nosepiece (3) the objective lenses (4) the arm (5) the coarse adjustment knob, (6) the fine adjustment knob (7) the stage, (8) the stage clips (9) the condenser (10) the diaphragm (11) the light or mirror and (12) the base of the microscope.

Findings from the study revealed that students at primary and secondary schools have difficulties in identifying the parts of the Bunsen burner and the microscope. In using the Bunsen burner, only two secondary school students were able to explain the correct functions of air holes during the interview. However, despite the ability to explain the theoretical concepts, none of the students could show the correct techniques of manipulating the air hole during the execution of task from MSTT. The following excerpt from an interview at late transition demonstrated the student’s abilities in identifying parts of the Bunsen burner. The excerpt also highlights the student's capabilities in applying theoretical knowledge learned, coupled with procedural knowledge constructed through practical work:

Researcher:	Can you name this part of the Bunsen burner? (showing the gas hole to Student 9)
Student 9 :	I am not sure teacher.
Researcher:	Do you know what the function is?
Student 9 :	Hurm…Maybe to control the amount of gas…so that combustion can take place.
Researcher:	What do you think will happen if I close the gas hole after lighting the burner?
Student 9 :	If it is closed, the surrounding air cannot enter the Bunsen burner…So incomplete combustion will occur.
Researcher:	What happens if I let the gas hole open?
Student 9 :	A blue flame will appear. It is hotter than the yellow flame.
Researcher:	I did not see you trying to control the air flow by opening and closing the air hole during execution of the first task. Can you explain why? From this discussion I can see that you recognize the function of this particular part.
Student 9 :	I am not sure about it, teacher.

(S9b, Ln. 25-36)

For other students, identifying parts of the Bunsen burner was a challenging task for them to grasp. The following excerpts from interview session at early and late transition illustrated their difficulties,

Researcher:	Can you show me where the air hole is?
Student 12:	I am not sure.

(S12a, Ln. 94-95)

Researcher:	Can you name this part? (pointing at the gas valve)
Student 9:	I do not know. Usually the teacher helps us when we need to use the Bunsen burner.

(S9a, Ln. 106-108)

Researcher:	Can you name me this part? (showing the air hole)

Student 7 : No…(giggles)
Researcher: Do you know what the function of this part is?
Student 7 : I am not sure teacher.

(S7b, Ln. 32-36)

In using the microscope, students at primary and secondary schools were incapable of identifying parts of the apparatus and their functions. From the interview conducted at early and late transition, most of the students admitted that they were unaware of the need to identify the different parts of the microscope, as illustrated in the following audio transcripts,

Researcher: What about the microscope? Can you name me any part of the microscope?
Student 7: I forget. Ermm…my teacher gave a copy of the microscope picture with all the labels but I did not read it.

(S7b, Ln.38-40)

Researcher: Can you name this part of the microscope (pointing to the coarse adjustment knob)?
Student 6: Sorry but I am not sure of it, teacher.
Researcher: Alright. Can you name me any part of the microscope?
Student 6: This is the lens (pointing to the objectives lens)
Researcher: What type of lens? Can you be more specific?
Student 6: Erm…(laughing). I am not sure, but I know how to use it.
Researcher: You told me that you can operate this apparatus. So why can't you identify the part?
Student 6: I rarely use it and I don't think it is important for me to memorize each part of microscope

(S6b, Ln.38-40)

Laboratory observation at mid-transition also indicated that teachers did not put much stress on the importance of learning each part of apparatus and its specific functions. For instance in using the microscope, most of the teachers only focused on the use of the coarse adjustment knob and technique in manipulating the objective lenses.

Understanding the basic principle in using and handling of apparatus

Not all students have the opportunity to use the Bunsen burner at primary school, as admitted by one of the student at early transition, "*We never get any opportunity to use the Bunsen burner. We learn about the Bunsen burner through demonstration by the teacher*," (S13a, Ln. 63-64). From the interview, students and teachers stated that the Bunsen burner was labeled as a dangerous apparatus in the laboratory. As a consequence, these students felt intimidated and clearly did not acquire sufficient skills in using the Bunsen burner during transition.

In some cases, secondary school students admitted that they do not encounter any difficulties in handling sequential apparatus because of their prior experience at primary school;

> Researcher: So what do you think about your skills in using an apparatus such as the Bunsen burner and microscope?
>
> Student 8: Most of them are easy to use because I have used them back in primary school.
>
> (S8b, Ln. 27-29)

The basic principle in using Bunsen burner includes the ability to handle the apparatus appropriately. For example, during early transition, the students seem hesitant to touch the Bunsen burner as the Bunsen burner was already lighted, without realizing that the burner's tank was not even hot as manifested in the following quotes;

> He tried to take out the Bunsen burner from under the tripod stand. He pulled out the burner by dragging the tag that hangs by the gas knob.
>
> (Obs.1, Ep.4, S5a)

> She held the gas knob and slowly dragged the Bunsen burner, from under the tripod stand.
>
> (Obs.1, Ep.4, S9a)

At early transition I have encountered a few episodes which indicated that the students have difficulty estimating the amount of gas needed to light the Bunsen burner as shown in the following quote;

> Student 4 lighted the candle without hesitation. She turned the knob and brought the candle closer to the Bunsen burner. There was no flame (Note: the burner knob was not turned sufficiently. There is not enough gas to light the burner).
>
> (Obs.1, Ep.2, S4a)

In some episodes, students at late transition could not recall the basic technique to light up the Bunsen burner during their transition to secondary school as illustrated in the following excerpts;

> He took the Bunsen burner and placed it under the tripod stand. He turned the gas knob without lighting the Bunsen burner. He told the researcher he forgot how to light the burner.
>
> (Obs.3, Ep.2, S5b)

> He picked up the lighter and brought it closer to the barrel without turning the gas knob (Obs.3, Ep.2, S12b)

Some students demonstrated inappropriate skills in lighting the Bunsen burner, for example Student 13 lighted the burner from under the tripod stand. This technique can be observed at early and late transition. Student 12 and a few of his friends have the routine of turning off the Bunsen burner each time they took the reading of temperature. The following excerpts were taken from observation of MSTT during early and late transition;

> She slid the Bunsen burner under the tripod stand and turned the gas knob. She took the lighter and brought it closer to the barrel to light the burner (from beneath the tripod stand).
>
> (Obs1, Eps2, S13b)

> He repeated the same act. He turned the gas off each time he measured the water temperature.
>
> (Obs.1, Ep.5, S12a)

In using the microscope, students encountered difficulties in performing basic technical skills of using the apparatus during transition. For instance, some students did not realize the function of the coarse adjustment knob which is a round knob on the side of the microscope used for focusing the specimen. This difficulty can be illustrated in the following excerpts taken from observation at early and late transition;

> She adjusted the fine adjustment knob (not the coarse adjustment knob) and looked through the eyepiece.
> (Obs.2, Ep.2, S13a)

> He looked through the eyepiece and started drawing something at his worksheet (without even adjusting the coarse adjustment knob).
> (Obs.2, Ep.3, S7a)

> She did not even use the coarse adjustment knob during this experiment until her friend asked her to do it. She did as what her friend suggested. (Obs.4, Ep.2, S4b)

The problem in the above mentioned quotes was also noticeable not only for the use of course adjustment knob, but it also involved difficulty in using other parts of microscope as illustrated in the following excerpts from early and late transition;

> She placed the glass slide on the stage and tried to use the stage clip. The researcher has to show her the correct way of using it.
> (Obs.2, Ep.2, S13a)

> He asked the researcher how to adjust the slide, so that the specimen will be in the middle of the stage. (Obs.4, Ep.2, S5b)

> She carefully placed the slide on the microscope stage. She had a hard time to use stage clips. (Obs4, Eps2, S4b)

The ability to prepare slides for specimen has also been considered as an important aspect of technical skills during transition that needs to be acknowledged.

The following findings illustrated students' varied abilities in preparing slides. The first excerpt was taken from Student 9 who demonstrated an appropriate technique in preparing a wet mount slide. The following excerpt on the contrary illustrates how Student 6 attempts to carry out the same task:

> She placed a few drops of pond water on the glass slide. She positioned one end of the cover slip on the slide and slowly lowered the other end to prevent air bubbles. She carefully picked up the glass slide and put it on the stage. She used the stage clip to hold the slide.
>
> (Obs.2, Ep.1, S9a)

> He placed a few drops of water sample on the glass slide. He covered the specimen with a glass slide cover, by dropping it on the slide. He pressed the slide cover; too hard he did not realize that he already broke it. He placed the slide with a broken slide cover on the stage.
>
> (Obs.2, Ep.2, S6a)

Student 6 should lower the glass slide cover gently at 45^0 angle with one edge touching the slide first and let the liquid to spread out between the glass slide and its cover, without applying pressure as given in the instruction from MSTT.

Another common mistake done by the students at early transition was using too much liquid on the slide until the glass slide cover 'floats' and creates a thick layer of water. This allows the microorganism to swim around and be out of focus.

> He put a few drops of the fresh water sample on the slide. He dropped the glass slide cover slowly on the glass slide and pressed it. The exceeded amount of liquid causes the cover to 'float'.
>
> (Obs.2, Ep.1, S8a)

At secondary school, the task was more complicated because it involved the use of onion cell as specimen and the students took longer to prepare the slide. Preparing slides was a difficult task for the secondary school students to master, even though they have already conducted the same experiment during mid-transition. The following excerpts demonstrated some of the students struggle in preparing slides at late transition;

She has no problem to find the inner epidermal layer of the onion, but the specimen was too small and it was folded when she placed it on the glass slide. (Obs.4, Ep.1, S4b)

He carefully took out the inner layer of the onion, trying his best to take out the largest layer as he could. He spent five minutes to fulfill this step. He placed the onion epidermal layer on the slide. It was too wide so he has to tear the small part of the layer and placed it on the slide. He re-adjusted the placement of the specimen by using a scalpel. (Obs.4, Ep.1, S5b)

I also noticed that students tend to use their fingers to place the onion membrane on the slide (refer to Figure 4.11), for instance from the observation of Student 1, "*He spread out the membrane on the surface of a clean glass slide by using his fingers,"* (Obs.4, Ep.1, S1b). However most of the secondary school students showed progressions in using cover slip as demonstrated in the following excerpts:

He placed one edge of the glass slide cover at 45^o angle and lowered it carefully. He put his finger on the cover slip to eliminate the air bubbles. He took a filter paper and placed it at one side of the cover slip to absorb the excessive iodine solution.
(Obs.4, Ep. 2, S1b)

He took the cover slip and lowered the glass slide cover gently at 45^0 angle with one edge touching the slide. Carefully he let go of the other end of the cover slip. (Obs.4, Ep.1, S7b)

Figure 4.11 Handling of the specimen by using fingers

Correct sequences in using Bunsen burner and microscope

Although some of the primary school students at early transition seem rather afraid to work with fire, most of them show confidence in operating the Bunsen burner. Students' technical skills of using Bunsen burner have shown some progress during the period of transition. However, none of the students practiced the appropriate technique of lighting the burner sequentially. They were unaware of the function of the air hole and the correct technique of controlling the amount of gas. The inability to recognize the sequence of using the apparatus will affect the students' awareness of the appropriate precautions and measures that should be taken during the using and handling of the Bunsen burner.

The general sequence of using the Bunsen burner includes a few important steps:

(1) Ensure that the Bunsen burner is in good working condition before using it.

(2) Turn the collar of the Bunsen burner to ensure the air-hole is closed.

(3) Light up the candle or lighter before turning the gas on.

(4) Turn the gas on and bring the lit candle or gas lighter closer to the top of the barrel.

(5) Put out the candle or gas lighter after the flame is lit.

(6) Open the air-hole so that the flame changes to the non-luminous blue flame.

(7) Adjust the gas knob accordingly in order to change the flame intensity.

All of the primary school students were not aware of the appropriate techniques in manipulating the air hole during the using and handling of Bunsen burner. The same situation still occurs following their transition to secondary school.

> However, like his friends, he did not bother to adjust the air hole to obtain a blue flame. The yellow flame from Bunsen burner went up and around the beaker. The beaker wall was blackened.
>
> (Obs.1, Ep.2, S5a)

> He turned the gas valve carefully and lighted the burner. He adjusted the flame and slowly brings the burner under the tripod stand (students did not bother to manipulate the air hole before and after lighting the burner) (Obs1, Ep. 2, S12a)

The following quote from Student 6 at late transition indicated that he has obtained the conceptual knowledge of manipulating the apparatus. However due to lack of practice, he was uncertain of the correct technique in using the collar and air hole of the burner,

> Researcher: Can you tell me the name of this part of the Bunsen burner and its function (showing the air hole of Bunsen burner to the student)?
>
> Student 6 : I am not sure of its name but we have to adjust this part in order to obtain blue flame during combustion.
>
> Researcher: Then why I did not see you use this part of the Bunsen burner to obtain blue flame during the task?
>
> Student 6 : I am not sure. I have learned about it in the first chapter of the science syllabus. My teacher demonstrated the procedure but I am not sure how to do it.
>
> (S6b, Ln. 29-33)

During the task, students have been given a candle to safely light up the Bunsen burner. They have to light the candle first by using a lighter, turn the Bunsen burner gas on and light it up. However, students at primary school tend to turn the gas on before lighting up the candle. This habit has also been discussed in the element *"Ignorance in safety and precautionary measures"* under the second element *"Functional aspects of performing laboratory tasks"* that emerge from this study. The common techniques used by the students at early transition are demonstrated in the following excerpt:

> Student 10 turned the gas on. He was busy looking for the lighter to light the candle. The smell of the gas lingered around us. He was not aware of this situation, he was busy lighting the candle.
>
> (Ep.2, Obs.1, S10a)

Most of primary school science laboratory use compound microscope that has a mirror to focus natural light source to the specimen. At secondary school, compound microscope with electric lighting is commonly found in the science laboratory. The sequence in using a microscope usually involves a few important procedures that require the students to comply. Even though the sequence can be a bit different according to different method, the same principle of manipulating the apparatus should be followed by the student in order to grasp the appropriate skills. This sequence has been proposed based on information gathered at pre-research phase and during observation of tasks with the students at preliminary research. Thus, this sequence is appropriate to be used in this study. The following steps give the general sequence of using the microscope:

1) Placement of microscope on a flat surface with ample space to work with.
2) Plug in the power cord into a proper outlet and switch on the light source to ensure the usability of the apparatus.
3) Rotate nosepiece to the lowest-power objective lens.
4) Place the specimen slide on the stage and secure it position by using stage clips. Make sure the specimen is placed directly under the objective lens.
5) Look through the eyepiece and adjust the amount of light entering the microscope by using a diaphragm. If the compound microscope uses a mirror to focus light, coordinate the mirror, condenser and diaphragm in order to get sufficient source of light.
6) Adjust the coarse adjustment knob until the specimen is in focus.
7) Adjust the fine adjustment knob until the focused specimen is well-defined.
8) Scan all parts of the slide at low magnification power to get an overview of the specimen.

9) Rotate the nosepiece to the 10x objective lens and carefully refocus the specimen.

10) Rotate the nosepiece to use the 40x objective lens. Adjust the lighting until the image is sharp and distinct.

From the proposed sequences of using microscope, the students' technical skills were reanalyzed, in order to get an in-depth understanding of the students' sequencing skills in using microscope at primary and secondary school.

At early transition the students' sequential skills were considered as insufficient. Consider the following excerpt as example,

> He used the stage clip to hold the slide on the stage. He adjusted the slide to be in the middle of the stage. He did not position the objective lens to the lowest magnifying power. He looked through the eyepiece and slowly adjusted the coarse adjustment knob. He changed the lens to 10x objective lens. He re-adjusted the lens and checked on the glass slide recurrently. He started drawing his observation.
>
> (Obs.2, Ep.2, S5a)

The previous excerpt showed the student's difficulty to follow the correct sequence of using the microscope. He did not use the lowest magnifying power of objective lens to observe the specimen and did not bother to coordinate the mirror, condenser and diaphragm in order to get sufficient source of light. The purpose of fine adjustment knob remains unknown for him. In another case, Student 13 has demonstrated inadequate sequencing skills in using microscope. She did not show any ability in using the stage clips, mirror, condenser, diaphragm and coarse adjustment knob in sequence. She did not bother to use the lowest magnification power objective lens, as illustrated in the following excerpt:

> She placed the glass slide on the stage and tried to find the stage clips. The researcher has to show her the stage clip. She clipped the slide properly. She adjusted the fine adjustment knob while observing the specimen through the eyepiece.
>
> (Obs.2, Ep.2, S13a)

However some of the students did display satisfying sequential skills in using microscope at early transition as demonstrated in the following excerpt:

> He used the stage clip to hold the slide and adjusted the slide position so it will be in the middle of the stage. He adjusted the objective lens to the lowest magnifying power by revolving the nosepiece and adjusted the coarse adjustment knob so the distance between the stage and objective lens will be further apart. He looked through the eyepiece and adjusted the coarse knob again.
>
> (Obs2, Eps 2, S8a)

The above mentioned excerpt indicates that the student did procure a moderate technical skill which still can be further improved during the phase of transition. At late transition, Student 8 displayed progression in using microscope, as illustrated in the following quote,

> He took the slide and placed it on the stage. He used the stage clip to secure the slide. He moved the slide by adjusting the stage knob to ensure the specimen was placed directly under the objective lens. He used the 4x magnification lens. He looked through the eyepiece while adjusting the coarse adjustment knob. He scanned all part of the slide to get an overview of the specimen by adjusting the stage knob. He rotated the nosepiece to the 10x objective lens and carefully refocused the specimen.
>
> (Obs.4, Ep.2 & 3, S8b)

Most of the students at late transition, however, still struggled to master the correct sequence in using the microscope, even after they have conducted similar experiments during the teaching and learning of this topic under the learning theme ‘Man and the Variety of Living Things’ in mid-transition. This can be proven by the following excerpts from observation of task at secondary school:

> She turned the microscope power source on and placed the slide on the stage. She had a hard time to use the stage clip. She started to observe the specimen by using the 40x magnification lens (highest power) and she told the researcher that she could not see anything. She rotated the nosepiece and used the 4x magnification lens to observe the specimen. She did not even use the coarse adjustment knob during this experiment until her friend asked her to do it.
>
> (Obs.4, Ep.2, S4b)

> He placed the slide on the stage and used the stage clip to hold the slide. He asked the researcher the way to move the slide on the stage. He did not know how to adjust the slide so that the specimen will be in the middle of the stage. The researcher asked the student to use the knob beside the stage to adjust it. He rotated the nosepiece and used the 10x magnification lens (the lowest power of objective lens is 4x).
>
> (Obs.4, Ep.2, S5b)

The findings showed that the students' sequential skills during transition from primary to secondary school were very basic. Much could be done to make the acquisition of these skills more meaningful to the student.

Ability to operate the task efficiently

This element refers to the method employed in using and handling of sequential apparatus during task execution. It can be recognized by the student's ability to use the sequential apparatus appropriately. For instance, some of the students showed awkward and choppy actions when using the Bunsen burner and the microscope. However some of them showed smooth operation of task. This element has been used as an indicator to understand the students' technical skills in using the sequential apparatus.

The level of guidance in performing technical skills can be determined from the students' performance of the detailed skills. This element also deals with supervision necessary in order to enhance the students' technical skills in the using and handling of sequential apparatus. It emphasizes the teacher's role as an instructor or 'model' in the science laboratory, as suggested by Bandura (1977).

The following excerpt illustrates an example of a student's performance in using sequential apparatus during early transition which requires much supervision from the teacher:

> She lighted the candle and brought it close to the top of the barrel of Bunsen burner without turning the gas knob. The researcher had to instruct her to slowly turn the gas knob. She tried to slow down the fire by turning the knob counter clockwise, but the flame got bigger so she turned it the other way around. It was too quick and the flame disappeared from the burner. (Obs.1, Ep.3, S13a)

The following excerpt on the contrary illustrates some of the episodes taken from the observation with students at early transition, who were able to work independently with minimum supervision from the teacher during the manipulation of apparatus. However, the student did not show the correct sequencing technique in using the Bunsen burner.

> He lighted the candle, confidently. He turned on the gas knob and brought the candle close to the top of the barrel. He blew the candle off and adjusted the gas knob so the flame got bigger.
> (Obs.1, Ep.3, S12a)

From the findings, we can assume that students may have a hard time when they first use the scientific apparatus. However with repetition and practice, this task will only require minimum attention as they would have already acquired the competency in using and handling of sequencing apparatus.

Functional Aspects of Performing Laboratory Task

Functional aspects of performing laboratory task can be defined as specific procedures (apart from the technical skills) which were related to the operation of manipulative skills. It consists of four (4) elements that emerged from analysis of the collected data during transition from primary to secondary school. The elements include: (a) operation of tasks during practical work, (b) management of time and workplace, (c) safety and precautionary measures, and (d) numeracy and technique of drawing specimen. Table 4.3 gives the definition of each sub-element emerged from the elements.

Figure 4.12 presents the elements and sub-elements of the functional aspects of performing laboratory tasks.

Table 4.3

Definition of Elements in Functional Aspects of Performing Laboratory Task

Elements	**Definition**
Operation of tasks during practical work	Manner as illustrated by students during the execution of tasks in the laboratory.
Management of time and workplace	Students' abilities to complete the tasks within the specified time frame and the students' attitudes in ensuring work area orderliness and neatness, especially in the placement of apparatus.
Safety and precautionary measures	Practices to avoid danger to individual and damage to the surroundings.
Numeracy and technique of drawing specimen	Includes elements such as tendency in making assumptions, measuring and the skills in drawing specimens.

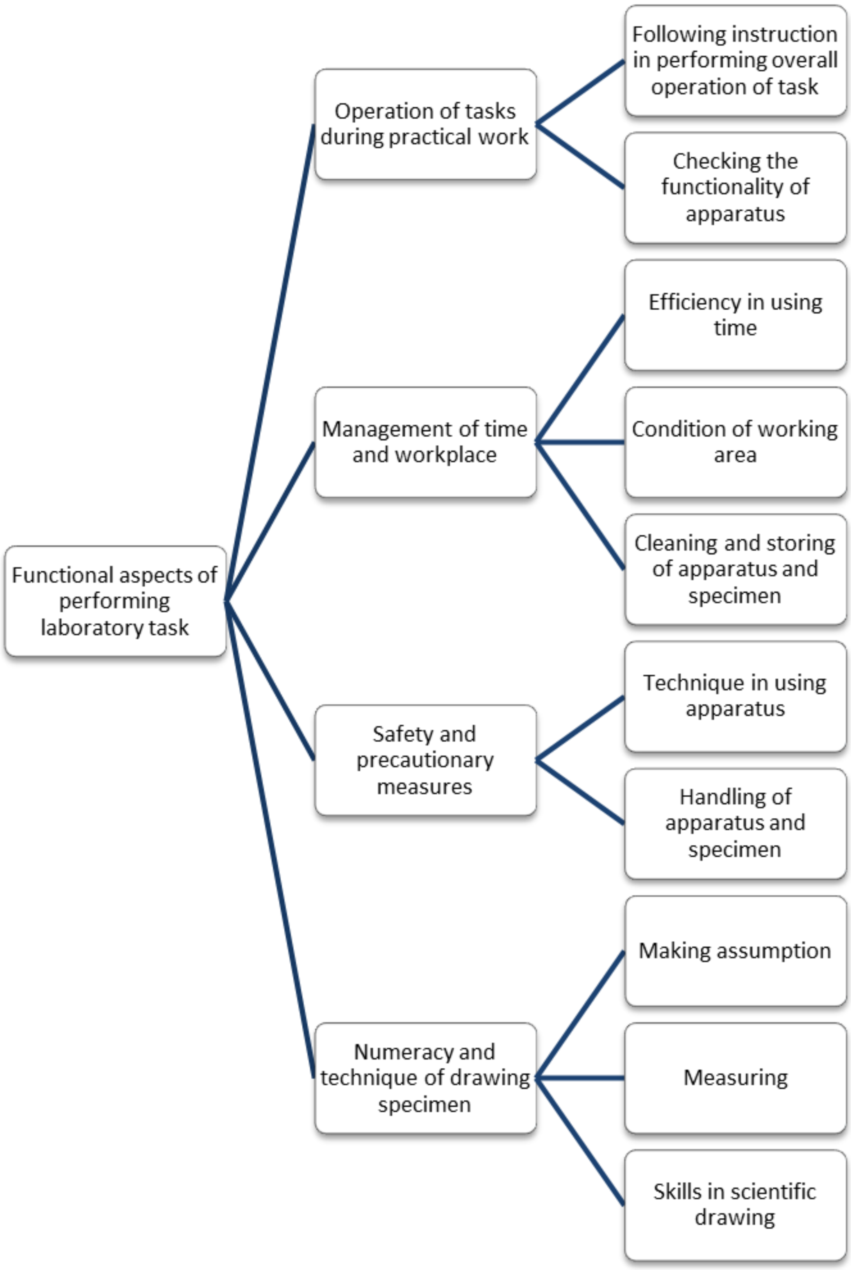


Figure 4.12 The elements and sub-elements of the functional aspects of performing laboratory tasks

Operation of tasks during practical work

It was found that students' manipulative skills during transition portrayed a non-systematic operation of tasks during the execution of experiment in the science laboratory. This element emphasized two (2) sub-elements as represented in Figure 4.13.

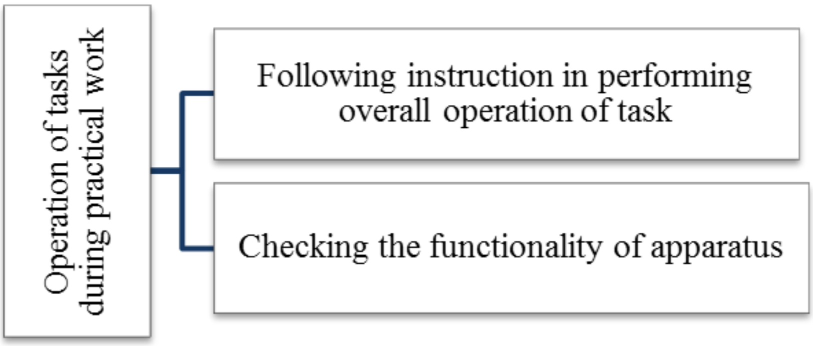


Figure 4.13 Sub-elements in operation of tasks

The systematic operation of tasks was characterized by the organized manner as illustrated by the students during the execution of tasks in the laboratory. Systematic in this context focuses on the student's methodical ability and acts as one of the important aspects of manipulative skills in order to ensure a smooth execution of task. However during transition the students displayed difficulties in following instructions and failed to check the functionality of apparatus before executing the task.

Following instructions in performing an overall operation of task

Manipulative skills in Transition Tasks (MSTT) were designed with minimum but comprehensive instructions which were adequate for the students to comprehend and follow. This is to prevent the students from performing the 'laboratory cookbook' type of experiment in the tasks. The students should be able to follow the procedure and use their prior knowledge, acquired since Years Four, Five and Six of schooling and demonstrate their ability in using and handling scientific apparatus during the execution of MSTT.

Difficulty in following instructions in this context can be defined as the students' problems in following the experimental procedure methodically. In primary school, the common mistake most of the students demonstrated during the tasks was heating the unmeasured volume of water. The procedure of the task from MSTT clearly instructed the student to measure 200 ml of distilled water before heating. The following observation transcripts portrayed this phenomenon at early transition:

> Student 5 picked up the beaker filled with water and placed it on the tripod stand without measuring the water. They were given a measuring cylinder to measure the volume of water.
> (Obs.1, Ep.1, S5a)

> He placed the beaker on the top of the tripod stand without measuring the volume of water. (Obs.1 Ep.3, S10a)

> He lit the Bunsen burner and slowly brought it under the tripod stand. He picked up the beaker of water and placed it on the tripod stand. He did not measure the volume of water used in this task.
> (Obs.1, Ep.3, S12a)

Most of the students showed progress in this sub-element during late transition. However in another situation, some of them, for instance, Student 12, still faced difficulties following instructions in performing the overall operation of a task. He only realized his mistakes when the water in the beaker took a longer time to heat as presented in the following transcript.

> "He touched the beaker a few times. He told the researcher that the beaker was not even warm. He re-read the given worksheet and realized he had missed a few steps. He told the researcher he did not measure the water by using the measuring cylinder. He read the beaker meniscus. The volume was about approximating 250ml."
> (Obs.3, Ep.2, S12b)

From the interview conducted after the task at late transition, the student admitted that he did not read the procedure carefully and as a consequence, he had to repeat the procedure from the very beginning.

The problem in following instructions also occurred in the context of stirring solutions. Students also performed this before taking the temperature so that the heat will be evenly and uniformly distributed. During early transition at primary school, only one of the students was able to follow this step every time she took the water temperature and she continued the practice throughout her secondary schooling. Observation during early transition also showed that some of the students did follow the instruction; however they used the wrong apparatus to stir the liquid, as portrayed from the following observation. The unsuitable technique was also observed during late transition.

> He picked up the thermometer from the table and immersed it carefully in the water. He stirred the water using the thermometer. He brought his eyes closer to the meniscus to read it.
>
> (Obs.1, Ep.3, S12a)

In using the microscope, problems in following instructions were more obvious in secondary school. Some of these students overlooked the step especially when it involved the staining of specimen on microscope slide for better definition. For example, during observation of the third task in MSTT, Student 4 *"placed the glass slide cover on the specimen. She forgot to put the iodine solution. She pressed the glass slide with her finger. She read the given worksheet and realized that she had skipped the important step."* (Obs.3, Ep1, S4b).

This kind of error can be avoided through careful study of the working procedure combined with the students' prior or existing methodical knowledge in manipulating the apparatus. This practice was exhibited as in the following transcript on a particular student at late transition:

> He took a small piece of the specimen and placed it on the glass slide. He took his time to read the manual again. He reached for a bottle of iodine solution and placed a drop of the solution on the specimen.
>
> (Obs.4, Ep.1, S6b)

Checking the functionality of apparatus

Scientific apparatus are tools that are used to measure, observe and gather scientific data in experiments. One of the features of manipulative skills that emerged during this study was that most of the students were unable to ensure the functionality of apparatus before, during and after their manipulation. The inability to do that has resulted in undesirable consequence during task execution. For instance, at early transition, Student 5 used the thermometer without checking it thoroughly. She realized that the mercury column was separated when she had already immersed the thermometer into the heating water. The unwanted episode interrupted the task because she needed to replace the thermometer consequently the temperature of the water being heated needs to be measured according to the time period given.

During the early phase of transition, only Student 12 was able to perform good practices in using the thermometer. He "*picked up the thermometer, took a glance at the stem and examined it closely before he immersed it into the beaker to take the initial temperature of the water*" (Obs.1, Ep.2, S12a). This similar episode did not occur during the observation session with other students.

At the mid and late phase of transition, the good practice of ensuring functionality of thermometer was employed by many of the students. These skills were not exhibited by the primary school students during early transition. The following excerpts portrayed the students' skills at late transition;

> He picked up the thermometer. He took a close look at the bulb and the stem of the thermometer. He took his time to examine the thermometer and placed it back on the table.
>
> (Obs.3, Ep.2, S12b)

> He took the thermometer, checked the bulb and brought the stem closer to his eye before taking the temperature of the water.
>
> (Obs.3, Ep.2, S8b)

In this category, some of the students at late transition not only demonstrated progression in using and handling of the thermometer but also in the manipulation of other apparatus, for instance the Bunsen burner. Most of them were capable of checking the functionality of the Bunsen burner during the heating of solution and made an effort to adjust the flame accordingly.

> He turned the gas knob a little more and the flame got bigger. He checked on the flame consistently while waiting for the water to boil. (Obs.3, Ep.2, S7b)

> He waited for the water to boil. He lowered his head once in a while to check on the flame. (Obs.3, Ep.2, S1b)

In manipulating the microscope, not much difference has been observed at early, mid and late transitions. Students did not give much consideration in checking the functionality of the apparatus beforehand in order to ensure the systematic operation of the given task, either at primary or secondary school. However, from the observation of the tasks from MSTT, it can be concluded that the students have developed acceptable working procedures on the basis of limited instructions given to them by teachers during transition to secondary school. In order to be competent in learning manipulative skills, students have to engage themselves in an active role in performing practical work.

Management of time and workplace

The second element of this research is the issue of non-effective management of time and workplace during the execution of scientific tasks. This task-oriented element was perceived as the students' difficulties in completing the tasks within the specified time frame and the students' attitude in ensuring work area appearance in terms of orderliness and neatness, especially in the placement of apparatus. Three sub-elements have been identified and represented in Figure 4.14.

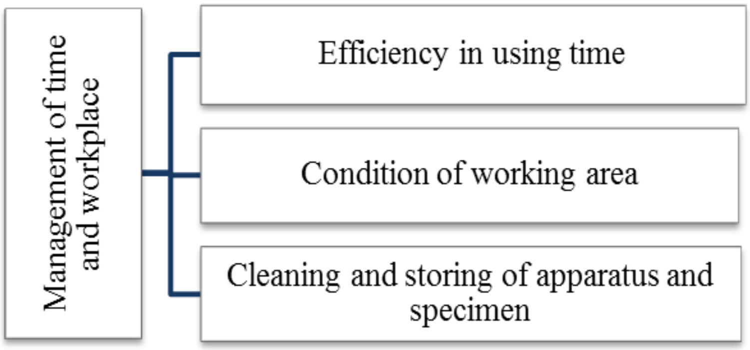


Figure 4.14 Sub-elements of management of time and workplace

Efficiency in using time

Efficiency in this context can be defined as the student's capability to complete the experiment methodically within the given time frame to get the best results. Efficient individuals work well and fast and are good at organizing their work. Students at early transition demonstrated lack of efficiency during task performance especially when it involved the use of Bunsen burner.

Difficulty may occur due to the lack of practice in using this apparatus during their primary school science experiments. It may affect the student's level of confidence when using the apparatus for example;

> He made his eyes parallel to the meniscus and read the initial temperature. He put the thermometer down. After a short while he picked up the thermometer again and immersed it back into the beaker. (Obs.1, Ep.2, S6a)

When this condition took place, the student's competency in manipulating the apparatus was affected, hindering the opportunity to gain efficiency. The following examples exhibit the observation of primary school students at early transition during the execution of MSTT. Being distracted may affect their efficiency in using time because the procedure needs to be repeated for the target to be achieved.

> There was no flame. The burner knob was not turned sufficiently and there was insufficient gas to light the burner. She lighted the candle again and brought it closer to the top of the barrel. She turned the gas knob more than he did before and this time it worked.
> (Obs.1, Ep.2, S4a)

> He turned off the Bunsen burner and he took the reading of the temperature. He did this every time he took the temperature.
> (Obs.1, Ep.6, S6a)

At late transition, some of the students still show their inefficiency in this sub-element. For example, Student 12 did not show progression in using the Bunsen burner during transition. He turned off the Bunsen burner each time he took the temperature, as practised at early transition. The following observation transcript was taken from an episode during late transition at secondary school.

> He waited for the temperature to get consistent. He turned off the Bunsen burner and wrote the result in the given worksheet. He took the matches and lighted the candle again.
> (Obs.3, Ep.3, S12b)

Condition of working area

In order to ensure task execution takes place in an applicable condition, students should ensure that their working area appearance is orderly and neat. Good utilization of available working space is one of the criteria of appropriate manipulative skills. The disorganized placement of apparatus during experiment may impede the students work flow during task completion, as shown in the following transcript at early transition:

> Student 1 placed the beaker on the top of the tripod stand, in the middle of the table surface; quite far from the end of the table where he stood. (Obs.1, Ep.1, S1a)

The following excerpt illustrated that the student was having difficulties reading the thermometer because of the unsuitable arrangement of the apparatus:

> "How can I read this?" he mumbled to himself. It was difficult for him to read the thermometer because the apparatus were set quite far from the end of the table. (Obs.1, Ep.3, S1a)

In another situation, some students showed unawareness in employing the suitable procedure to ensure the neatness of their working area. The following excerpts portrayed the student's attitude during the task, which may in turn, cause an unwanted incident:

> Student 4 poured the water into the measuring cylinder, too fast, the water spilled out from the beaker to the surface of the table. She did not bother to wipe the table and continued with her experiment. (Obs.1, Ep.1, S4a)

In contrast, from the observation of MSTT at late transition in secondary school, I noticed the students portrayed some improvement and awareness in employing effective management of their workplace.

> Cautiously he poured the measured water into an empty beaker. He placed the beaker on the tripod stand. He moved the measuring cylinder, empty the beaker and the salt container further from his working area. (Obs.4, Ep.1, S7b)

> The beaker was very near to the end of the table. She realized the situation and moved the beaker further away from the edge of the table. (Obs.1, Ep.1, S9b)

Both of the above-mentioned excerpts captured the scenario that the students were trying and making the effort towards ensuring the orderliness of the apparatus when carrying out the task, particularly in placing of equipment and materials used. This element is also very much related to the safety procedure that should be adapted in conducting scientific investigations.

Cleaning and storing of apparatus

The ability to clean and store apparatus after usage is one of the sub-elements under the effective management of workspace. It was interesting to note that most of the students at early transition, at both primary schools A and B, were capable of cleaning and storing apparatus after using them, even though no clear guideline as to how the students should carry out the procedure, was given.

During the performance of Task 1 from MSTT, the majority of the students were able to clean up their workspaces appropriately. The beaker and measuring cylinder were washed and carefully placed beside the sink for them to dry off. In addition, the thermometer was replaced in the casing. The Bunsen burner, wire gauze as well as the tripod stand were also placed back. Among all, Student 7 and Student 13 have shown good examples of how they were able to clean their workspace properly, as illustrated in this following transcript:

> He carefully took out the Bunsen burner from under the tripod stand. He turned the gas off and took the hot beaker down by using a dry towel. He poured the water in the sink, washed the beaker and placed it beside the sink. He went back to his place and put the thermometer back in its plastic casing.
>
> (Obs.1, Ep.6, S7a)

> She picked up the tongs and carefully took down the hot beaker. She held the beaker with a towel and cautiously walks to the sink. She cleaned the beaker and placed it beside the sink. She applied the same procedure on the measuring cylinder.
>
> (Obs.1, Ep.7, S13a)

Both the excerpts captured episodes of the students' awareness in cleaning and storing apparatus which then become one of sub-elements emerged from the data. The good practices can also be observed during the completion of Task 2 which involves the manipulation of the microscope, as illustrated in the following video transcripts:

> He took out the slide from the stage. He removed the slide cover and washed the slide and the slide cover. He dried it with a clean tissue and placed it back at the table. (Obs.2, Ep.4, S5a)

> He adjusted the coarse knob to its initial position, far from the microscope stage. He held the stage clips and carefully removed the glass slide from the stage. He walked to the sink to wash the slides and dried it with tissue. (Obs.2, Eps.5, S7a)

From all these excerpts at primary school, the skills shown by Student 7 were most impressive, resulting in an eagerness for continual observation of the student's skill at secondary school. During the second phase of this study, this student was able to transfer the good skills after five months of schooling, as did his fellow friends at secondary schools C and D. The next excerpts were extracted from observation of Task 1 and Task 2 of Student 7 at late transition, who displayed progression in this sub-element during transition:

> He turned the gas off and took the Bunsen burner from under the tripod stand. He took a small towel to hold the hot beaker and brought it to the sink. He ran the tap water to cool it. He washed the beaker and placed it beside the sink. He applied the same procedure with the other equipment; beaker, measuring cylinder, spatula and thermometer. (Obs.3, Ep.4, S7b)

> He took the glass slide and went to the sink. He washed the glass slide and the slide cover. He wiped and put it back in the box. (Obs.4, Ep.3, S7b)

The next quote and figure again indicated that the student's skills at primary school have been further enhanced during late transition.

> He picked up the slide, took a pair of forceps and walked to the dustbin. He used the forceps to remove the specimen and threw the specimen away. He washed the slide, slide cover and forceps. He used a piece of clean tissue to wipe the slide and put it back in the box. He turned off the main switch of the microscope and pulled out the plug. (Obs.4, Ep.3, S8b)

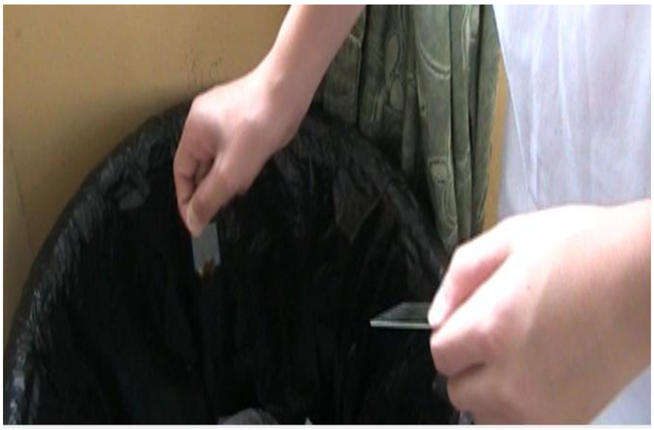


Figure 4.15 Cleaning the apparatus

However, there are still some cases of unawareness in the aspect of cleaning and storing of apparatus during late transition. It was noticeable as illustrated in the following video transcript where the student, *"left the slide on the microscope, submitted his worksheet to the researcher and started packing his belonging"* (Obs.4, Ep.3, S1b).

Findings revealed that efficiency in this context mostly depend on the students' ability to master the technical skills in using and handling scientific apparatus. Therefore this category of manipulative skills required continuous practice and repetition of skills during transition from primary to secondary school. The laboratory observation at mid-transition indicated that the teacher plays a scaffolding role in polishing the students' manipulative skills so that the students were able to work effectively.

Safety and precautionary measures

A number of students exhibited dangerous techniques in carrying out scientific tasks in the laboratory during the execution of tasks during transition from primary to secondary school. From the analysis of findings, two sub-elements have been identified and represented in the following Figure 4.16,

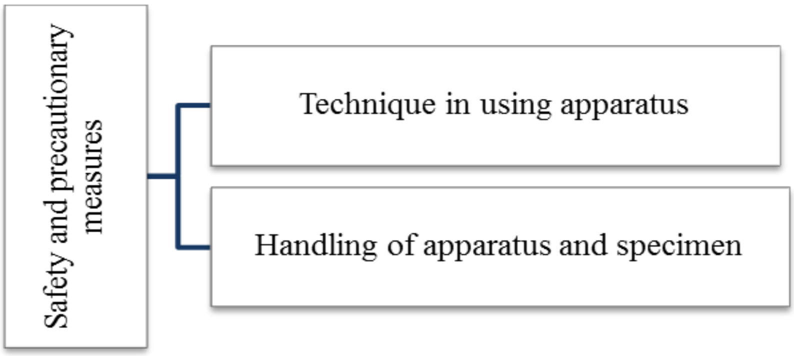


Figure 4.16 Safety and precautionary measures

Technique in using apparatus

Findings from early transition revealed that most of the students performed unsafe techniques in using the apparatus, especially in using the Bunsen burner. The notion is evident in the following excerpts:

> Student 1 turned the gas knob. The hissing sound from the Bunsen burner can be heard clearly. In the meantime he reached for the lighter and tried to light up the candle. The smell of gas lingered.
> (Ep.1, Obs.1, S1a)
>
> Student 10 turned the gas on. He was busy looking for the lighter and tried to light the candle. The smell of the gas lingered around us. He was not aware of this situation as he was busy lighting the candle.
> (Ep.2, Obs.1, S10a)

Observation showed that this was the most common mistake demonstrated by primary school students at early transition. The students should not turn the gas on before lighting the candle. From interviews conducted after the task, the students admitted that they have been introduced to the Bunsen burner several times by the teacher while studying at primary school. Some of the teacher restricted the student from manipulating the Bunsen burner themselves as told by Student 9, "We never get the chance to use Bunsen burner. The teacher told us that it is dangerous. We just observed the teacher doing it when she demonstrated the experiment in the science laboratory." (Int.1, Ln. 72-74, S9a). From the observation of MSTT, the student showed difficulty in using the Bunsen burner. She lighted the candle and brought it to the top of the barrel without turning the gas knob on. When she was asked about it during interview, she answered "I just follow what I observe during demonstration. I am not aware on how to use the gas knob," (Int.1, Ln. 76-78, S9a).

On the other hand, a number of students at early transition showed moderate ability in using the Bunsen burner, as what has been observed in the following transcript. However, they did not acquire the skills in manipulating the air hole before and after lighting the Bunsen burner.

> He lighted the candle. Cautiously, he turned the gas knob and brought the candle near to the top of the barrel. He blew the candle and adjusted the gas knob so the flame went bigger.
>
> (Eps.2, Obs.1, S8a)

The observation of MSTT at late transition showed that almost all of the students displayed acceptable skills in manipulating the Bunsen burner though none of them could manipulate the air hole correctly. The air hole should be closed by adjusting the collar of the Bunsen burner before lighting the burner and re-opened after lighting it to facilitate complete combustion. In one case, a student turned on the gas knob without lighting the candle beforehand and admitted that he forgot how to use the Bunsen burner. However, observation of manipulative skills at late transition indicated that some improvement did occur during transition.

Most of the students at primary and secondary school demonstrated safe technique in using measuring cylinder. In handling the thermometer, some dangerous techniques were displayed by the primary school student as illustrated in the following figure and video transcript:

> He took the thermometer and placed it in the beaker. The thermometer seemed unstable but the situation did not bother him.
>
> (Eps.2, Obs.1, S7a)

Figure 4.17 Placing the thermometer in the beaker

This unsafe technique applied by students was observed during mid and late transition. The students left the thermometer in the beaker during heating and some intervention had to be carried out in order to prevent any unwanted incident. It was clear that the students were not aware of the awaiting danger during the execution of task.

In using the microscope, most of the problems occurred during the slide preparation. In primary school, students tended to press the glass slide cover when preparing the specimen. This can also be observed during transition to secondary school. The following excerpts illustrated how Student 6 repeated the same error during transition:

> He placed the slide cover harshly and pressed very hard on the slide until the glass slide cover broke. (Eps.1, Obs.2, S6a)
>
> He placed a drop of iodine solution on the specimen. He took a slide cover, and placed it harshly on the glass slide. He adjusted the position of the specimen by pressing the slide cover with his finger.
> (Eps.2, Obs.4, S6a)

Figure 4.18 Student 6 pressed the slide cover

From the excerpts above, it was apparent that the students at secondary schools repeatedly commit the same error even though they had performed a similar experiment during laboratory lesson with their classmates during mid-transition.

Handling of apparatus and specimens

The second sub-element highlighted risky and unsafe acts in the experimental procedure. It emphasized students' inappropriate handling of scientific apparatus, which can be damaging to the apparatus as well as to the students. The students have the tendency to do it unintentionally, for example while waiting for the water to boil as illustrated in the following excerpts and Figure 4.19, 4.20 and 4.21,

> He held the thermometer while waiting to take his third reading of the temperature. He held it vertically, at the end of the stem, placing it in between his fingers, like holding a pen. The thermometer bulb was in contact with the surface of the table.
>
> (Eps.5, Obs.1, S5a)

> She read the procedure while her left hand held the thermometer, holding it upright and pushing it at the table top. She tapped the thermometer bulb to the surface of the table, "Tap! Tap!"
>
> (Eps.2, Obs.1, S9a)

Figure 4.19 Handling of thermometer

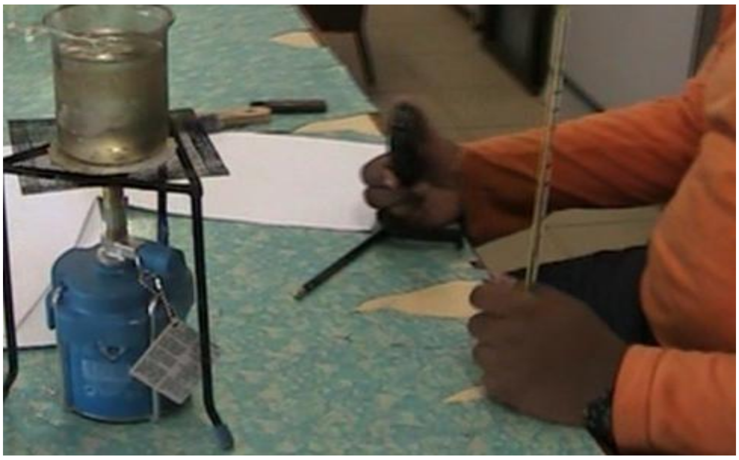


Figure 4.20 Handling of thermometer

Figure 4.21 Student places the thermometer close to the edge of the table

Both of the excerpts were taken from observations of MSTT during early transition at primary school. The rough handling of thermometer could affect the entire apparatus, for example the separation of the mercury column.

On the other hand, some students were gentler in handling the microscope during execution of the second task. They held the slide cautiously and rotated the nosepiece carefully. In contrast, Student 7 however has shown carelessness while handling the microscope, by holding the microscope arms with his right hand to drag it near to him (Eps.2, Obs.2, S7a).

The students were not aware of the dangerous acts performed at late transition. The notion is evident in the following quote,

> He waited for the water to boil. Once in a while he touched the surface of the hot beaker. The researcher warned him of the consequence of his action. (Eps.2, Obs.3, S12b)
>
> He checked the boiling solution once in a while. He was too near; his face was directly above the beaker. The researcher asked him to be careful of his action. (Eps.4, Obs.3, S12b)

Excerpts above showed the students' alarming practices during transition. The similar risky situation was noticed during observation of the third task from MSTT;

> He went out from the science laboratory to get something from his bag and he left the boiling water unattended while he did that. (Eps.2, Obs.3, S1b)

From this element, it can be concluded that the safety and precautionary measures are important aspects of manipulative skills which ward off impending danger to individual and damage to the surrounding. Findings from the research at early, mid and late transition revealed that most of the students have neglected the safety procedures while busy executing the given tasks. Students failed to foresee the consequences of the erroneous technique and teachers were not able to notice the dangerous technique due to the large number of students in a classroom. These inappropriate techniques may lead to the occurrence of unwanted incidents in the laboratory which can be damaging not only to themselves but also to people around them. Observation at mid transition indicated that unclear safety guideline delivered by the teacher can also be a factor that contributes to the lack of awareness during scientific investigation.

Numeracy and improper technique of drawing specimen

It was found that manipulative skills of both primary and secondary school students portrayed a difficulty in numeracy and lack of proper practice in drawing specimens. Three (3) sub-elements (please refer to Figure 4.22) have emerged during the analysis of the observation transcripts and analysis of documents.

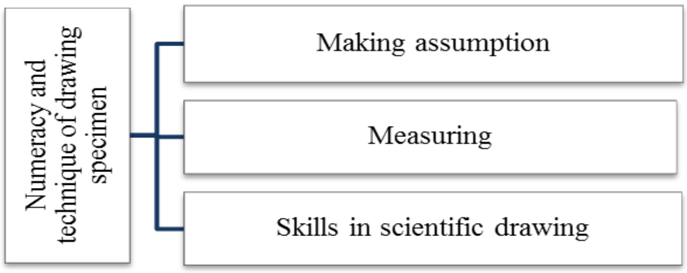


Figure 4.22 Sub-elements in numeracy and technique of drawing specimens

Making Assumptions

Based on observation of the first task, almost all of the primary school students assumed that the initial temperature of water was 0^oC whereas in reality, the temperature should read about 27^oC. From the interview, they admitted that it has been a common practice for them to consider the initial reading of any measurement as 'zero'. Some of the students believe that the statement was true without showing any effort to take the initial temperature of the water, as demonstrated by Student 1 and Student 5. They did not even measure the initial temperature of the water and wrote it as ‘0’.

In other cases, though the students did place the thermometer in the beaker to measure the initial water temperature, they however, ended up assuming the temperature of the water as 0°C, as illustrated by the following excerpt and Figure 4.23;

> He placed the thermometer into the water to take the initial temperature. 'Initial temperature, it should be zero…', he presumed and wrote '0' on the worksheet.
>
> (Ep.2, Obs.1, S7a)

Time (min) *Masa (min)*	0	2	4	6	8
Temperature of water when heated (°C) *Suhu air yang dipanaskan (°C)*	0°C	50°C	80°C	90°C	95°C

Figure 4.23 Student 7 results

Out of all the primary school participants from two primary schools, only one student was able to take the correct initial reading of the water temperature by actually measuring it:

> She picked up the thermometer to get the initial temperature of the water. She kept her eyes parallel to the thermometer scale when taking the temperature. She wrote the initial temperature as 28°c.
>
> (Ep.2, Obs.1, S13a)

Time (min) *Masa (min)*	0	2	4	6	8
Temperature of water when heated (°C) *Suhu air yang dipanaskan (°C)*	28°c	35°c	41°c	50°c	62°c

Figure 4.24 Student 13 results

Observation at mid transition supported the facts that the students have tendency to assume the initial reading as "zero". Thus there is enough empirical evidence to suggest that during transition, most of the students were not actually 'seeing' but believing or assuming without measuring methodically.

Measuring

According to the analysis of curriculum specification conducted at the pre-research stage, technique of measuring the volume of liquids has first been introduced to Year Four student under the topic of 'Measurement'. Students have been trained in the appropriate usage of beaker and measuring cylinder, two of the basic equipment in the laboratory for measuring volume of liquids.

However the findings at early, mid and late transition indicated that students still encountered difficulty complying with the correct procedure of reading the meniscus of graduated apparatus. Some did not seem to give attention to ensure their eyes were parallel to the water meniscus, as shown in the following excerpt;

> Cautiously he poured the water into a 100ml measuring cylinder. He stopped before the bottom meniscus reached the 100ml line. He did not lower his head to check on the meniscus in order to avoid parallax error. (Ep.1, Obs.1, S6a)

Despite the above-mentioned excerpt, most of Year Six students were aware of the correct position of their eyes when measuring volume of liquids and this can be verified by the following excerpts during task observation and interview with Student 4;

> She poured the water into 100 ml measuring cylinder. She lowered her head; her eyes were parallel to the water meniscus. Cautiously, she transferred the water from measuring cylinder into the 250 ml beaker.
> (Ep.1, Obs.1, S4a)

> Researcher : I can see that you lowered your head when reading the water volume of measuring cylinder. Why did you do that?
> Student 4 : Yes...I did that to avoid mis-reading of the water volume. Our eyes should be at the same level as the water….at 100 ml.
> (S4b, Ln. 32-36)

However, when I examined closely, Student 4 did not measure the liquid by observing the bottom level of the meniscus, but she read the upper meniscus of the liquid instead. Students ensured that their eye position is at the same level of the meniscus to avoid parallax error but they tend to read the upper level of the meniscus of the solution. Thus the volume will be lesser than the actual volume of liquid needed for the experiment. This problem occurs with almost all of the participants.

The students seem much more confident in using this apparatus during the observation of MSTT at late transition. From the interview, they admitted that they have been using measuring cylinder for a few times. However from the observation, the students' technique did not develop as I expected and this can be observed from the following excerpt,

> He lowered his head to observe the meniscus. He stopped when the upper meniscus reached 100ml line. He poured the measured water into an empty beaker and placed it on the tripod stand.
>
> (Ep.1, Obs.3, S6b)

In using the thermometer, a worrying trend during transition was noticed. Some students were unable to give correct reading of the water temperature and take the reading of water temperature as 3.0^{o}C instead of 30^{o}C, 3.8^{o}C instead of 38^{o}C. The answers were certainly unacceptable. In other cases, the students measured the water temperature as 30.3^{o}C, 50.7^{o}C and 60.7^{o}C (please refer to Figure 4.25). This showed that the students were unable to practically connect the basic concepts of heat and temperature, learned theoretically.

Time (min) *Masa (min)*	0	2	4	6	8
Temperature of water when heated (°C) *Suhu air yang dipanaskan (°C)*	0°C	30.3°C	50.7°C	60.7°C	

Figure 4.25 Student 12 result

As conclusion, the findings indicated that students at early, mid and late transition faced difficulties when it comes to the issue of utilizing the correct technique in reading the meniscus. This problem will affect their ability in using basic graduated apparatus, such as beaker and measuring cylinder and other complex apparatus such as volumetric apparatus, which will be used later in their education journey. Volumetric apparatus are the accurate and precise apparatus used in volumetric analysis, such as the volumetric flask and volumetric pipette.

Scientific Drawing

Students' drawings have been analyzed according to the framework constructed earlier at pre-research stage. The framework consists of seven (7) main criteria that act as key elements in scientific drawing. The criteria include:

(1) The use of pencil in drawing
(2) The use of line drawing
(3) Neat drawing
(4) Availability of appropriate title of the drawing
(5) Magnification of drawing is indicated
(6) Correct label of scientific drawings
(7) Authentic drawing

Students' displayed different abilities in scientific drawing at early transition. Primary school students used line drawing in illustrating scientific specimen. Line drawing in this context can be defined as drawings which consist of distinct single lines, without gradations in shade or hue, to represent the observed scientific specimen. Students did use line drawing to portray their observation as presented in the following figure. However, the drawing has not been labeled with specimen name and magnification power used during the observation.

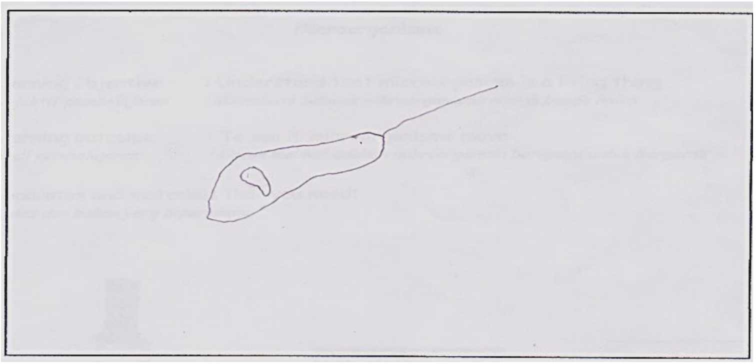


Figure 4.26 Student 6 scientific drawing at early transition

One of the criteria highlighted in the framework is the neatness of scientific drawing. Scientific drawing should be positioned at the center of the given space and fill the space provided. It must also be large and clear enough so that every structure can be distinguished easily. There is enough evidence to claim that most of the students at early transition did not fulfill this principle. Take the following drawing for instance (Figure 4.27 and 4.28). The specimens drawn were too small. The drawings were unproportionate, as compared to the space provided in the paper for the students to illustrate their observation.

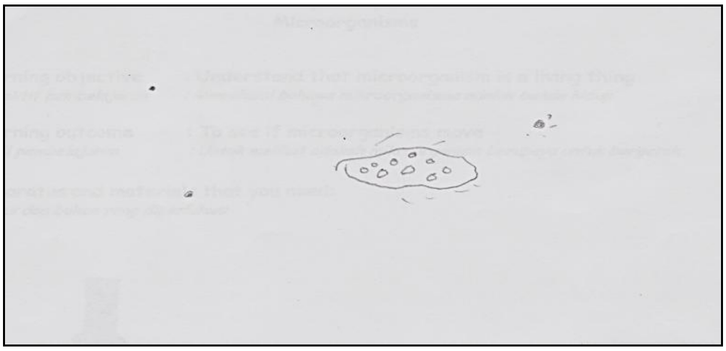


Figure 4.27 Student 10 scientific drawing at primary school

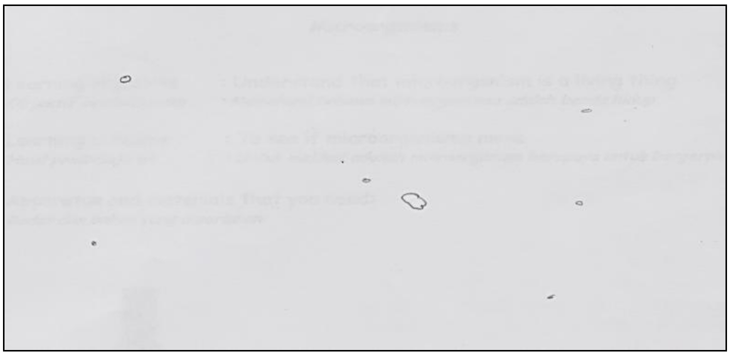


Figure 4.28 Student 12 scientific drawing at primary school

Both of the above mentioned drawings have not been labeled appropriately with the specimen name and the magnification power used during the observation. From the analysis, this has been the students' common flaw in scientific drawing, either at early, mid or late transition. None of the students at primary school were able to label the drawings clearly and correctly, based on their observation of specimen as shown in the following figure;

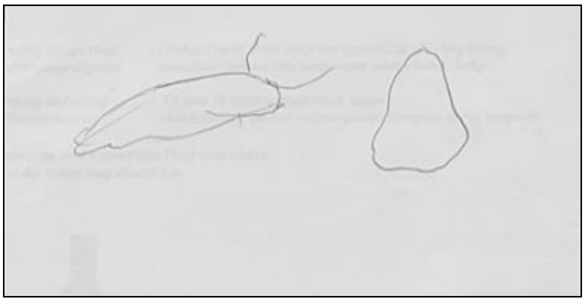


Figure 4.29 Student 9 scientific drawing at primary school

There was not much progression occurring during the transition to secondary school. For instance, one of the criteria of a good scientific drawing is that it must be labeled with the specimen name. Students should be able to name the specimen correctly and give a clear and concise title that explains what is being illustrated. During transition, students demonstrated inability to acquire this criterion. At late transition, only one student was able to label the name of the specimen observed in the given task, as shown in Figure 4.30. All the other students were unable to label the drawing either at primary or secondary school. However Student 13's drawing was not neat and he drew his observation by using pen. The use of pen in scientific illustration is prohibited. It can be implied that these students are still in the initial stage of learning to draw and are prone to commit errors in drawing.

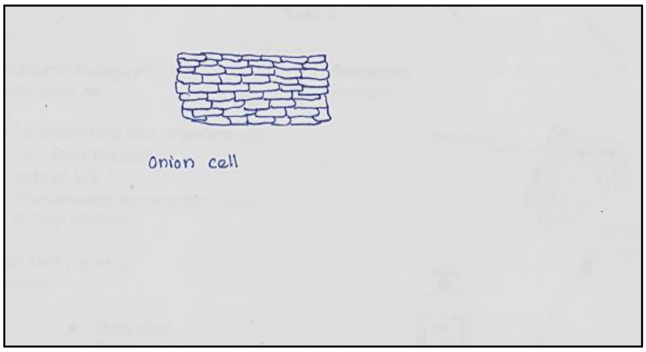


Figure 4.30 Student 13 scientific drawing at secondary school

Findings indicated that students were still unable to draw scientifically during late transition (refer to Figure 4.31, 4.32 and 4.33). They were unable to draw the onion cell according to standard. The drawings were too small and were not drawn in the middle of the provided space.

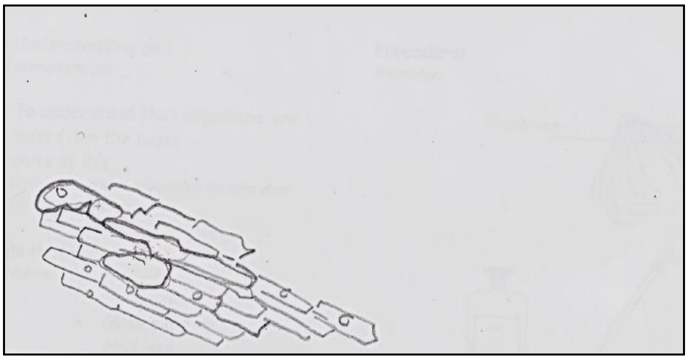


Figure 4.31 Student 8 scientific drawing at secondary school

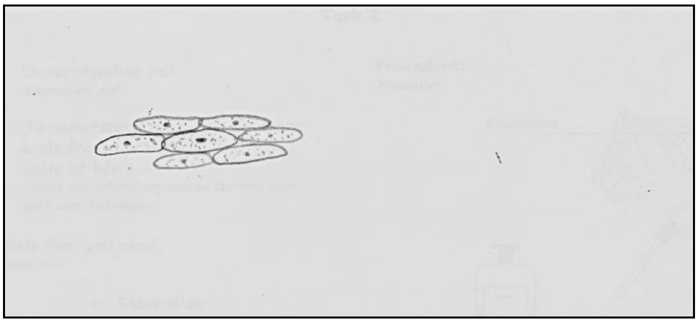


Figure 4.32 Student 4 scientific drawing at secondary school

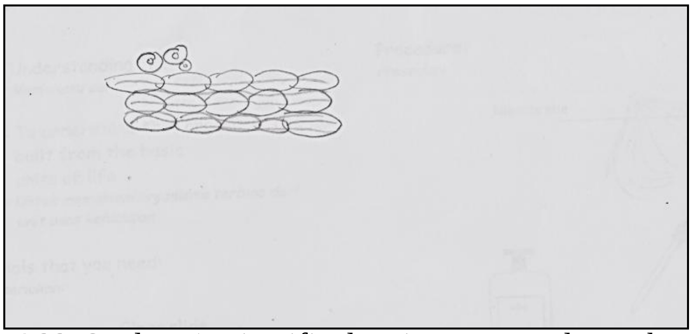


Figure 4.33 Student 1 scientific drawing at secondary school

The drawings at late transition indicated that the students had difficulty showing the appropriate level of neatness of scientific drawing during transition. Scientific drawing should be drawn using the correct scale and labeled with the magnification power used during the observation. Analysis of students' drawing showed that none of them were aware that they had to adhere to these principles. The following drawing (Figure 4.34) was one of the decent examples of the student's illustration of onion cells at secondary school, where he had drawn one section of the specimen as a representative of the entire specimen. However the student was unable to label and provide the magnification of the drawing.

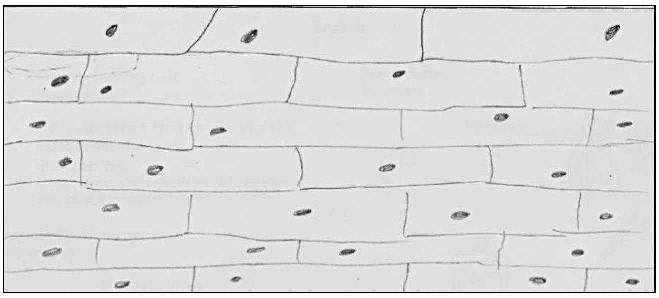


Figure 4.34 Student 7 scientific drawing at secondary school

The students should be able to give correct labels to their scientific drawing. For example plant cells should include the following labels - cell membrane, cell wall and nucleus. Each label line must be straight and should not overlap with other label lines in order to ensure the drawing is neatly organized. None of the students at early transition labeled their drawing with appropriate scientific terms to explain their observation. However at secondary school, a number of students were able to display progression in this particular criterion, as shown in Figures 4.35 and 4.36;

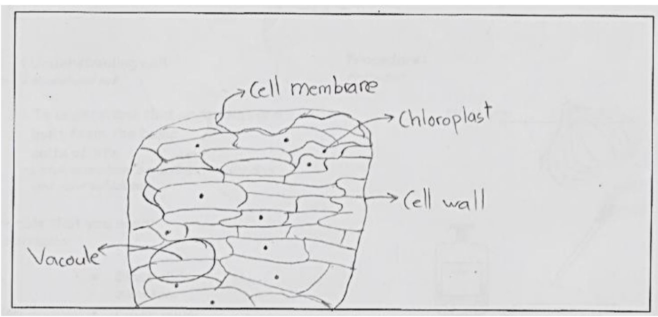


Figure 4.35 Student 5 scientific drawing at secondary school

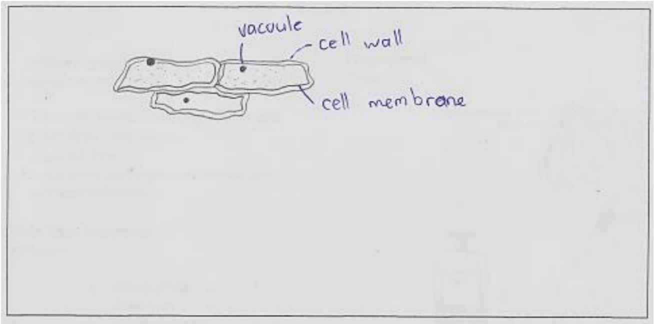


Figure 4.36 Student 9 scientific drawing at secondary school

The above mentioned drawings indicated that some of the Form One students were able to label their observation of specimen accordingly and with proper guidance, the skills may improve.

During transition, most of the students drew the specimen similar to what they had observed in textbooks, as indicated by the following scientific drawing (Figure 4.37). For instance, at late transition, they drew one single plant cell for their observation during the execution of laboratory task. Students should draw what they actually observed, as opposed to what they think they should be seeing.

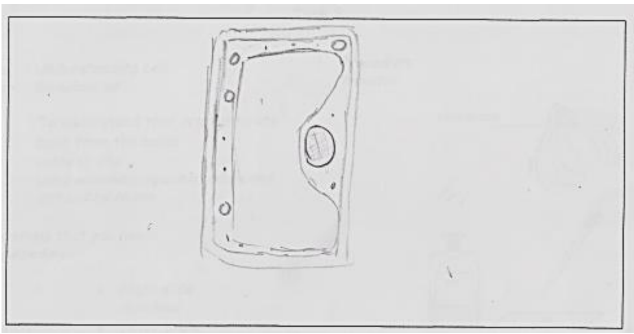


Figure 4.37 Student 6 scientific drawing at secondary school

Analysis of the students' drawings during transition has revealed that the students showed different ability and inconsistency in drawing specimens. Some students used pens to draw their observation and most of them did not bother to label the drawing. They failed to give full titles and scales or magnification of the drawing.

These problems need to be addressed by the teacher in order to facilitate a smooth transition in this sub-element.

THE DIFFERENCES IN THE ACQUISITION OF SKILLS AT EARLY PHASE AND LATE PHASE OF TRANSITION

The third section of this chapter discusses the differences of each element in primary and secondary schools in order to answer the second research question. The discussion focused on the differences at early transition, mid-transition and the late transition. In the context of this study, early transition occurred at the end of Year 6, about four months before the students enter secondary school. In this phase, students were interviewed and their manipulative skills in conducting tasks from MSTT were observed. During mid-transition (beginning of Form 1), the students were observed during practical activities in the science laboratory. Late transition in this study refers to the phase toward the end of Semester 1 where the students were needed to conduct other tasks from the MSTT. The differences in every element and sub-element of manipulative skills have also been embedded in the discussion of the findings. This section is aimed at identifying the differences in manipulative skills acquisition during transition and a discussion will proceed according to the elements.

Technical Skills

In general, the students did not show much progress in technical skills of using graduated and sequencing apparatus. The first two elements of technical skills were considered as the basic skills for the students to acquire. In the first element of recognizing apparatus and their functions, most of the students were able to recognize the apparatus although some found it difficult to give the exact function of any one given apparatus - for example, the function of the Bunsen burner and the microscope. At late transition, the same problem still occurred. However as presented during the data analysis, some students misunderstood the functions of the measuring cylinder and the beaker. This conflicted with what they have explained to me during the interview at early transition. The students have chosen to use the beaker instead of the measuring cylinder to measure 100ml of water. It has become a common practice for the students especially at the early transition to use the beaker as a measuring apparatus. The beakers should not be used to obtain accurate measurement of volume. This phenomenon still occurred during mid and late transitions but with fewer recurrences.

In identifying parts and features of an apparatus and its functions, this element did not show much progress where students in early, mid and late transition were unable to identify the parts of graduated and sequencing apparatus. In the case of the sequencing apparatus, the problem of identifying important parts has affected the students' ability to be competent in handling the apparatus. In order to use the apparatus effectively, students have to acquire knowledge about the apparatus itself. The inability to do so will impede their ability to master other elements of technical skills. For instance, during mid-transition at secondary school, the students have been introduced to every detail of the parts and features of the microscope; yet they failed to portray their knowledge in these elements during the interview session at late transition. The achievement in other elements of technical skills depends on the students' ability to master the basic skills. For example, if the procedure requires the students to use the fine adjustment knob to bring the specimen into focus, the students will encounter difficulty to follow this step because they are unable to identify the fine adjustment knob.

Recognizing an apparatus, its parts and knowing its specific function is the basic technical skills for the students to acquire. Recognition is necessary as the first step toward being able to make effective use of the apparatus. Furthermore, once the apparatus has been recognized, it is possible to relate the apparatus with particular safety related information which has been listed as one of the element in functional aspects of performing laboratory tasks.

Most of the students displayed incompetency in performing the basic principles of using and handling the graduated and sequential apparatus during transition. There was not much difference between students' skills at early and late transition. There is a serious gap between the students' theoretical knowledge and their practices in using and handling the apparatus during transition. For instance, most of the students were able to explain the basic theory of using the thermometer during the interview conducted at early transition. However this knowledge was not practiced during the execution of task from MSTT. Similarly when handling the thermometer, the thermometer bulb was made to touch the bottom of the beaker while taking the temperature and the thermometer was also used to stir the solution even though a glass rod had been provided. These scenarios were displayed at early, mid and late transition.

Findings also revealed that the students' basic skills in using sequential apparatus at early and late transition were unsatisfactory, especially in using the Bunsen burner where the proper technique of usage was not exhibited by either one of the students . As expected, some students who were able to explain the correct technique of using the Bunsen burner (during interview at secondary school) did not show the ability to practice the skills during task execution.

One of the elements in technical skills of using graduated apparatus discussed is the issue of parallax error. Almost all of the students manifested their awareness in avoiding parallax error in using graduated apparatus during transition. However, most of them did not realize that they had practiced inaccurate methods to fulfill this particular criterion. For instance, most of them lifted the measuring cylinder in order to ensure the meniscus was parallel with their eye level, or tilted their head while taking the measurement; a few of them placed the measuring cylinder on the tripod stand and the rest were not too concerned about the appropriate method in avoiding error. Ironically, these inaccurate methods or approaches in avoiding standard errors during taking measurements were displayed during late transition. The same phenomenon was observed in using the thermometer. Most of the students took out the thermometer from the beaker in order to take the reading of the temperature. The students knew the fact that their eyes have to be parallel to the meniscus but this was not exhibited while conducting the task.

The findings of this study showed that the students' sequential skills during transition from primary to secondary school were very basic. Most of the students at secondary school still struggled to master the correct sequence in using the microscope. None of the students practiced the appropriate technique of lighting the burner sequentially during early, mid and transition. They were not aware of the function of the air hole and the correct technique of controlling the sufficient amount of gas during combustion.

Functional Aspects of Performing Laboratory Task

The first element in this dimension reflected the students' operation of task during execution of practical work which comprised two sub-elements: following instructions in performing overall tasks and checking the functionality of apparatus before executing the task. The students showed some progress during the transition period. However, difficulties in following instruction still occurred at late transition especially concerning the proper techniques in staining specimen. Among the most significant changes observed at late transition was in the sub-element of checking functionality and appropriateness of the apparatus. The good practice of ensuring functionality of apparatus was employed by many of the secondary school students at mid and late transition - for example, when examining the thermometer before usage it and checking of the functionality of the Bunsen burner before and during heating. However, not much difference was observed in the using of the microscope where no efforts were made to check the apparatus prior to its usage.

In the second element, three sub-elements emerged from analysis of data which were the efficiency in using time, condition of the working area and cleaning and storing of apparatus. In early transition, students displayed poor skills in using time and ensuring an organized work area condition. However, acceptable skills in practicing cleaning and storing apparatus were observed since early transition. During late transition, collective findings found that some progression occurred in these sub-elements especially in cleaning and storing of apparatus. From these findings, it can be concluded that the students' appropriate skills in management of time and work space during early transition have been transferred during the period of transition, though much can be done to narrow the gap in this element to ensure a smooth operation of task.

One of the elements explored the students' safety and precautionary measures taken during practical work. Safe technique when handling apparatus during transition was only observed in the using and handling of measuring cylinder. Findings from early transition revealed that most of the students performed unsafe technique in using the apparatus such as the using of the Bunsen burner. At late transition, none of the students can manipulate the air hole correctly which can affect their safety during the using and handling of the apparatus. In handling the thermometer, some dangerous techniques have been displayed by the primary school students at early transition. However, observation at secondary school indicated that some improvement occurred during transition where most of the students have applied safer techniques in using the thermometer. In using the microscope, most of the problems occurred during slide preparation where the students tended to press hard on the glass slide cover when preparing the specimen. This technique was displayed at early and late transition phases. Overall findings for this particular element on safety indicated that during transition most of the students have somehow neglected the safety procedures required during scientific experiments in the laboratory. This issue may get in the way of using the apparatus competently.

The final element of functional aspect in performing experiment discussed issues of making assumption, measuring and scientific drawing. The observation data at primary school indicated that almost all of the Year 6 students in this study showed tendencies to assume the initial temperature of the water as 0^{o}C. It was iterated in the interview that it has been a common practice for the students to consider the initial reading of any measurement as “zero”, for example, the initial speed of a car or the initial volume of water is equal to zero.

All of the students did not show an adequate measuring technique in measuring solutions at early transition. They did not measure the solution by observing the bottom level of the meniscus, but by reading the upper meniscus instead. The students did not show any progress in this particular element during transition. From the interview at early and late transitions, the students admitted that they were not even familiar with the term ‘upper and lower meniscus’. The teachers only stressed on the importance of reading the meniscus parallel to the eye-level, without explaining the correct procedure in order to ensure the accurateness of their reading. When asked during mid-transition laboratory observation, the teacher explained that in the science syllabus the students are not required to learn such a technique to get the accurate measurement.

In measuring the temperature, most of the problems in reading the meniscus occurred at early transition. For instance, the students were not able to give the correct reading of the water temperature and took the reading of the water temperature as 3.0^oC instead of 30^oC and 3.8^oC instead of 38^oC. The task challenges the students' abilities in relating what they had learnt in theory with the real situation during practical work. Students should realize the facts that that melting point and boiling point of water is 0^oC and 100^oC respectively, and water at room temperature is at 27^oC. If the students understand these facts, they will be able to evaluate that a room temperature reading of 3.0^oC and 3.8^oC is certainly unacceptable.

The students displayed different abilities in the sub-element of "scientific drawing" at early and late transition. Based on the proposed framework on analyzing students' drawing, the students' skill during transition can be categorized as inadequate. For instance, almost all of the students failed to label as well as provide the full title and magnification scale for scientific drawings at early and late transitions. The problem is, however, expected, since as indicated through the laboratory observation at mid-transition, teachers always gave students the expected illustration of scientific drawings during discussion, but not detailing on the specific criteria of scientific drawings. In fact, scientific drawings should be taught since primary school as one of the criteria of manipulative skills in PEKA (the UPSR Science Practical Work assessment). The teacher did not emphasize the important aspect as to what constitutes an acceptable scientific drawing, focusing instead on giving the answer from the practical book for the students to copy.

In conclusion, from the findings I have found that there are differences in the students' acquisition of technical skills and functional aspects of performing scientific experiments. Significant gaps in manipulative skills can be observed during the period of transition. The gap in the context of this study can be detected when students show no progress or even regression of skills during transition. The issues need to be recognized and resolved for the students to experience a smooth transition in science. Research evidence suggests that specific programs need to be constructed to address the gap during the period of transition. Based on past studies and from the findings, there is a need to come out with intervention resources in the context of this study. Thus I have prepared a resource guide called 'Meniti Peralihan' (Bridging the Gap during Transition). The preparation of the resource guide will be thoroughly discussed in the next section.

FIVE LEVELS HIERARCHY OF LEARNING TECHNICAL SKILLS DURING TRANSITION FROM PRIMARY TO SECONDARY SCHOOL

The findings from technical skills of using apparatus showed a continuity of the element which can be served as a hierarchy of learning technical skills. The pattern in technical skills reflects as a hierarchy which can be mapped with the psychomotor domain taxonomy similar to Ferris and Aziz's psychomotor domain (2005). The psychomotor domain taxonomy models which have been discussed in Chapter 2 (e.g., the Ferris and Aziz, Simpson and Dave psychomotor domain) provides direction in constructing a hierarchy of learning technical skills that is pertinent for students to master during the transition from primary to secondary school.

Technical skills in this study refer to skill, abilities and knowledge required for accomplishing a specific task in the laboratory. The skills include knowledge and skills needed to properly manipulate and operate scientific apparatus when executing a scientific task. Five elements of technical skills emerged during data analysis. These elements have been organized into a systematic hierarchy of learning technical skills during transition from primary to secondary school.

The hierarchy assumes that student advancement to the next level of skills depends on achievement of the lower level of technical skills. The findings showed that the students' ability to obtain an advanced skills level was only made possible by mastering of basic skills level (refer to Table 4.4). For example, the students' difficulty in mastering the basic level of technical skills - which refer to the recognition of an apparatus and identification of its parts, will impede their understanding of principles in using the apparatus. This problem may affect the students' ability to operate the task efficiently.

Table 4.4

Five (5) Levels Taxonomy of Learning Technical Skills

Technical Skills		
Recognition of apparatus and its function		BASIC
Identification of part of apparatus and its function		
Understanding of the basic principles in using and handling of apparatus		
Approaches to minimize standard errors during measurement (Graduated apparatus)	Correct sequences in using apparatus (Sequential apparatus)	
Ability to operate the task efficiently		ADVANCED

The learning of manipulative skills during practical work depends on the students' development of cognitive abilities. In this taxonomy, a higher level of technical skills involves more complex cognitive and psychomotor abilities. Students need to integrate their psychomotor skills (hands-on) and cognitive ability (minds-on) when performing specific scientific tasks in the science classroom in order to be competent in manipulating a certain apparatus. Table 4.5 explains each level of technical skill in the taxonomy.

Table 4.5

Taxonomy of learning technical skills during transition from primary to secondary school

Technical Skills	Explanation
1) Recognition of apparatus and their functions	The most basic technical skill which involves student ability to recognize any particular scientific apparatus and its specific function(s). Students should not only be able to recognize the apparatus and state its function(s) but they have to practically demonstrate their understanding by using the correct apparatus according to its function. Example: Student should be able to recognize the function of a measuring cylinder as a measuring tool and be able to differentiate between the function of a beaker and a measuring cylinder during science experiments. Measuring cylinder is used to make accurate measurements of liquid volumes and beakers should only be used for ball park estimations.
3) Understanding of the basic principles in using and handling of apparatus	Concerns on the student's ability to understand the basic principles of using apparatus and practice the appropriate technique of handling it in order to obtain accurate results for the experiment. Students should be able to perform the correct procedure of using the apparatus to avoid damage to the object or hazard to anyone. Example: In using the thermometer, among the basic principles that the students should understand is the appropriate way of handling the thermometer which include avoiding holding it at the tip of the stem, immersing the correct end (the bulb) into the solution, not letting the bulb touch the base of the beaker and avoiding using the thermometer to stir the solution.
4a) Approaches to minimize standard errors during measurement	Focus on the student's ability to avoid or minimize parallax error when using graduated apparatus by practicing the appropriate techniques. Students should be able to relate the conceptual and procedural understanding in order to obtain accurate measurement. Example: In using the measuring cylinder, most of the students are aware of the need to ensure their eyes are

	parallel to the meniscus. However, the approach that they display in order to accomplish the criteria can be inappropriate, for example, by lifting the measuring cylinder and overlooking the basic principle which is to place the cylinder on a flat surface.
4b) Sequences in using apparatus	Focus on the ability to identify the sequence of using the apparatus. The competency in sequencing can be related with student awareness in implementing appropriate precautious measures during the using and handling of the apparatus. Most of the apparatus use the same principle of operation, even though the sequence can slightly differ according to the apparatus. The suitable sequence of using the apparatus should be followed by the student in order to be familiar with the apparatus which in turn will lead to greater efficiency in handling. Example: In using the Bunsen burner, the collar of the Bunsen burner should be turned before the user starts to light up the burner so that the air-hole is closed. After the flame is lit, the air hole needs to be open so that the flame changes to a non-luminous blue flame. Inability to recognize this sequence will affect the student's awareness on the appropriate precautious measures that should be taken during manipulation of the Bunsen burner.
5) Ability to operate the task efficiently	Concern with the student ability to manipulate the apparatus and perform the work efficiently and confidently. Student possesses, and uses required technical knowledge and skills to do the task at a high level of accomplishment. At this level, the skills can be performed independently with accuracy and exactness. Student needs to master the basic technical skills of using apparatus in order to reach to this level of competency. Students are able to perform a task by using the tools skilfully, for which the tools were designed. This technical skill can be determined by observing the level of guidance that the student needs in performing scientific tasks. Example: Some of the students show awkward and choppy actions when using the microscope. This serves as an indicator that the student has difficulties in mastering the basic level of technical skills. However, some of them exhibit smooth operation of task when using the apparatus and are able to work independently without much supervision from the teacher.

APPLICATION OF THE FINDINGS: PREPARATION OF MANIPULATIVE SKILLS RESOURCE GUIDE

The findings of the study revealed that the main problem arising from the research was that most of the students were unable to master the manipulative skills in using the four basic apparatus during transition and this will impede their science learning in secondary school. Responses from primary and secondary school teachers have prompted a need to prepare some form of guide to be used either at the end of Year Six or at the beginning of Form One. This section addresses the second part of the second research question of this study which is to narrow the gap in manipulative skills to ensure a smooth transition in science learning. Preparation of this resource guide was not the original intention of this study. This study is not a developmental research. However it is strongly felt that there is a need to prepare this guide based on the emerging findings, in order to facilitate teachers in bridging the gap between primary and secondary school and to establish a smooth continuity in manipulative skills.

INSTRUCTIONAL DESIGN MODEL

Like with the preparation of any instructional materials, this resource guide is constructed based from analysis of three instructional design (ID) models. The term instruction design (ID) can be defined as the systematic and organized process for analyzing, designing, developing, evaluating and managing the instructional process efficiently (Dick, Carey & Carey, 2001; Isman, Abanmy, Hussein, & Al-Saadany, 2012). Since this is not a developmental research, the instruction design models have provided guidelines or frameworks to organize and structure the process of creating instructional activities. In this study, three ID models have been reviewed for ideas in preparing the materials for the resource guide. The ID models are the Isman, ADDIE, and ASSURE instructional design models.

Isman's (2011) instructional design model provides effective methods of organizing learning activities in a long-term basis. The theoretical assumptions underpinning the model are based on behaviorism, cognitivism and constructivism theories. The theories play an important role for the students to construct new knowledge in learning. In order to achieve the objectives of learning, instructional processes should follow the five stages of input, process, output, feedback and learning (Isman, 2011). The steps and the stages of the model are as in Figure 4.38.

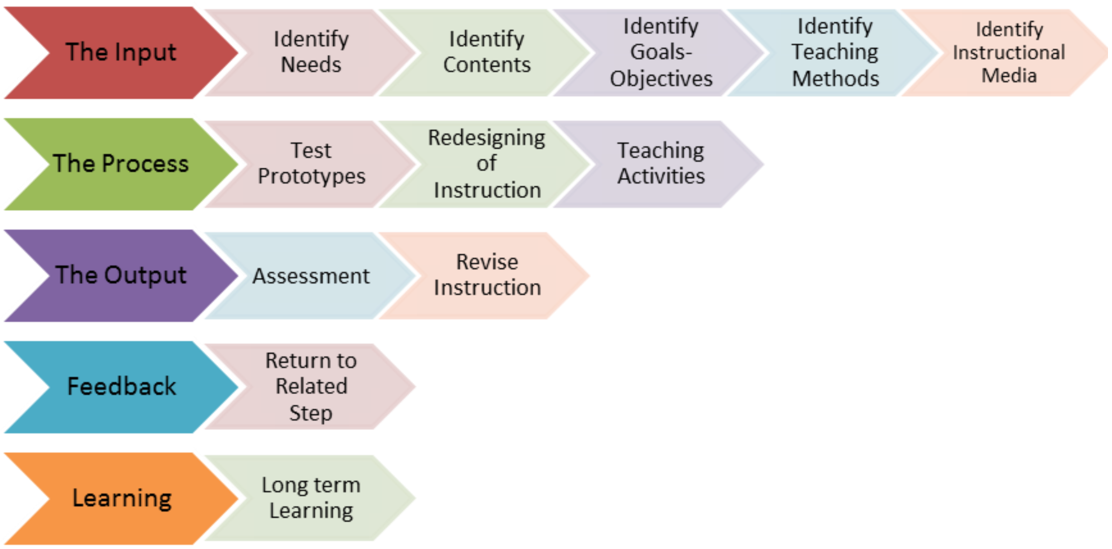


Figure 4.38 The steps and stages of Isman ID Model (2011)

The ASSURE model (Heinrich, Molenda, Russell, & Smaldino, 1996) is an instructional model widely used in designing instruction that integrates technology and online materials into the teaching process. The ASSURE model consists of six dimensions (refer Figure 4.39). The model is underpinned by constructivism theory which states that knowledge is constructed by the learner based on the prior knowledge which stems from the learners' previous experiences. The interesting fact about the

ASSURE model is it gives new teachers a general roadmap to follow in order to help them think more like experts. Teachers have to follow the six dimensions under this roadmap in order to achieve the objective of learning.

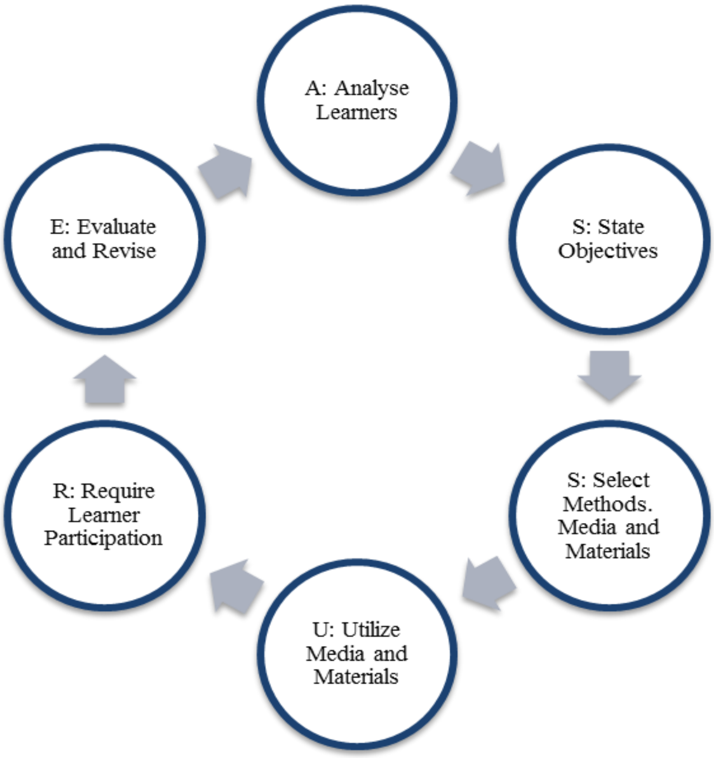


Figure 4.39 The components in ASSURE Model

‘Analyze learners’ emphasizes the importance of analysing the learners’ required skills and appropriate learning styles based on their prior knowledge. ‘State objectives’ relates to the construction of desired learning outcomes and objective of instruction. ‘Select methods, media and materials’ require the teachers to select, modify or design appropriate methods, media and materials to achieve the learning objective. In ‘utilize media and material’, an operation plan which involves pilot testing and adjustment of the teaching material should be developed to ensure effective instructional condition. ‘Require learner participation’ demands teacher to keep an active engagement during instruction, in line with the constructivist learning theory. Finally, “evaluate and revise” refers to the evaluation of the student's performance, the process of teaching, the materials and the assessment methods (Smaldino, Russell, Heinich, & Molenda, 2005).

The ADDIE Model is the systematic instructional design model which serves as a basic framework for almost all instructional design models (Isman, Abanmy, Hussein & Al-Saadany, 2012). Figure 4.40 lists the five (5) phases of the 'process' model.

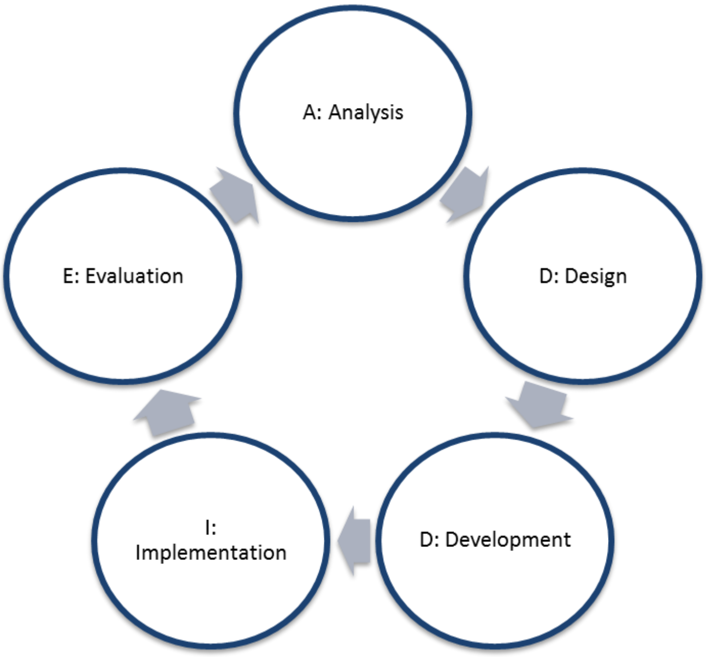


Figure 4.40 Five phases of ADDIE Model

The ADDIE Model guides the process of creating effective educational courses and materials for the learners. The model follows the following phases:

(a) Analysis: The pre-planning phase where the information is gathered to assess the what, who, why and how aspect of activity.

(b) Design: Identify the learning objectives and desired outcomes. The phase includes the design of content, strategies and teaching instruction for a learning module.

(c) Development: Develop the materials based on design phase.

(d) Implementation: Begin teaching and learning - putting the plan into action based on the developed materials.

(e) Evaluation: Critically check for effectiveness of the instructional program

From the analysis of the three ID models, I found that ADDIE Model serves as a basic framework for most of the design models such as ASSURE and Isman instructional design models. The ID models provide an organized way to develop learning activity and instructional programs to ensure competent performance by the learners.

Any ID model is developed based on the specific theoretical foundation, for instance, the ASSURE model uses constructivism theory and the Isman Model integrates behaviourism, cognitivism and constructivism. Thus, the researcher's theoretical consideration plays a role in gauging the appropriateness of using each model. Developing an instructional material takes a lot of effort, time and consideration. For instance the construction of the Isman Model involves five main steps and contains twelve different stages, which are certainly time-consuming.

After much consideration, I decided to use a modified framework of the ADDIE Model. I focused on three main phases which are guided by the ADDIE Model and the materials were then revised, based on the evaluation process feedback.

PHASES OF PREPARING 'MENITI PERALIHAN' RESOURCE GUIDE

The resource guide is a guide given to teachers during the period of transition, which includes diagnostic tests, manipulative skills rubrics and scoring guides to determine the student's level of competency. It is designed to give information that the teachers will need in order to ensure a smooth transition in manipulative skills. The resource guide is named 'Meniti Peralihan' which means 'Bridging the Transition Gap'. The resource guide has been prepared in the Malay language because the Malay language is the medium of instruction in teaching and learning of science at primary and secondary schools. The three (3) phases of preparing the resource guide are (1) analysis (2) design and development and (3) implementation and evaluation.

Analysis

Analysis phase is the pre-planning phase where all the related information for the study is gathered. In this study, a needs analysis was conducted in order to get a comprehensive understanding of the phenomenon. Issues related to transition in science manipulative skills have been analyzed and discussed thoroughly in the review of literature (refer Chapter 2). The information also emerged from the analysis of data which has been thoroughly discussed in the previous section. Findings from this study showed that students have the tendency to assume science at primary school and secondary school as two different subject matters and they confronted difficulty in understanding the continuity of learning science during the transition period.

This issue has also been raised during an interview with a secondary school teacher, where she suggested that science teachers during transition should "*ensure the same method in acquiring scientific data in primary and secondary school is used so the students will not be confused*," (ST2b, Ln. 95-97). This can also be supported by findings from Galton et al. (2003) and Hawk and Hill (2004). Hawk and Hill (2004) claim that scientific knowledge at secondary school has not been built based on the students' prior knowing where teaching and learning has been viewed as fragmented, subject-based and with minimum collaboration in the classroom.

From the understanding of the phenomenon, potential solutions for the problem can be identified. Literatures (for e.g. Braund, 2009; Galton, 2002) suggest that specific programs need to be constructed to address the gap during the period of transition. Based on the needs analysis of the past studies and also from the findings of this study, a resource guide called 'Meniti Peralihan' ('Bridging the Transition Gap') has been prepared.

Design and development of 'Meniti Peralihan' resource guide

'Meniti Peralihan' resource guide has been prepared based on the earlier phase of analysis. The guide can be implemented during the transition period, at the end of Year Six (early transition) and at the beginning of Form One (late transition). The primary objective in preparing this resource guide is to bridge the gap in teaching and learning of science manipulative skills during transition.

The findings of this particular study indicated that in order for the teacher to efficiently bridge the gap in science manipulative skills during transition, there is a need to gauge the student's level of competency. Once the students' competency has been determined, teacher will be able to enhance their manipulative skills accordingly. The rationales of preparing the resource guide are stated in Figure 4.41.

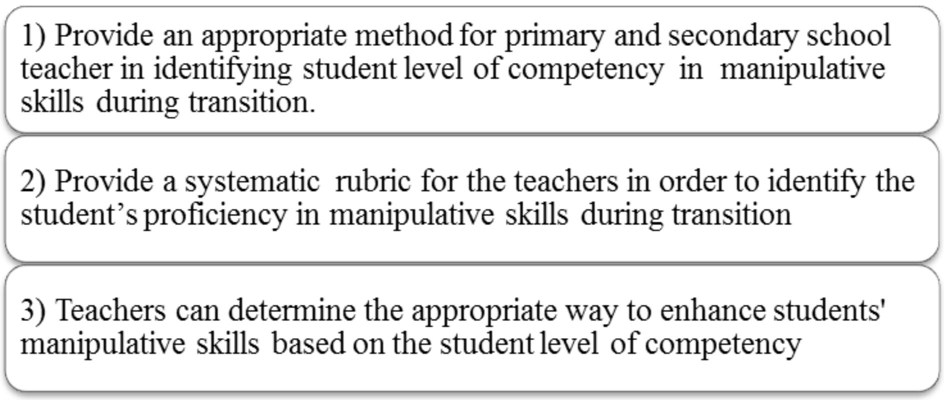


Figure 4.41 Rationale for the 'Meniti Peralihan' resource guide

The resource guide has been designed in booklet form. Some of the pages can be photocopied for class use, for example the diagnostic test and the 'Manipulative Skills Competency' form.

The first section of the resource guide is the diagnostic test of student's manipulative skills. Diagnostic test served as an instrument for systematic identification of the student's problem in manipulative skills. Four (4) activities were proposed (as shown in Table 4.6). Activity A involved the use of measuring the cylinder, the thermometer and the Bunsen burner. Activity B involved the use of microscope which includes the preparation of slide. All of the activities were taken from the MSTT.

Figure 4.42 are the example of the activities from the guideline, which has been written in the Malay Language. The information such as learning objectives, learning outcomes, apparatus and materials needed for the experiment, experiment procedures and table for results are provided in the activity sheet for each diagnostic test.

In Figure 4.42 (Activity A(ii)), students are required to conduct an experiment to understand how the presence of salts affects the boiling point of water. The learning outcome is to measure the water temperature when impurity such as salt is added to the solution. Students' skills in using the measuring cylinder, the thermometer and the Bunsen burner will be observed during the execution of this experiment. The apparatus and materials needed for the experiment are beakers, thermometers, Bunsen burners, measuring cylinders, tripod stands, spatulas, glass rods, lighters, candles, tongs, distilled water and salt. A guide depicting simple procedures of the experiment for students to follow, are given. They have to write their results in the given space and state the safety procedures they have taken for this experiment.

Table 4.6

Activities for diagnostic test

Activity	**Primary School**	**Secondary School**
Activity A: Understanding Water	Activity A (i)	Activity A (ii)
Activity B: Science Under The Microscope	Activity B (i)	Activity B (ii)

The second section consists of manipulative skills analysis rubric. There were two rubrics provided in this resource guide: rubric for Activity A and Activity B (refer Appendix M). During the execution of activity A and B, teachers are required to observe the students' ability, and to give points for each criterion: low = 0 mark, intermediate = 1 mark and high = 2 marks. The total score will reflect the student's ability in manipulative skills for each category. The criteria and categories in the rubric were based on the dimensions and elements from the findings of this research. The main categories include: systematic operation of task, management of time and workspace, safety and precautionary measures, numeracy, scientific drawing, technical skills in using measuring the cylinder, the thermometer, the Bunsen burner and the microscope, as well as the preparation of slide for specimen.

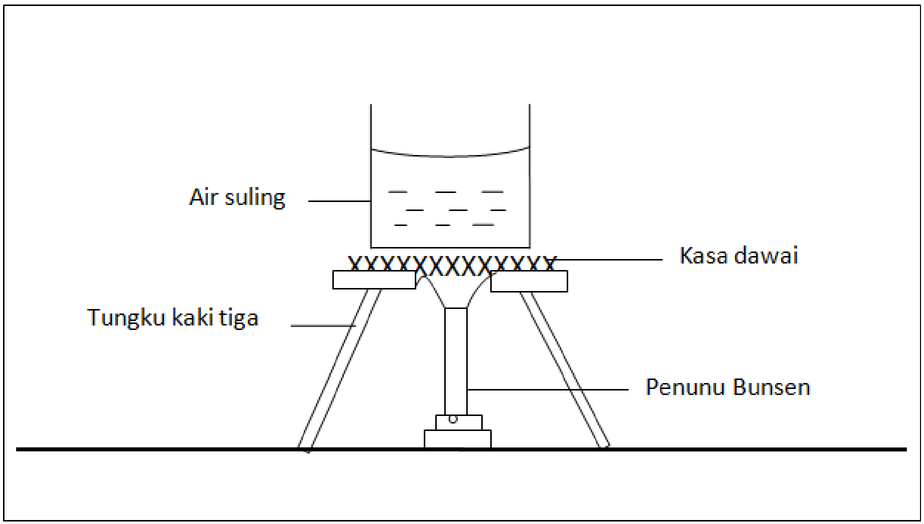
The scoring rubrics for the resource guide were guided by steps of marking rubric (for e.g. Stevens & Levi, 2005). The teachers were asked to give feedback on the categories which describe the level of quality of skills (ranging from basic, intermediate to high level of competency). The scoring rubrics were revised on the basis of the teachers' feedback. Table 4.7 summarizes the criteria for the categories in rubrics A and B.

<u>Eksperimen</u>

Objektif pembelajaran	:	Untuk memahami bagaimana kehadiran garam akan mempengaruhi takat didih air
Hasil pembelajaran	:	Untuk mengukur suhu air apabila ditambah bendasing seperti garam
Kemahiran penggunaan alat yang diperhatikan	:	Silinder penyukat, termometer dan penunu Bunsen

Radas dan bahan :

Bikar	Pemetik api
Termometer	Rod kaca
Penunu Bunsen	Lilin
Silinder penyukat	Penyepit
Tungku kaki tiga	Air Suling
Kasa dawai	Garam
Spatula	Papan asbestos



Prosedur:

1. Sediakan radas seperti yang ditunjukkan dalam rajah di atas.
2. Sukat 100 ml air dan tuangkan ke dalam bikar yang bersih.
3. Nyalakan penunu Bunsen dan didihkan air suling.

Figure 4.42 Activity A(ii)- to understand how the presence of salts affects the boiling point of water

Table 4.7
Summary of Criteria for Each Category

Category	Criteria
Systematic operation of tasks	1. Following instructions in performing overall operation of task 2. Checking the functionality of apparatus 3. Communication with group members to ensure a systematic operation of task
Management of time and workplace	1. Using time 2. Condition of working area before, during and after experiment 3. Cleaning and storing of apparatus and materials
Safety and precautionary	1. Safety procedure during experiment 2.Technique in using apparatus in order to prevent unwanted damage
Numeracy	1. Making assumptions 2. Skill in reading meniscus of measuring cylinder 3. Skill in reading meniscus of thermometer
Scientific drawing	1. Use pencil to draw 2. Production of neat line drawing 3. Appropriate title of the drawing 4. Correct label of scientific drawings 5. Magnification of drawing is indicated 6. Authentic drawing – based on observation
Technical Skills in Using Apparatus	(i) The use of measuring cylinder to measure volume 1. Ability to recognize apparatus, their features and functions 2. Using appropriate measuring cylinder in measuring volume of solution 3. Placement of measuring cylinder 4. Eye position when reading meniscus 5. Efficiency in using measuring cylinder 6. The need for guidance (ii) The use of thermometer to measure temperature 1. Ability to recognize apparatus, their features and functions 2. Technique in holding the thermometer 3. Using the correct part of the thermometer to measure temperature. 4. Ensuring the thermometer bulb does not touch the bottom or the wall of the beaker. 5. Wait for the temperature to be stable by stirring the solution before taking the temperature.

6. Eye position when reading meniscus
7. Appropriate way of taking the measurement of the water temperature (did not take the thermometer out from the solution)
8. Efficiency in using the thermometer
9. The need for guidance

(iii) The use of the Bunsen burner

1. Ability to recognize apparatus and their function
2. Ability to identify parts and features of apparatus and their functions
3. Manipulation of gas hole before lighting the Bunsen burner (the collar of the Bunsen burner should be turned so that the air-hole is closed)
4. Light up the candle/lighter before turning on the gas
5. Manipulation of air hole after lighting up the Bunsen burner (Open the air-hole, so that the flame changes to the non-luminous blue flame)
6. Efficiency in using the Bunsen burner
7. The need for guidance

(iv) Slide preparation

1. The use of correct stain in appropriate amount
2. Technique in using the slide cover

(v) The use of the microscope

1. Ability to recognize apparatus and their functions
2. Ability to identify parts and features of apparatus and their functions
3. Handling the microscope (techniques in holding it and placing on flat surface)
4. The use of stage clips to secure the specimen slide
5. The use of the lowest magnification power objective lens by rotating the nosepiece
6. Ability to coordinate the mirror, condenser and diaphragm in order to get sufficient source of light.
7. Adjustment of the coarse adjustment knob until the specimen is in focus.
8. Adjustment of the fine adjustment knob until the focused specimen is well-defined.
9. Efficiency in using microscope
10. The need for guidance

63

SENARAI SEMAK KEMAHIRAN MANIPULATIF (SKM)

MODUL A

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	Sederhana	Tinggi
(A) OPERASI KERJA YANG SISTEMATIK **Semasa eksperimen didapati bahawa murid:**				
1.	Kebolehan untuk mengikut peraturan dan arahan secara keseluruhan	Tidak dapat mengikut peraturan dan arahan secara keseluruhan mengikut prosedur yang diberikan	Boleh mengikut peraturan dan arahan secara keseluruhan dengan sederhana, mengikut prosedur yang diberikan	Dapat mengikut peraturan dan arahan secara keseluruhan dengan efektif mengikut prosedur yang diberikan
2.	Pemeriksaan dan pengenalpastian kerosakan pada alatan sebelum penggunaan	Tidak dapat memeriksa dan mengenalpasti sebarang kerosakan/ ralat pada alatan	Memeriksa kebolehgunaannya alatan sebelum menjalankan eksperimen namun tidak dapat mengenalpasti sebarang kerosakan/ralat pada alatan	Dapat memeriksa dan mengenalpasti sebarang kerosakan/ralat pada alatan sebelum menggunakannya
3.	Komunikasi dengan rakan sekumpulan	Tidak berkomunikasi secara efektif dengan rakan sekumpulan	Berkomunikasi secara sederhana dengan rakan sekumpulan	Berkomunikasi secara efektif dengan rakan sekumpulan

Universiti Malaya

Figure 4.43 First page of manipulative skills rubric for Activity A

Figure 4.43 shows an example of rubric for Activity A. Each of the criteria is divided into three main levels of acquisition which are low, intermediate and high. The first criteria in category A “Systematic operation of tasks” is on student ability to follow instruction in performing overall operation of task. For the ‘low’ level of acquisition, the student is unable to follow overall instructions and the given procedures for the experiment. For the ‘intermediate’ level, the student is able to follow the instruction and procedures but not as effective as the student in the ‘high’ level. The second criterion in the same category is on checking the functionality of the apparatus before use and the third criterion is about the student’s communication skill in the overall operation of tasks. The teacher has to determine the student level of acquisition for each of the criteria in this category and give the appropriate points: ‘0 mark’ will be given to student with low level of acquisition, ‘1 mark’ for intermediate and ‘2 marks’ for those in the high level. This will be followed by the second category of “Management of Time and Workspace”.

There are three (3) criteria under Category A “Systematic operation of tasks”. Thus the maximum point a student can obtain in this category is six marks and the minimum mark is zero. In order to determine the level of competency for each category, the teacher needs to refer to a score guide as illustrated in Figure 4.44.

SKOR BAGI TAHAP KECEKAPAN KEMAHIRAN MANIPULATIF

Kategori	Asas (Basic)	Sederhana (Intermediate)	Tinggi (High)
Operasi Kerja Yang Sistematik	0 – 1	2 - 4	5 – 6
Pengurusan Masa Dan Tempat Kerja	0 – 1	2 - 4	5 – 6
Langkah Pengawasan Dan Keselamatan	0 – 1	2 – 3	4
Numerasi	0 – 1	2 - 4	5 – 6
Lukisan Saintifik	0 – 6	7 - 11	12 – 14
Kemahiran Teknikal Dalam Penggunaan Alatan (Aktiviti A)			
Penggunaan Silinder Penyukat Untuk Menyukat Isipadu Cecair	0 – 4	5 – 9	10 – 12
Penggunaan Termometer Untuk Mengukur Suhu Cecair	0 – 6	7 – 15	16 – 18
Penggunaan Penunu Bunsen Untuk Pemanasan	0 – 5	6 – 11	12 – 14
Kemahiran Teknikal Dalam Penggunaan Alatan (Aktiviti B)			
Numerasi	0 - 1	2 – 4	5 – 6
Lukisan Saintifik	0 - 6	7 – 11	12 – 14
Penyediaan Slaid	0 - 1	2 – 3	4
Penggunaan Mikroskop	0 - 8	9 – 16	17 – 20

Figure 4.44 The scoring guide to determine student competency level

The cumulative score for each category will determine the student's level of competency. This score will provide a guide for teachers in determining the student ability in every category of manipulative skills. For example at primary school, Student A scores cumulative of 1 mark in the first category, the 'Systematic operation of tasks'. From the score guide, under this first category, '0-1 marks' is categorized as 'basic level' competency, '2-4 marks' as 'intermediate level' and '5-6 marks' signifies 'high level' competency. Student A will be categorized under the 'Basic' level of competency for this particular category (refer Figure 4.44). However in using the thermometer the student scores 16 out of 18 marks which is categorized under 'high level' of acquisition of skills. From this information, the secondary school teacher should acknowledge Student A's difficulty in performing systematic operation of tasks and can continue to improve the student's skills in this specific category. In using the thermometer, Student A is considered as proficient but the teacher can analyze the criterion which did not attract full marks- for example, there is the possibility that Student A did not stir the solution using the glass rod.

Teachers need to write down all the scores in the 'Manipulative Skills Competency Form' as in Figure 4.45. From the score, teachers can determine the student level of competency for each and every category and summarize the student's level of competency.

BORANG PENGESANAN TAHAP PENGUASAAN KEMAHIRAN
MANIPULATIF
MODUL B

Nama Pelajar :
Kelas :
Guru Pemeriksa :
Arahan :
Guru memberi skor bagi setiap kriteria dalam kategori mengikut skema berikut:
Rendah = 0 markah; Sederhana = 1 markah; Tinggi = 2 markah

Kategori	**Skor**	**Tahap Kecekapan**
Operasi Kerja Yang Sistematik	/6	
Pengurusan Masa Dan Tempat Kerja	/6	
Langkah Pengawasan Dan Keselamatan	/4	
Lukisan Saintifik	/14	
Kemahiran Teknikal Dalam Penggunaan Alatan		
Penyediaan Slaid	/4	
Penggunaan Mikroskop	/20	

Komen Pemeriksa:

Figure 4.45 ‘Manipulative Skills Competency’ Form for Activity B

The third section of this resource guide contains a description of each level of competency in manipulative skills. The guide describes the general criteria of a student with ‘basic’, ‘intermediate’ or ‘high’ competency of manipulative skills. It was constructed based on the research findings and the theories underpinning this research. For example, students with high level of competency of manipulative skills demonstrate smoothness and efficiency in manipulative skills, display high skills to achieve the learning objective and are able to adapt their skills to a new situation. The skills can also be applied with minimum supervision. At this level, the movement has been ingrained the students’ minds and most of the action is automatic, where practices will enhance the students’ precision and accuracy of manipulative skills.

Implementation and Evaluation

The following phase focuses on the implementation and evaluation of the prepared ‘Meniti Peralihan’ Resource Guide. In the evaluation phase, there is the need to critically consider the appropriateness of the resource guide in order for it to be implemented in our local context. The resource guide was implemented and evaluated by a group of teachers. For this purpose, a two-day workshop in a teacher training institute in Kota Bahru, Kelantan was organized. The implementation and evaluation phase was conducted in Kelantan because approval to collaborate with the Kota Bahru Teacher Training Institute, as well as the Kelantan State Education Department to conduct the ‘Meniti Peralihan’ workshop, had been obtained.

Initially forty (40) school teachers agreed to participate in this two day workshop. The teachers came from 40 different primary and secondary schools in the Kota Bahru district of Kelantan. However only 39 teachers participated in this workshop and these teachers have an average 14 years of experience in teaching the science subject at school (Year Six and Form One Science). (Appendix N)

The two day workshop included an introductory talk, brainstorming session and the evaluation of the resource guide by primary and secondary school teachers. In the introductory session, the objectives, overall procedure and the findings of the study were introduced. This is to allow the teachers to get a clear picture of the study and their important roles in evaluating the resource guide. In the discussion or brainstorming session, the teachers were put into eight groups where they were given a set of problems related to the issue in learning manipulative skills. From the session, all the teachers admitted that their students’ manipulative skills are weak and much guidance is needed and this was similar to the findings of this study. Their teaching and learning of manipulative skills were conducted during practical work in accordance to criteria in

PEKA. The teachers explained that the assessment of students' manipulative skills were made through three mediums (a) observation during practical work, (b) the students' ability to give accurate reading, and (c) appropriate scientific drawing in the practical report. Teachers also raised the issues and challenges in teaching manipulative skills during transition. Among the issues are time constraint, lack of laboratory apparatus, students' attitudes and safety issues.

The evaluation of the resource guide was conducted in two sessions; with primary school teachers and secondary school teachers. The teachers were requested to go through the whole resource guide. At the end of the session, they were asked to give their feedback on the appropriateness of the resource guide. Eight open-ended questions were asked to encourage meaningful answers from the teachers (refer Appendix O). The analysis of answers for each aspect of the given questions is as follows:

(1) Clarity of the explanation

During the design and development phase, among the issues to ponder was the suitability of word and sentence structure used to construct the materials in this resource guide. The experiments (Activity A and B) should be easily understood for the students, whereas the rubrics and instruction for teachers should be well-defined so that teachers can get a clear picture of their role. From the written responses, all the primary and secondary school teachers agreed that the instruction and explanation in the resource guide are clear, systematic and suitable for the students during the early and late transition period. Among the responses were:

> Yes, the given explanations (in the resource guide) conform to the student's ability. (ST3, Ps.)
>
> Clear and satisfying, can assist teachers in teaching and learning of manipulative skills. (ST11, Ps.)

> Yes, it is systematic and helpful for teacher to identify what is to be evaluated during practical. (ST9, Ss.)
>
> The structure of the sentence and language used are simple and clear. (ST12, SS.)

(2) Suitability of the activities or tasks

The teachers who participated in this evaluation phase were experts because of their vast and wide experience in teaching science during transition. Thus, the teachers play an important role in validating the suitability of the given tasks in determining students' level of competency. All the responses from the primary and secondary school teachers in regard to this aspect were constructive. They admitted that the activities were suitable to be used for basic experiment and from the observation of the activities, teachers were able to determine students' level of competency in manipulative skills during transition.

(3) Relevancy of the represented criteria in the rubric

The third aspect focused on the relevancy of the criteria in the rubrics in the context of science learning. The criteria were constructed based from the research findings. The following excerpts illustrate the teachers' responses to the third question,

> Yes, it can be used as guide (to teacher) and it follows the students' appropriate level of competency. (ST1, Ps.)
>
> It is relevant to the science curriculum for primary school. (ST13, Ps.)
>
> Yes it is relevant and follows the curriculum of secondary school. (ST4, Ss.)

(4) Clarity of the underlined criteria in the rubric

From the given feedback, the teachers have no problem comprehending all the criteria and among the given response from primary and secondary science teachers were 'it is easily understood' (ST4, Ps.) and 'simple criteria, easily understood' (ST1, Ss.).

(5) The usability of the Manipulative Skills Competency instrument

As an instructor, it is important for the teacher to be able to follow the instruction in the resource guide accordingly. The important aim of the resource guide is to determine students' ability or level of competency in manipulative skills. Thus the appropriateness of 'Manipulative Skills Competency Form' needs to be determined.

Most of the teachers found this instrument practical, for instance Primary Teacher 5 responded that "it is suitable, systematic and can be used to determine the students' level of competency, in accordance with the criteria proposed in the rubric". It can also guide the teachers to identify what needs to be evaluated during practical work (ST9, Ps.) and to determine which categories of skills need improvement during transition (ST7, Ss.).

(6) The suitability of the resource guide to be implemented in school during the period of transition

The teachers gave a warm response toward the 'Meniti Peralihan' Resource guide. It can assist the secondary school teachers in identifying the students' competency of manipulative skills during transition to secondary school (ST1, Ps.). It is systematic and comprehensive (ST9, Ps.) and can help teachers and students to understand the concepts of manipulative skills based on the criteria proposed in the rubric (ST13, Ps.). The resource guide can also be used to assist teachers in school-based assessment (ST1, Ss.) and facilitate students to increase their proficiency in manipulative skills.

(7) Improvement to the resource guide

The final question needed the teachers to give some recommendations for improvement. Among the recommendations are:

(i) to add more safety measures (ST2, Ps.)

(ii) to use the resource guide to support PEKA assessment (ST8, Ps.)

(iii) separate the resource guide for primary school and secondary school (ST9, Ps.)

(iv) come out with a certificate or a form of students manipulative skills competency at primary school and this evidence of competency level needs to be given to the secondary school science teacher during transition to secondary school (ST1, Ss. & ST14, Ss.)

The evaluation phase with the experts was followed by revision of the resource guide. Most of the modifications and adjustments made to the guide focused on the structure and arrangement of the resource guide to facilitate its use by science teachers. The instruction has been clarified to avoid any difficulties in implementing all the resource guide materials. An ‘Observation Mark Sheet’ to assist teachers in recording students’ marks during observation was also created (refer to Appendix P and Q). The mark sheet is to be used once they have familiarized themselves with the criteria from the rubrics. The marks from this ‘Observation Mark Sheet’ can be transferred to the ‘Manipulative Skills Competency Form’.

This workshop has received very positive feedback from the experts. The experts from primary and secondary schools agreed that this resource guide should be implemented as it facilitates science learning during the period of transition. It is hoped that this resource guide can serve as an important instrument in bridging the gap in science during transition. Once the teacher can identify the student level of competency and their weaknesses and strengths in manipulative skills, their focus will become clearer and from here the skills can be further molded, until they achieve the autonomic stage of performing manipulative skills. Figure 4.46 summarizes the phases in preparing the resource guide.

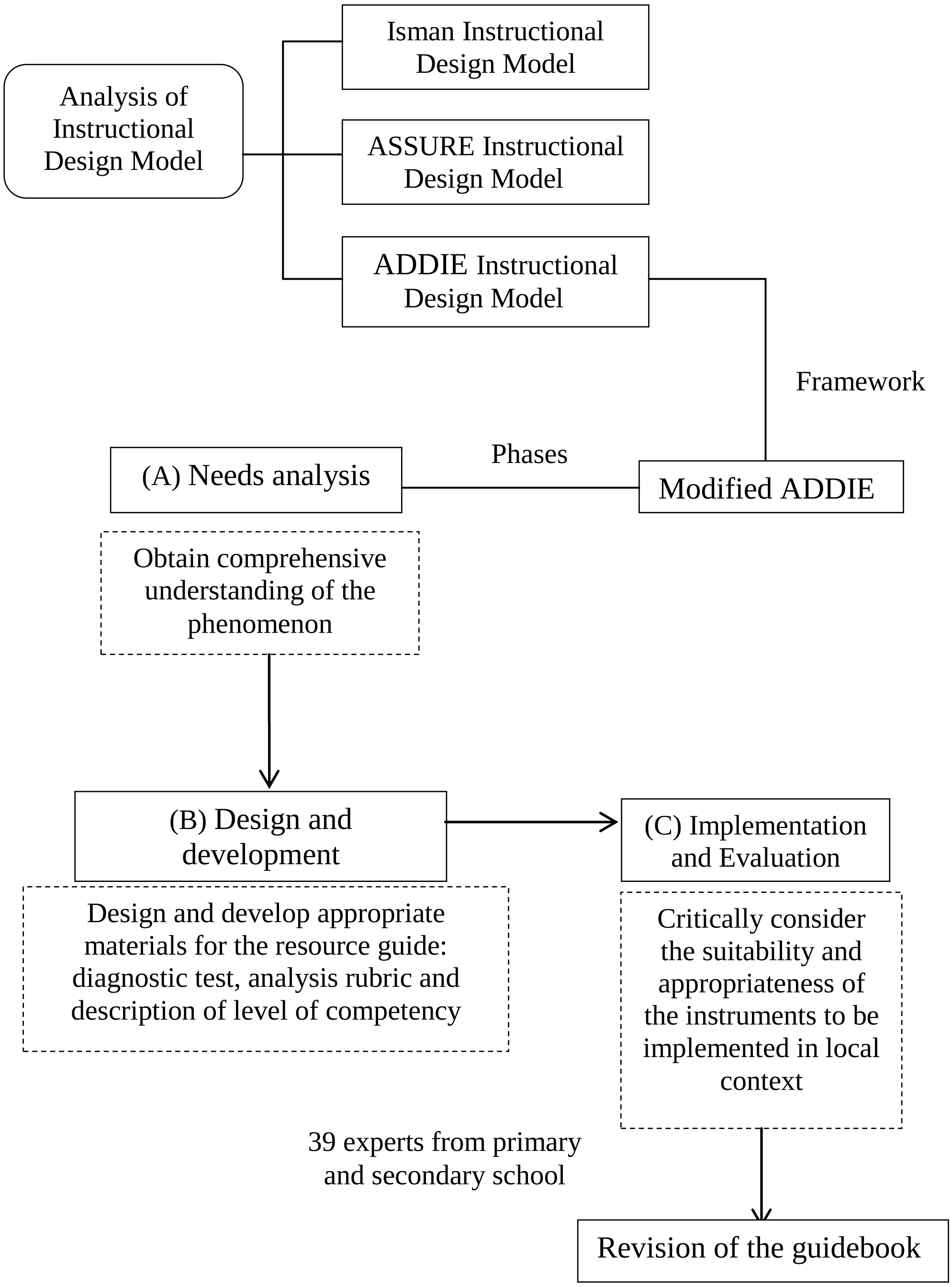


Figure 4.46 Flowchart of the preparation of 'Meniti Peralihan' Resource Guide

CHAPTER SUMMARY

This chapter describes the findings of the present study. The purpose of the study was to explore and investigate the acquisition of students' manipulative skills during the transition from primary school (Year Six) to secondary school (Form One) by employing a qualitative approach. This study examines the differences in the students' ability to perform manipulative skills at primary school and secondary school, and to obtain an understanding of these skills during transition by looking at the students' capability in handling four sets of laboratory apparatus: the Bunsen burner, the microscope, the thermometer and the measuring cylinder.

The overall findings can be presented as in Figure 4.47. The main arrow represents the direction of the process of transition from primary school to secondary school. During the phase of transition, students should acquire the elements and sub-elements in two dimensions of manipulative skills. The dimensions are: (1) technical skills and (2) functional aspects of performing laboratory task. Each dimension comprises important elements and sub-elements that the student should be able to grasp in learning manipulative skills during transition. The student's competency in mastering the dimensions and elements will serve as a strong basis for them to further enhance these skills at upper secondary school.

To conclude, most of the evidence shows that the majority of the participants had responded positively toward the practice of using and handling scientific apparatus in the science laboratory. Even though the students did not display sufficient manipulative skills during transition from primary to secondary school, some of them have shown progression in using scientific apparatus.

In this chapter I have also presented the phases of the preparation of the 'Meniti Peralihan' Resource Guide. The resource guide was prepared based on the findings of this study. I have discussed three instructional design model which are the Isman, ASSURE and ADDIE models. The modified ADDIE model has been used as a framework for preparing the resource guide. Three phases of constructing 'Meniti Peralihan' Resource Guide have been discussed thoroughly, which involved the analysis phase, design and development of the materials, and implementation and evaluation phase by the experts. The main aim of the resource guide is to bridge the gap between primary school and secondary school during transition by focusing on the students' ability in manipulative skills. The experts' opinions of the suitability and appropriateness of this resource guide in our educational context may be used to support the findings of this study. The next chapter will discuss on the summary of the findings, conclusion and discussion of the study and recommendations for further studies.

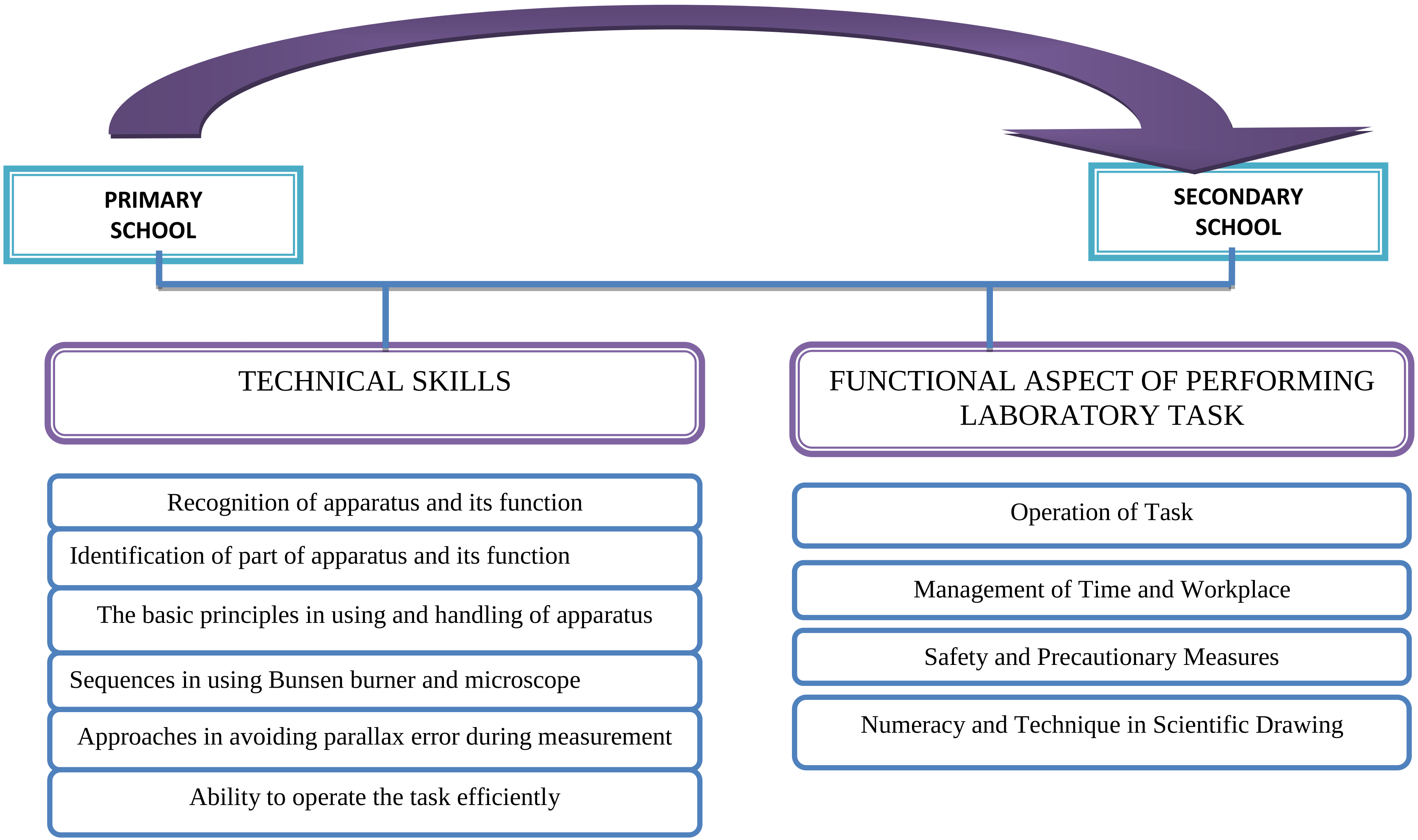


Figure 4.47 Manipulative skills during transition framework

CHAPTER 5

SUMMARY, CONCLUSION, DISCUSSION, IMPLICATIONS AND SUGGESTIONS

INTRODUCTION

In this last chapter the overview of the research, conclusions, discussion, the implications of these collective findings and suggestions arising from this study are provided. The first section gives a brief account of the research including the problem statement, methodology, data analysis and findings, based on the research questions posited. Conclusion of the study is then presented in the following section. This is followed by the discussion of the findings obtained through the study. This chapter will also discuss the implications of the present study for theory and practice. Recommendations are made to give practitioners some guidelines in implementing the findings from this study. Suggestions for future research are then presented in the final section.

SUMMARY: AN OVERVIEW OF THE RESEARCH

Practical work plays a major role in science (Hofstein & Mamlok, 2007; Lawton, 1997; Trowbridge, Bybee & Powell, 2000; Wolfinger, 2000). Science practical emphasizes learning through inquiry-discovery where students are encouraged to learn through discovery of environmental phenomena. Through scientific experiments, students get an opportunity to investigate a phenomenon, draw conclusions by themselves and at the same time practice the scientific skills in the laboratory, including the skills in manipulating apparatus.

In Malaysia, research in science manipulative skills is still limited and much can be done to improve students' laboratory skills. An issue of backwardness or gap in research on the transition process from primary to secondary school exists from the perspective of this country (Noraini Zainal Abidin, 2009). These issues need to be examined further and analyzed in detail. Hence, scientific research needs to be done with an appropriate methodology as an eye-opener to the relevant stakeholders in the local education context. Thus the purpose of the study was to explore and investigate the acquisition of students' manipulative skills during transition from primary school (end of Year Six) to secondary school (early Form One) by employing a qualitative approach. The research questions guiding this study focused on 2 areas of inquiry. The research questions are:

1. What are students' manipulative skills during (a) early transition, (b) mid-transition, (c) late transition?,

2 (a). What are the differences in the aspect of manipulative skills that could be identified among the students during transition?, and

(b). If there is a difference, how can the differences or the gap be narrowed for a smooth transition in manipulative skills?

A qualitative study was employed as the backbone of this research. In order to gain better understanding of this phenomenon, I have selected the basic qualitative research design. The methodology of this research is guided and supported from the analysis of the previous researches in the field of school transition and from researches in manipulative skills. A preliminary study had been carried out before conducting the actual study to get an insight into the phenomenon and to familiarize with the data collection technique.

The main criterion for selecting the schools for this study was based on typical case sampling simply because the school was not unusual in any way and it reflected the average phenomenon of interest (Merriam, 2009; Patton, 2002). The schools were typical in the aspect of the laboratory facilities and each participant from the school experienced transition. Based on the criterion, two primary schools and two secondary schools in Gombak district were chosen for this study. Ten students were selected by their science teacher to participate in this study. Qualitative measures used in this study include individual observation while performing the MSTT, interviews and analysis of scientific drawings. This study was conducted over a period of 11 months beginning on early August 2011 until the end of June 2012. In order to minimize the 'observer effect', I engaged in a familiarization phase for one week where I took the opportunity to build the rapport with the students so they could be themselves during execution of the tasks.

Data from the various sources were collected and organized into a manageable format. All video and audio data were transcribed. These data were then analyzed inductively using the constant comparative method of analysis which involved the process of coding, categorizing and development of themes from information that emerged from the collected data. I had to find general patterns out of the analyzed data, in order to make a robust conclusion of the findings. Refining the thematic framework involved logical and intuitive thinking in ensuring that the research objectives are being addressed appropriately (Ritchie & Spencer, 1994). The reliability and validity of this research was established through the application of triangulation of data and methodology, member check, audit trail and prolonged and persistent field work.

The first research questions addressed Year Six and Form One students' manipulative skills during the transition period. From the analysis of individual observation, the questions have been answered in the form of dimensions and elements emerged during the thematic analysis. The dimensions are: (1) technical skills and (2) functional aspects of performing laboratory task. Each dimension consists of important elements and sub-elements that the student should be able to grasp in learning manipulative skills during transition. The students' ability in mastering the dimensions, elements and sub-elements will serve as a strong basis for them to further enhance these skills at upper secondary school. Research question 2(a) addressed the differences in the aspect of manipulative skills that could be identified between primary school and secondary school students. Most of the evidence showed that the majority of participants had responded positively toward the practice of using and handling scientific apparatus in the science laboratory. They were cooperative in every session conducted at primary and secondary school. However the majority of students did not display sufficient manipulative skills during transition from primary to secondary school. The gap can be detected when students show no progress or even regressed in the manipulative skills during transition. Thus in order to narrow the gap in learning manipulative skills during transition, I have come out with a resource guide called 'Meniti Peralihan'.

I have briefly discussed three instructional design models which are the Isman, ASSURE and ADDIE models. The modified ADDIE model has been used as the framework for preparing the resource guide. Three phases of preparing the 'Meniti Peralihan' resource guide have been discussed thoroughly, which involved the analysis phase, design and development of the materials and evaluation phase by the experts. The main aim of the resource guide is to bridge the gap between primary school and secondary school during transition by focusing on the students' ability in manipulative skills. This study proposed that the resource guide can be possibly used in the science classroom during transition.

CONCLUSION AND DISCUSSION

Based on the findings, three conclusions can be drawn from the study. The first conclusion is students' manipulative skills during transition can be described by the understanding of elements and sub-elements in technical skills and functional aspects of performing laboratory tasks.

Manipulative skills during transition can be described by understanding of elements and sub-elements in technical skills and functional aspects of performing laboratory tasks

Psychomotor domain is generally given the least amount of attention in the course of academic instruction. Bloom (1956), for instance, had come out with learning taxonomies for the cognitive and affective domain and stated that psychomotor domain was not very useful and that not much research has been done on it. Thus in science education, manipulative skill has always been known as a neglected domain. This current study, however, shows that this domain is an important aspect of science learning.

The results of the study suggest that manipulative skills acquisition is very much associated with the students' acquisition of scientific knowledge. Students perform the skills by the inputs that they perceive from declarative memory which involved retention of information. This finding is consistent with Trowbridge et al. (2000) who claimed that the desired behavior in manipulative skills is not an end in itself but the means for cognitive and affective learning in science education. The affective learning concerns student's attitude and interest in science and inculcation of science related values. The results of the study also suggest that students look forward to conducting scientific investigation and the opportunity to use advanced laboratory apparatus in secondary school. This is in line with Lawton (1997) who claimed that students taught by using hands-on experiments will have a better attitude regarding the subject. The ability to master appropriate technique in using apparatus will affect the students' attitude in doing science and this attitude will carry into later years of schooling.

However, the findings clearly show that a gap exists between students' declarative stage and procedural stage where their understanding and knowledge of using and handling apparatus given during interview were not related with their skills' performance. This claim is supported by research by Ferris and Aziz (2005) where they reported that university students' competency in the laboratory skills did not correlate with their performance in examination and assignment work. Based on the past research (e.g., Ferris & Aziz, 2005; Hofstein & Mamlok, 2007), good technique in handling and manipulating scientific apparatus is important because it can reduce, minimize, and control for misinterpretations and may minimize the error in scientific experiments.

Definition of manipulative skills is ambiguous and debatable. As uncovered in this study, manipulative skills can be described in terms of their elements and sub-elements in the aspects of technical skills and functional aspects of manipulating apparatus. Thus, based on the findings of the present study, the following sub-sections will discuss the definition of manipulative skills.

Definition of Manipulative Skills

Most of the researches conducted in manipulative skills used quantitative methodology (e.g., Aina, 2006; Siti Mariam, 2006; Wan Dalila Hanum, 2006). However the best way to understand manipulative skills is through observation as proposed by Johnstone and Al-Shuaili (2001), Kempa (1986) and Lunette et al. (1981). This is clearly demonstrated in this study where students performed the intended skills during the tasks' observation.

From the observation, two major dimensions have emerged. Each dimension can be described by its elements and sub-elements.

The dimensions and elements can be used to define the students’ manipulative skills in the context of the present study. Two (2) main dimensions were uncovered which are the (a) technical skills and (b) functional aspects of performing laboratory task. In the present study, manipulative skills can be defined as psychomotor skills that enable students to use and handle science apparatus and specimens in the approved manner which can be explained through students’ ability in technical skills and functional aspects of performing laboratory tasks in the context of scientific investigation.

Manipulative skills have a broad definition. For example, Braund (2008) defined manipulative skills as short-term actions or routines that underpin practical work. Trowbridge et al. (2000) defined the psychomotor domain in science as a set of skills that involve physical manipulation of apparatus, skill development and proficiency in using tools such as scientific instruments. Some of the findings in this study are in agreement with Eglen and Kempa’s (1974) statement which clarified manipulative skills as including methodical working, experimental techniques, manual dexterity and orderliness in using apparatus.

Technical Skills

Technical skills can be organized into a systematic hierarchy of learning technical skills. Based on the hierarchy, it can be deduced that the students’ ability to obtain an advanced skills level was only possible once they master the basic skill level. This is in agreement with findings from Dave (1970), Ferris and Aziz (2005), Gagne (1985) and Simpson (1972). The current hierarchy concerns on the acquisition of technical skills specifically for the transition period which involve students at upper primary school and lower secondary school. The six technical skills are given in Figure 5.1.

The basic technical skills involve the students' ability to recognize an apparatus and identify its parts and functions. Recognition is necessary as the first step toward being able to make effective use of the tools or materials. Once the apparatus and its parts have been recognized, it is possible to relate it with other important information.

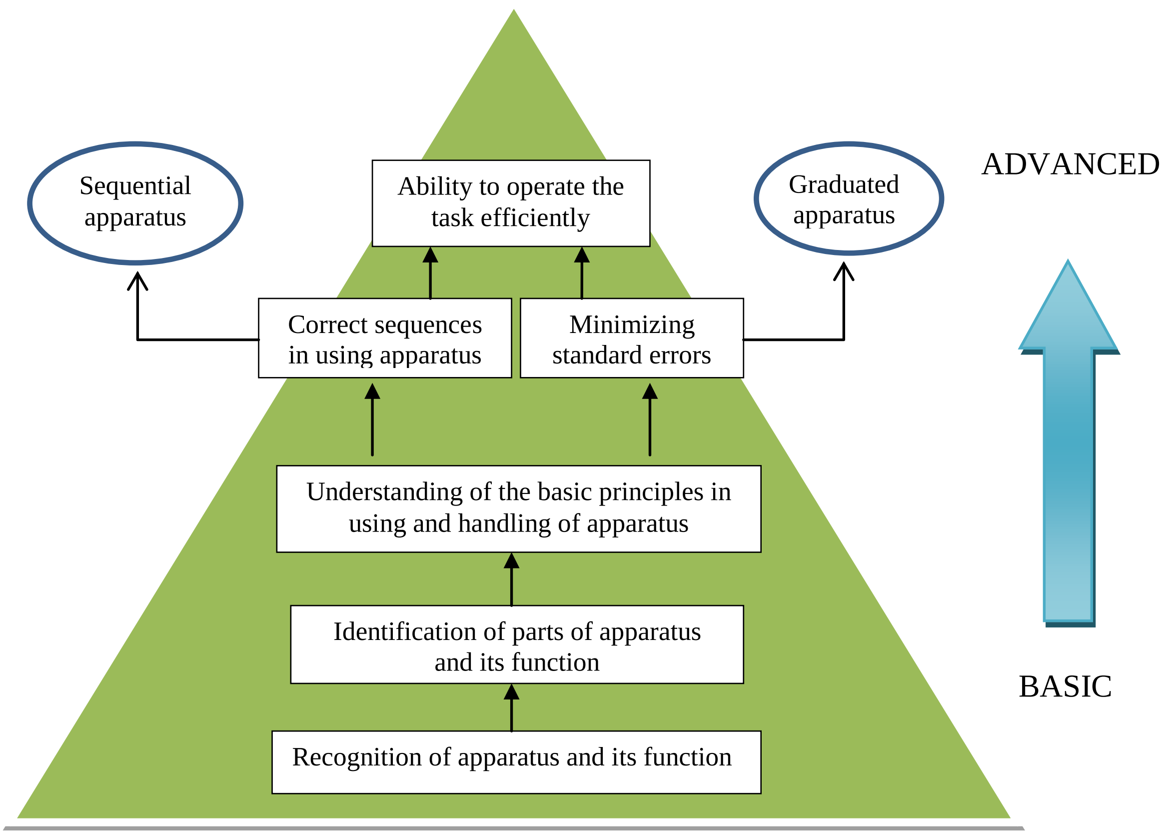


Figure 5.1 Five (5) levels hierarchy of technical skills

This finding is consistent with Ferris and Aziz's (2005) first level of psychomotor domain taxonomy which explains that recognition of tools and materials is vital for student's effectiveness and safety of handling scientific apparatus. In the current study, students showed poor skills in identifying the parts of an apparatus and its function. The difficulty in this element needs to be tackled at the lower level of learning science to ensure smooth operation of task and to prevent the problem from affecting the students' skills at higher levels of learning. Azizi et al. (2008) who investigated teacher trainees majoring in Chemical Education revealed that most of the respondents show poor capability in handling the Bunsen burner and were unable to name the different parts of the Bunsen burner and the function of each part.

The results of the study also suggest that students' understanding of the basic principle in using and handling apparatus depends on their ability in recognizing an apparatus and identifying its parts and function. This element also concurs with Ferris and Aziz's (2005) third level of psychomotor domain which concerns the student's ability to hold the tools, set the tools in action and perform the tasks in the most basic form. This current study indicated that most of the students are still struggling to acquire these fundamental technical skills.

In understanding the basic principles in manipulation of apparatus, the findings revealed that students were unable to master the appropriate technique and basic skills in using apparatus. This could be attributed to the teaching and learning of science at this level that did not emphasize concrete understanding of principles in scientific investigation. For example, students were introduced to the basic rules and principles of using thermometer in Year 5 but they did not understand the rationale behind every principle. They should understand why the tip of the thermometer should not touch the walls or bottom of the container. If the thermometer bulb touches the container, the temperature of the glass will be measured instead of the temperature of the solution. Stirring the solution during heating provides a better representation of the entire solution.

The results of the study also suggest that the learning of basic technique in using apparatus depends on students' ability to process the observed events during teacher's demonstration and try to repeat the action by referring to detailed instructions. The findings of the study also align with findings from Bandura (1977), Dave (1970) and Simpson (1972).

Bandura's observational learning theory (1977) discussed the process of "attention" which stated that students' observational skills and sensory capabilities can influence the accuracy information retention. This finding is also consistent with Dave's (1970) "imitation" category of skills learning which explained that students' replication of skills can only occur by referring to an exemplar. In the context of my study, the teacher is the exemplar or model in learning manipulative skills. Simpson's (1972) category of "guided response" in the learning of psychomotor domain explains that the early stage in learning a complex skill includes the process of imitation, and trial and error.

The fourth elements that emerged in technical skills of using graduated apparatus is the approach to minimize standard errors during measurement. Students are expected to acquire the skills of reading the scales of the basic measuring instruments and should be able to record the accurate measurement. The ability to master technical skills among students is different. This is clearly demonstrated in the study where technical skills can only be developed through practice and repetition. As the students learn to manipulate the apparatus, they increase their skills and become more efficient in obtaining meaningful data from their science experiences. The difficulties in reading meniscus occurred when the students only read about the skills and have not been given much opportunity to conduct scientific laboratory investigation.

The skill of measurement is a basic foundation in acquiring higher measuring skills which need accuracy (Woolnough & Allsop, 1985). This supports the claims that difficulty in mastering the appropriate skills to minimize parallax error may impede the students' ability to be efficient in using the graduated apparatus. The findings of this study also concur with the study by Rohaida Mohd Saat (2003) who stated that errors such as parallax error need to be minimized in order to achieve accurate and precise readings. As a result, improper manipulative techniques could affect students' experimental results.

In the elements of correct sequences in using apparatus, the findings show that the students' sequential skills during transition from primary to secondary school were very basic. This is corresponding to the hierarchy of learning technical skills during transition which stated that achievement of higher level skills depends on the achievement of the lower skills level. Thus the ability to obtain higher skills level was only made possible by achievement of lower skills. This is clearly demonstrated in the findings of this study.

The inability to recognize the sequence of using the apparatus will also affect the students' awareness of the appropriate precautionary measures that should be taken while handling an apparatus. Students should be given ample opportunity to manipulate sequential apparatus since primary school so that learning of the sequential skills becomes habitual and the movements become smooth. This finding is consistent with Simpson's psychomotor domain (1972) which stated that competency can only be achieved by practice.

The skillful performance of technical skills involves complex movement. According to Woolnough and Allsop (1985), the students' proficiency in manipulative skills is indicated by a quick, accurate and highly coordinated performance. It can be recognized by their ability to use the apparatus efficiently and confidently. This concurs with the research finding which categorized the students' "ability to operate the task efficiently" as performing the task without hesitation and with smooth task operation. Students are expected to able to use the apparatus competently, for which the tools were designed. The finding is also in accordance with Ferris and Aziz's (2005) psychomotor domain which concerns with the student's ability to perform work tasks efficiently and effectively.

Functional Aspects of Performing Laboratory Tasks

The first element on operation of tasks during practical work explains the manner the students illustrated during task execution in the laboratory. It involves students' ability to follow instruction in performing overall operation of task and checking the functionality of apparatus. The systematic operation of tasks was characterized by the organized manner that the students illustrated during the execution of tasks in the laboratory. Systematic in this context focuses on the student's methodical ability and it acts as one of the important aspects of manipulative skills in order to ensure a smooth task execution. In this study, the Manipulative skills in Transition Tasks (MSTT) were designed with minimum but comprehensive instruction which were adequate for the students to comprehend and follow. This is to prevent the students from performing the laboratory tasks in a cookbook style in completing them. This element corresponds to Dave's second level of psychomotor domain taxonomy which describe that students at this level should be able to perform scientific investigations in a recognizable fashion by following a general instruction (Dave, 1970).

Management of time and workplace can be defined as students' ability to complete the tasks within the specified time frame and the students' attitude in ensuring that the appearance of their working area was orderly and neat, especially in the placement of apparatus during experiments. Findings revealed that efficiency in this context mostly depends on the students' ability to master the technical skills in using and handling scientific apparatus. It involves three sub-elements which are: the efficiency in using time, condition of working area, and the cleaning and storing of apparatus. Some studies in manipulative skills have based their results on how fast students can carry out the procedures (e.g., Kempa, 1986). It is implied that leaving the laboratory early is an indication that students are performing better, meaning that they are making fewer mistakes. ‘Efficient use of working time’ also listed as one of the criteria for observation of manipulative skills as suggested by Eglen and Kempa (1974).

In order to ensure task execution in an applicable condition, students should ensure that their working area appearance is orderly and neat. This is clearly demonstrated in the findings of this study where the disorganized placement of apparatus during experiments impeded the students’ work flow during task completion. The findings support research by Eglen and Kempa (1974) which listed orderliness in using apparatus as one of the criteria of manipulative skills. This sub-element is also related to the safety procedure that should be adopted in scientific investigation.

Findings indicated that the majority of students were able to clean up their workspace appropriately even though there was no clear guideline on how they should carry out the procedure. The proper technique in cleaning and storing of scientific equipment is well known as one of the criteria of manipulative skills for example in research by Abu Hassan (2004) and Trowbridge, Bybee, and Powell (2000).

The element of safety and precautionary measures involve the practices to prevent danger to the individual and damage to the surroundings. Overall findings for this element on safety indicated that during transition, most of the students have somehow neglected the safety procedures that should be taken during scientific experiment in the laboratory. This element is important to be acknowledged during scientific investigation because it may get in the way of competent apparatus usage. The safety skills should be among the first elements to be taught to the students in any introduction to the laboratory and the safety procedures should be recapitulated during experiments. The inability to emphasize this element may get in the way of students’ confidence in handling scientific apparatus. Student should be given opportunity to handle the apparatus with care and not to be intimidated. For example, from the interview, students stated that Bunsen burner is labelled as a dangerous apparatus in the laboratory. As a consequence, these students clearly did not acquire sufficient skill in using the Bunsen burner during transition. This concurs with the research findings by Woolnough and Allsop (1985) and Ferris and Aziz (2005).

Technique of the safe and systematic handling of apparatus is essential part of manipulative skills (Woolnough & Allsop, 1985). The element also corresponds to Ferris and Aziz (2005) second level of psychomotor domain which stated that every tool and material in the laboratory has the appropriate technique of handling it, in order to avoid damaging the object or other objects in the surrounding area.

The element of numeracy and technique in scientific drawing includes sub-elements such as tendency in making assumption, measuring and the skills in drawing specimens. According to Woolnough and Allsop (1985), there was a tendency for students to give answers based on prior knowledge rather than observation made during experiment. This can be demonstrated through observation during early transition. In making assumption, the students placed the thermometer in the beaker to take the measurement of initial water temperature, but they ended up assuming the temperature of the water as $0^{o}C$. There is enough empirical evidence to suggest that during transition, most of the students were not actually “seeing” but believing or assuming without measuring methodically.

In the context of this study, measuring can be defined as a skill in reading the scales of measuring instruments or apparatus and the ability to record measurement accordingly. One may argue on the appropriateness of this sub-element to be categorized as manipulative skills. However, literature indicated that the measuring skill in science process skills is inseparable from manipulative skills. Moni et al. (2007) listed “to perform accurate measurement” as a dimension of manipulative skills in the laboratory. Doran, Fraser, and Giddings (1995) listed measuring and manipulating as specific skills in the same category of ‘Performing’. The skills of measurement are fundamental and serve as a basic foundation in acquiring higher measuring skills which need more accuracy. Thus the inability to master the correct technique in measuring will get in the way of acquiring higher skills in measuring. For example, during transition, students encountered difficulty in reading scales of the measuring cylinder. They ensured that their eye position is at the same level of the meniscus to avoid parallax error but they tended to read the upper level of the meniscus of the solution. Thus the volume will be lower than the actual volume of liquid needed for the experiment. This problem needs to be acknowledged by teachers.

According to Woolnough and Allsop (1985), experimental skills involve the need to develop the skills of observation. The results of the study also suggest that students demonstrate their content of knowledge through scientific drawing. Drawing skills underlie students' ability to communicate results through observation in science. Students need a proper and clear guideline as to what constitutes a good scientific drawing. Due to the dominance of the theoretical content students are more inclined to observe the right thing and do not bother to observe carefully. Based on the proposed framework of analyzing students' drawing, students' skill during transition can be categorized as inadequate.

Research by Wekesa (2013) indicated that insufficient literature in this area contributes to lack of drawing skills among secondary school students. Students faced problems in making proportional drawing, drawing using free hand, displaying neat drawing and calculating magnification of the drawings. This is clearly demonstrated in the findings of this study. Almost all of the students failed to label, give the full title and magnification scale for the scientific drawing at early and late transition. Findings of laboratory observation during mid-transition indicated that students were not adequately supervised on the specific criteria of the appropriate scientific drawing. Usually the teacher gave them the answer on the whiteboard and the students' were asked to draw the specimen on the space provided in their workbook. Thus, the lack of guidance from the teacher can probably explain the poor performance in this sub-element during transition. The findings of the study are also in agreement with Wakesa (2013) which explain that the strategies used in developing the skills in drawing are still insufficient.

Narrowing the gap during transition from primary to secondary school

In the current study, the gaps can be defined in two aspects. The first gap is when the students show no progress and even regression during transition. For instance some students could not recall the basic technique to light up the Bunsen burner during the late transition. The second gap is the gap between conceptual understanding (theory) and procedural understanding (practical). The gap in this aspect may impede the students' ability to solve scientific problems. Findings of this study indicate that students have a basic understanding in most of the elements in manipulative skills. Some of the students showed minimal progression during transition and cases of skills regression were also found.

According to the past studies conducted in this area, students' development of manipulative skills can be considered as unsatisfying. For example a study conducted with Year Five students at primary school, a year before transition shows that students manipulative skills were categorized as very poor (Mohd Anuar, 2000). Another study conducted with Form Two students, one year after transition shows that students' ability in using Bunsen burner, handling of chemicals and skills in drawing specimen were poor and unsatisfying (Wan Dalila Hanum, 2006). However the skills in cleaning and storing the apparatus were satisfying. These findings were similar to the findings of this present study.

Studies with Form Four students indicated that 60% of them have low ability in reading the scale of instruments correctly (Siti Mariam, 2006). They cannot give accurate reading for the measuring cylinder, burette, thermometer, ammeter and voltmeter. The finding is in line with the findings of the current study where students have difficulty in measuring. According to Siti Mariam (2006), students also struggle to master the correct method of using the thermometer and they stirred the solution using the thermometer before taking the temperature measurement. This is also in line with the findings in this study.

Mariam Faridah (2007) conducted a research to investigate Form Four students' skills of handling three scientific apparatus: burette, pipette and microscope. Overall, students' proficiency in handling these apparatus is at the modelling level. Students showed the ability to copy the steps of handling apparatus and tools through trial and error to acquire the appropriate skills. The proficiency in skills of using microscope is the lowest among all. According to Mariam Faridah (2007), Form Four students have problems in using appropriate magnification power when observing the specimen. The same difficulty was noticed in the current study. The research shows that students still struggle to master the appropriate technique in handling sequential apparatus at higher secondary level.

From the findings of the various studies, I can conclude that students still faced difficulty in mastering manipulative skills not only at primary and secondary school, but they also experienced the same problem at higher learning institutions. The continuous development of manipulative skills has not been well addressed in our science learning.

The Gap According to Learning Theories

The advancement in science learning generally depends on two interrelated areas, those cognitive in nature and those that relate to practical activities. Understanding and application of these areas enable the students to construct their fundamental concepts in science (Gott & Duggan, 1995; Kempa, 1986). However, the distinction between these areas is only a matter of convenience because in reality both of these skills are acquired simultaneously. For instance in this study, the learning of manipulative skills do not only depends on students' psychomotor ability or procedural understanding in manipulating the apparatus but involves their conceptual understanding.

From observation, students displayed good attitude when they involved in hands-on experiments where they have the chance to touch and manipulate the materials to get an understanding of scientific ideas. This is in accordance with Piaget's (1985) theory of cognitive development which explains that primary school students are in the concrete operational phase of their development. In order to make the learning of science more meaningful, invisible things must be represented in concrete form to enable the student to grasp the scientific concepts. Almost all of the students in this study expressed their interest in science subject. To them, science is seen as an interesting subject due to its distinct features which are scientific investigation and the opportunity to manipulate scientific apparatus.

Findings of this study are also in line with the current paradigm which focuses on learning that supports a variety of learning domains. The cognitive domain has always been emphasized in most types of learning (e.g., Bloom, 1956) and Gagne (1985). The learning of psychomotor skills and the development of affective skills is equally vital to ensure a total learning of every individual in the science classroom. This is also in agreement with Reigeluth (1999) who claimed that cognitive learning is no longer the only primary focus of education.

Findings have indicated that the gap in conceptual understanding and procedural understanding may impede students' ability in performing manipulative skills. The gaps can be explained by using the theories adopted in this study which are the Act-R theory (Anderson, 1982) and Bandura's observational learning theory (Bandura, 1977).

Act-R Theory

Conceptual understanding in learning is also known as *declarative knowledge* (Anderson, 1982). When the learner receives instruction and information about particular skills, the instruction will be encoded as a set of facts about the skills. These sets of facts will be interpreted further to generate desired behavior. Findings show that most of the students were able to interpret the facts from the particular knowledge in the using and handling of apparatus. For instance, during the interviews, students were able to explain the theoretical concept of using the thermometer and this reflected their declarative knowledge in using the apparatus.

The second stage in ACT-R theory is the *procedural stage* which involves skill performing and generation of particular behavior that reflects knowledge from the declarative stage. According to Anderson (1982), at this stage the knowledge of scientific theory that has been rehearsed in the working memory at declarative stage should be interpreted and the outcomes were represented as productions which were represented by students' skills in using the apparatus. However, the findings from this study indicated that the students at this stage did not illustrate the ability to apply the skills of using the scientific apparatus appropriately. Their procedural knowledge did not reflect the declarative knowledge that they constructed earlier. The problem gets more serious for those students who were unable to acquire the declarative knowledge of the apparatus.

The declarative knowledge about skills are analyzed and manifested in the procedural stage through a process known as knowledge compilation (Anderson, 1982). In this current study the difficulty in interpreting declarative knowledge into the desired action maybe due to disruption or interference during the process of knowledge compilation. However according to ACT-R Theory, declarative knowledge has to be recalled and rehearsed to make it available and active in working memory for use in the next stage. As skill is repeated, it will increase the strength value and decrease the time it takes to perform the skills (Anderson & Lebierre, 1998). Findings clearly show that not enough recall took place during transition from primary to secondary school although practice serves as a medium for converting declarative knowledge into procedural form. Thus, it can be concluded that the lack of rehearsal and practice in this study affected the students' process of knowledge compilation. As a result, automation phase which is the final stage in the ACT-R theory of manipulative skills could not occur during the transition to secondary school.

In order to achieve the stage of automation, repetition in handling the apparatus is the most important factor because learning of manipulative skills can only improve through practice. The performance of manipulative skill will gradually be more accurate and can be accelerated through practice and repetition as mentioned by Anderson and Lebierre (1998). Findings indicated that ACT-R theory is able to provide a thorough explanation on the interrelation between cognitive ability and manipulative skills as in how the information is processed and transformed into a specific movement.

Bandura's Observational Learning

The findings of this study indicated that imitative or observational learning plays an important and significant role in manipulative skills acquisition. However students' competency in task performance is fully dependent on their ability to process the observed event through teachers' demonstration of the skills.

During classroom observations in the current study, teachers consistently started the practical activity by showing the appropriate technique in manipulating scientific apparatus through demonstration and verbal instruction. This is in accordance with

Bandura's (1977) *attention process* where manipulative skills were acquired through demonstration of skills by the teacher where they play their essential role as a 'live model'.

The behavior enacted by the teacher was coded and retained by the students where students' observational skills and sensory capabilities influence the accuracy of the information processing. This process is quite similar with the declarative stage in ACT-R theory. Most of the students were able to explain what the rules of thumb were when using scientific apparatus and they have no difficulties understanding this particular process.

The *retention process* in Bandura's learning theory can be associated with the knowledge compilation process in ACT-R theory where it is accountable for coding of the skills demonstrated from the attention process and the storage of the verbal and visual codes in memory. According to Bandura (1977), when information was cognitively stored, it can be retrieved, rehearsed and strengthened long after the observational learning has taken place. Thus the students will have the ability to utilize information long after it has been observed. Students in this study learned about the skills in using scientific apparatus as early as in Year Four (e.g., measuring cylinder). Repetition of teachers' demonstration enhances the students' cognitive ability and mental processes.

The real challenge can only be observed during the third process which is known as '*motor reproduction*'. This process determined to what extent the learned behavior is translated into performance. This process is quite similar to the procedural stage in ACT-R theory. According to Bandura (1977), this process includes the cognitive selection and organization of responses which have been accumulated during the attention and retention processes, followed by execution of the acquired skills. Students were unable to display efficient skills in motor reproduction. The lack of practice can be one of the contributing factors for this problem.

From interviews, most of the students admitted that demonstration technique is the most popular technique applied by the science teacher especially when it involved the use of complicated and dangerous apparatus such as Bunsen burner and microscope. Students had the opportunity to observe the teacher but they did not get much opportunity to manipulate the apparatus by conducting hands-on experiments. In other words the process of attention and retention in the science classroom was not continuously followed by motor reproduction.

Students showed positive attitude during the data collection phases at primary and secondary school. Most of them struggled to use the scientific apparatus. They display their hesitation during the experiment but realized this is a good opportunity for them to practice their skills in handling the scientific apparatus as told to me during interview. The findings concur with Bandura's (1977) theory which stressed on the *motivational process* to encourage the students in performing manipulative skills.

Intervention in bridging the gap

Opportunity to Conduct Scientific Investigation

The study indicated that students' cognitive ability did not reflect their true ability in manipulative skills. Science manipulative skills need to be continuously developed since primary school. This study concurs with Braund (2008) which stated that students rarely see the development of their practical skills as a continuous process. Science in primary and secondary school has to be distinctively different from one another but at the same time there is a need in maintaining the continuity of the science curriculum. In primary school, commitment emphasized the cognitive, social, physical and emotional growth of each student. Science at this level should focus on fostering the skills and attitudes necessary for scientific investigation because primary school students learn science with curiosity and interest. However, in lower secondary school, the commitment slowly starts to change toward academic preparation.

In the learning of manipulative skills, the students' performances are clearly dependent upon the basic skills learned earlier. Adequacy can only be achieved by practicing. The smoothness of action and precision differentiated the performance of novice and expert in development of manipulative skills. However findings indicated that the problems in mastering these skills occur because of a lack of opportunity to conduct experiments. The current strategies implemented in science were unable to enhance students' manipulative skills appropriately. This problem occurs at both primary and secondary schools.

The findings concur with the study by Rohaida Mohd Saat (2010) which stated that students entering secondary school were disillusioned with secondary science learning. Primary school students were enthusiastic about science because of its distinctiveness and the opportunity to conduct exciting experiments. This expectation was not fulfilled when they enter secondary school. The learning of science at secondary school was not much different from primary school. Too much emphasis has been given to the cognitive domain. Students obtained excellent result for science subject in examination but the result did not reflect their true ability in scientific skills.

Bridging the Gap

Findings of the study supported that effective engagement need to be built between primary and secondary school in order to bridge the gap in manipulative skills. Past research in transition has come out with numerous programs and interventions specifically addressing to support a successful transition. Nevertheless, not much progress has been made particularly in the field of science education. This current research has developed a resource guide specifically addressed to support a successful transition in science. The development of this resource guide is supported by many researches in transition (e.g., Braund, 2009; McGee, 1987; Mizelle & Irvin, 2000) who recommended numerous strategies for managing transition. This included activities on how to establish linkages between transition schools to bring primary and secondary school education together. The resource guide may help students to see manipulative skills as the skills that they can always use, rather than something that they have to starts again in secondary school.

Similar to the finding by Noraini Zainal Abidin (2009), students and teachers in this study did not really understand what “transition” was. Transition in Malaysia did not receive enough attention from educational authorities in terms of the preparation for adaptation from one stage to another. Thus, based on the findings there is a need to prepare a resource guide based on the emerging data, in order to facilitate teachers in bridging the gap in manipulative skills between primary and secondary school.

The resource guide activities provide assessment information that is meaningful for primary and secondary teachers so that a smooth continuity can be established. Further collaboration between primary and secondary school should be considered in order to bridge the gap during transition. Good relationship between primary and secondary school teachers can help to establish understanding and continuity for the pedagogical approach. However, this requires effort from teachers and school management as suggested by Galton et al. (2003), Hawk and Hill (2004) and Tilleczek (2007).

IMPLICATIONS FOR THEORY AND PRACTICE

The findings of this study, when taken collectively, provide powerful implications for the stakeholders. The results suggest several issues to consider when teaching manipulative skills.

Practical Implication in Science Teaching

The present study showed that students' manipulative skills were insufficient, similar to findings by Mohd Anuar (2000), Wan Dalila Hanum (2006) and Siti Mariam (2006). The findings from the present study imply that there might be a gap in teaching and learning of manipulative skills during transition. Primary school teachers need to provide exposure in manipulative skills to the students, so that when they enter secondary school their secondary school teachers can immediately focus on improving and strengthening those skills. During transition to secondary school, science teachers should only take time to review the students' manipulative skills in order for them to refresh their knowledge and skills in using scientific apparatus instead of teaching manipulative skills from scratch.

During the resource guide 'Meniti Peralihan' evaluation phase, primary and secondary school teachers admitted that they were unsure of what should be observed during laboratory work. The excessive number of students in the science classroom complicates matters. It is difficult for teachers to control the classroom and at the same time they have to ensure that each student acquired the intended manipulative skills. Therefore, the present study has provided the understanding into how manipulative skills can be assessed during transition, based on the emerging findings of this study.

Continuity in science learning is a significant aspect to be pondered during students' transition from primary to secondary school. The problem during school transition is that students have the tendency to assume science at primary school and secondary school as two different subject matters. They have difficulty in understanding the continuity of learning science at primary and secondary school. Students rarely put their skills into practice in secondary school, claiming that the subjects taught are different from what they were taught in primary school. In order to prevent the difficulties and to improve the students' ability in manipulative skills during transition, teachers should ensure the same method is used to acquire scientific data in primary and secondary school so the students are not confused. Thus the findings are valuable to teachers in designing their instruction in teaching manipulative skills. The five levels hierarchy of learning technical skills can be used as a guide for teachers to enhance the students' skills in handling of apparatus. Teachers must be aware of the students' different abilities in manipulative skills. This means that the approach in teaching manipulative skills has to be appropriate, in order to address the students' competency in handling apparatus. Innovative pedagogical approaches and effective instructional materials may be used to improve teaching and learning in order to enhance student learning and facilitate continuity in science.

Among the possible results from this study which can be practiced to narrow the gap between primary and secondary science is to initiate a dialogue among the science teachers to discuss what manipulative skills primary and secondary school students should have in order to ensure a smooth transition in science learning. Effective engagement has to be built between primary and secondary school and this requires effort from teachers and school management as suggested by Galton et al. (2003), Hawk and Hill (2004) and Tilleczek (2007). Further collaboration between primary and secondary school should be considered in order to bridge the gap during transition. The present study has tried to promote bridging the gap between primary and secondary school science through the development of the manipulative skills resource guide.

Intervention programs such as introduction to the science laboratory should also be considered as an initiative to facilitate a smooth transition in learning science. This program is best conducted during the first few weeks of transition to secondary school, before the teaching and learning of science takes place. The resource guide can be utilized to get an understanding of the students' level of competency in using and handling of apparatus.

Ensuring Teacher's Manipulative Skills Competency by Strengthening Teacher Development Programs

An important implication of the study is that teachers' attitude towards practical work plays a major role in their students' success. Teachers themselves need to acquire sufficient manipulative skills and knowledge in order to teach manipulative skills effectively in the science classroom. This research has shown that during transition from primary to secondary school, the teacher played the role as an expert and facilitator in the learning of manipulative skills. As experts, teachers are assumed to have a comprehensive and authoritative knowledge in science and it includes mastery in manipulative skills. From classroom observation I noticed that teachers play a major part in instructing the students to handle scientific apparatus and materials correctly. Instructing in this context can be defined as a structured process concerned with developing manipulative skills through guided practical experience, assessment and regular feedback in order for students to master the skills. Proper guidance could lead the students to better acquisition of the intended skills, based on the specific science curriculum prepared by the Ministry of Education. For instance, through demonstration, teacher ensures the students obtain correct and proper technique in using apparatus through imitation of skills. During group practical work, teacher assisted the students and corrected or guided those who encountered difficulties in handling the given task. However as mentioned in several previous studies (e.g., Azizi et al., 2008), one of the challenges faced by the science teachers is their insufficient ability in handling and using apparatus. Untrained teachers are not confident in handling the science classroom during practical work. Thus training program can help teachers to acquire the necessary knowledge and skills.

Implications for Scholars and Researchers

In this study I presented an in-depth definition of manipulative skills which emerged from the data analysis. The utilization of findings which have been arranged in detail into a resource guide was found practical and useful in assessing manipulative skills. The findings can possibly be used by future researchers to assess students' science manipulative skills.

This study also showed that a gap exists between primary and secondary schools in learning science. This evidence is important to justify the assumption that students need a specific intensive program to bridge the gap during transition. Therefore an appropriate bridging program should be carefully designed in order to narrow the gap during transition, not only in science subject but also in other subjects as well.

SUGGESTIONS FOR FUTURE RESEARCH

The purpose of this study was to understand students' manipulative skills during transition from primary to secondary school science. Study found that minimal research attention has been directed toward exploring the progression and continuity in learning science during the transition from primary to secondary level and issues relating to it.

Thus, more research is needed to follow up on the numerous issues raised in this study. Based upon the conclusions discussed in this study several suggestions are recommended for future research in this area:

(1) A quantitative measure can be conducted to examine the dimensions and elements transpired from this study. The validity of the findings can be established by carrying out studies with a larger sample of students during transition.

(2) This study focused upon transition in a suburban area. It would be interesting to explore similar studies in different localities which will provide similarities and differences in the findings of students' manipulative skills during transition.

(3) Due to the limitation of this study, it can only be conducted in one aspect of scientific skills which is the manipulative skills. I would recommend that further studies are conducted as a follow up to this study which includes transition in other aspects of science process skills for example in communicating or measuring and using numbers. It will also be interesting to explore the perception of transition in various contexts such as perceptions of students, parents and teachers involved in transition.

(4) In relation to the above recommendation, appropriate bridging resources should be carefully designed in order to narrow the gap during transition, not only in science subject but also in other subjects as well.

(5) There is a need to come out with a more comprehensive evaluation or assessment system in order to assess the students manipulative skills. The scoring done in this study was only based on the present system (for eg. from Practical Work Assessment (PEKA) and reviewed literature) since the Guide is just an extension of my work. This is not the main focus of my study. Thus a better evaluation system need to be developed in future by using the findings as a guideline.

CHAPTER SUMMARY

In this chapter I have presented three (3) conclusions which have been drawn from the study. Firstly, students' manipulative skills during transition can be described by the understanding of elements and sub-elements in technical skills and functional aspects of performing laboratory tasks. The second conclusion explained the gap in manipulative skills acquisition during transition from primary to secondary school which needs to be addressed appropriately. The third conclusion discussed the importance of bridging the gap in manipulative skills during transition from primary to secondary school. The results of the study suggested several issues to be considered when teaching manipulative skills. The implications of the study have also been discussed thoroughly in this final chapter.

LIST OF PUBLICATIONS AND PAPERS PRESENTED

Publications:

1) Jurnal Teknologi (University of Technology Malaysia) – SCOPUS
Title: Phenomenographic Study of Students' Manipulative Skills during Transition from Primary to Secondary School. (Status: Published, October, 2013)

2) SAINSAB ONLINE (University of Science Malaysia)–Refereed Journal
Category B
Title: Development Of Students' Manipulative Skills During Transition From Primary To Secondary School: A Preliminary Finding. (Status: Published, September, 2013)

3) Book chapter "Empowering the Future Generation through Science/Mathematics Education"
Southeast Asian Ministers of Education Organization-Regional Centre for Education in Science and Mathematics (SEAMEO RECSAM)
Title: Understanding Students' Technical Skills during Transition from Primary to Secondary School. (Status: Tentatively scheduled to be published by August 2014)

4) Eurasia Journal of Mathematics, Science & Technology Education - ISI
Title: Enhancing STEM Education during School Transition: Bridging the Gap in Science Manipulative Skills (Status: Published, June, 2014)

Conferences:

1) 20th Anniversary Celebration of the Ryoichi Sasakawa Young Leaders Fellowship Fund (SYLFF) Program at the University of Malaya. (31 May to 2 June 2010, University of Malaya, Kuala Lumpur)
Title of paper: The development of manipulative skills during transition from primary to secondary school.
(This doctoral study is endowed by Tokyo Foundation, Japan)

2) 4th. International Conference on Science and Mathematics Education (CoSMEd 2011). (15 to 17 November 2011, Southeast Asian Ministers of Education Organization-Regional Centre for Education in Science and Mathematics (SEAMEO RECSAM), Penang)
Title of paper: Development of Students' Manipulative Skills during Transition from Primary to Secondary School: Preliminary Findings.

3) 1st International Conference on World-Class Education (ICWED 2011). (5 to 6 December 2011, University of Malaya, Kuala Lumpur)
Title of paper: Progression of science learning during transition from primary to secondary school.

4) International Seminar in Science and Mathematics Education (ISSME) 2012. (5 to 8 September 2012, Johor Bahru).
Title of paper: Development of Students' Manipulative Skills during Transition form Primary to Secondary School: Findings from Primary School.

5) International Conference in Education (ICEd 2012) (December 2012, University of Malaya, Kuala Lumpur).
Title of paper: Learning Science during Transition from Primary to Secondary School.

6) 5th.International Conference on Science and Mathematics Education (CoSMEd 2013. (11 to 14 November 2013, SEAMEO RECSAM, Penang).
Title of paper: Understanding Students' Technical Skills during Transition from Primary to Secondary School

REFERENCES

Abu Hassan. (2004). *Perspektif Amali Sains: Kemahiran Saintifik*. Skudai, Malaysia: Universiti Teknologi Malaysia, Faculty of Education.

Aina Fariza binti Md Zin. (2006). *Tahap penguasaan Kemahiran Manipulatif di kalangan pelajar Tingkatan Empat di Daerah Johor Bahru, Johor*. Unpublished thesis, Universiti Teknologi Malaysia, Skudai.

Akerlind, G. S. (2005). Variation and commonality in phenomenographic research methods. *Higher Education Research and Development, 24*(4), 321-334.

Anderson, J. R. (1982). Acquisition of cognitive skill. *Psychological Review, 89*, 369-406.

Anderson, J. R. (1988). The expert module. In M. Polson & J. Richardson (Eds.), *Handbook of Intelligent Training Systems*. Hillsdale, NJ: Erlbaum.

Anderson, R. D. (1970). *Developing children's thinking through science.* Upper Saddle River, NJ: Prentice-Hall.

Anderson, J. R., & Lebiere, C. (1998). *The atomic components of thought*. Mahwah, NJ: Erlbaum.

Atkinson, P., & Silverman, D. (1997). Kundera's immortality: The interview society and the invention of the self. *Qualitative Inquiry, 3*, 304-325.

Aunola, K., Leskinen, E., & Nurmi, J. E. (2006). Developmental dynamics between mathematical performance, task motivation, and teachers' goals during the transition to primary school. *British Journal of Educational Psychology, 76*(1), 21–40.

Azizi Yahaya, Shahrin Hashim, & Fathiah Mohamed. (2008). Tahap Penguasaan Kemahiran Manipulatif Di Kalangan Guru Pelatih Kimia UniversitiTeknologi Malaysia. In Yusof Boon & Seth Sulaiman (Eds.), *Permasalahan dalam pendidikan Sains dan Matematik* (pp. 34-51). Johor: Penerbit Universiti Teknologi Malaysia.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

Bandura, A. (1989). Social cognitive theory. In R. Vasta (Ed.), *Annals of child development. Vol. 6. Six theories of child development*. Greenwich, CT: JAI Press.

Bany, M. A., & Johnson, L. V. (1975). *Educational social psychology*. Boston, MA: Macmillan.

Barber, B. K., & Olsen, J. A. (2004). Assessing the transitions to middle and high school. *Journal of Adolescent Research, 19*(3), 3-30.

Berzonsky, M. D., & Kuk, L. S. (2000). Identity status, identity processing style, and the transition to university. *Journal of Adolescent Research, 15*(1), 81-98.

Biggeri, L., Bini, M., & Grilli, L. (2002). The transition from university to work: a multilevel approach to the analysis of the time to obtain the first job. *Journal of the Royal Statistical Society, 164*(2), 293–305.

Bloom, B. S. (1956). *Taxonomy of educational objectives, the classification of educational goals – Handbook I: Cognitive domain*. New York, NY: McKay.

Bloom, B. S., & Krathwohl, D. L. (1956). *Taxonomy of educational objectives: The classification of educational goals. Handbook 1: Cognitive domain.* New York, NY: Longman.

Boejie, H. (2002). A purposeful approach to the constant comparative method in the analysis of qualitative interviews. *Quality & Quantity, 36,* 391-409.

Bogdan, R. C., & Biklen, S. K. (2007). *Qualitative research for education: An introduction to theory and methods*. Boston, MA: Allyn & Bacon.

Boon, S., Johnston, B., & Webber, S. (2007). A phenomenographic study of English faculty's conceptions of information literacy. *Journal of Documentation, 63*(2), 204 – 228.

Booth, A. (1997). On phenomenography, learning and teaching. *Higher Education Research & Development, 16*(2), 135 – 158.

Bowden, J. (2005). Reflections on the phenomenographic research process. In J. Bowden & P. Green (Eds.), *Doing Developmental Phenomenography*. *Qualitative Research Methods Series*. Melbourne, Victoria: RMIT University Press.

Braund, M. (2008). *Starting science…again? Making progress in science learning.* Thousand Oaks, CA: Sage.

Braund, M. (2009). Progression and continuity in learning science at transfer from primary and secondary school. *Perspective in Education, 2,* 22-38.

Braund, M., Crompton, Z., Driver, M., & Parvin, J. (2003) Bridging the key stage2/3 gap in science. *School Science Review*, *85*(310), 117-123.

Braund, M., & Driver, M. (2002, Sept). *Moving to the big school: What do pupils think about science practical work pre- and post- transfer?* Paper presented at the Annual Conference of the British Educational Research Association, University of Exeter, England.

Bryman, A. (2006). Integrating quantitative and qualitative research: How is it done? *Qualitative Research, 6*(1), 97-113.

Buffler, A., Allie, S., & Lubben, F. (2001). The development of first year physics students' ideas about measurement in terms of point and set paradigms. *International Journal of Science Education, 23*(11), 1137-1155.

Campbell, B. (2002). Pupils' perceptions of science education at primary and secondary school. *Research in Science Education, 3*, 125-130.

Clark, D. (1999). Learning domains or Bloom's taxonomy. Retrieved from http://www.nwlink.com/~donclark/hrd/bloom.html

Cocklin, B. (1999). Gumly Gumly Public School as a learning community: Sifting the rhetoric to locate the reality. In Retallick, J., Cocklin, B., & Coombe, K. (Eds.) *Learning Communities in Education: issues, strategies and contexts.* London: Routledge.

Cognato, C. A. (1999, October). *The effects of transition activities on adolescent self-perception and academic achievement during the progression from eighth to ninth grade.* Paper presented at the annual meeting of the National Middle School Association, Orlando. USA.

Creswell, J. W. (2008). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Upper Saddle River, NJ: Pearson.

Creswell, J. W., & Miller, D. L. (2000). Determining validity in qualitative inquiry. *Theory into Practice, 39*(3), 124-131.

Dave, R. H. (1970). Psychomotor levels. In Robert, J. A. (Eds.) *Developing and Writing Behavioral Objectives*. Tucson, AZ: Educational Innovators Press.

Delamont, S., & Galton, M. (1986). *Inside the secondary classroom*. London, UK: Routledge & Kegan Paul.

Delargey, M. J. N. (2001). How to learn science “quickly, pleasantly and thoroughly”: Comenian thoughts. *School Science Review, 82*(301), 79–84.

Demeo, S. (2005). Gazing at the hand: A Foucaultian view of the teaching of manipulative skills to introductory chemistry students in the United States and the potential for transforming laboratory instruction. *Curriculum Inquiry, 35*(3), 295–338.

Denzin, N. K. (1978). *The research act: A theoretical introduction to sociological methods*. Chicago, IL: Aldine.

Denzin, N. K., & Lincoln, Y. S. (1994). *Handbook of qualitative research*. London, UK: Sage.

Denzin, N. K., & Lincoln, Y. S. (2005). Introduction: The discipline and practice of qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage Handbook of qualitative research* (2nd ed.). Thousand Oaks, CA: Sage.

Diack, A. (2009). A smoother path: Managing the challenge of school transfer. *Perspective in Education, 2*, 39-51.

Dick, W., Carey. L, & Carey, J. O. (2001). *The systematic design of instruction*. Boston, MA: Allyn & Bacon.

Domin, S. D. (2007). Students' perceptions of when conceptual development occurs during laboratory instruction. *Chemistry Education Research and Practice, 8*(2), 140-152.

Doran, R., Fraser, B. J., & Giddings, G. J. (1995). Science laboratory skills among grade 9 students in Western Australia. *International Journal of Science Education, 17*(1), 27-44.

Dortins, E. (2002). Proceedings from *25th HERDSA Annual Conference*: *Reflections on phenomenographic process: Interview, transcription and analysis, in Quality Conversations.*

Eccles, J. S., Midgley, C., & Lord, S. (1991). What are we doing to early adolescents? The impact of educational contexts on early adolescents. *American Journal of Education, 99,* 521-542.

Eglen, J. R., & Kempa, R. F. (1974). Assessing manipulative skills in practical chemistry. *School Science Review, 56,* 737-740.

Feisel, L. D., & Rosa, A. J. (2005). The role of the laboratory in undergraduate engineering education. *Journal of Engineering Education, 94*(1), 121–30.

Ferris, T., & Aziz, S. (2005) A psychomotor skills extension to Bloom's taxonomy of education objectives for engineering education. *Exploring Innovation in Education and Research*. Tainan, Taiwan.

Fisher, D., den Brok, P., Waldrip, B., Dorman, J. (2011) Interpersonal behaviour styles of primary education teachers during science lessons. *Learning Environments Research [E]*, *14*(3), 187-204.

Fraenkel, J. R., & Wallen, N. E. (2008). *How to design and evaluate research in education.* New York, NY: McGraw-Hill.

Fuccia, D. D., Witteck, T., Markic, S., & Eilks, I. (2012). Trends in practical work in German science education. *Eurasia Journal of Mathematics, Science and Technology Education, 8*(1), 59-72.

Gagne, R. (1985). *The conditions of learning and the theory of instruction*, (4th ed.). New York, NY: Holt, Rinehart, & Winston.

Gagne, R., & Briggs, L. J. (1992). *Principles of instructional design*. New York, NY: Holt, Rinehart, & Winston.

Galton, M. (2002). Continuity and progression in science teaching at key stage 2 and 3. *Cambridge Journal of Education, 32*(2), 250-265.

Galton, M. Gray, J. M., & Ruddock, J. (2003). *Transfer and transitions in the middle years of schooling (7-14). Continuities and discontinuities in Learning.* Cambridge: Queen's Printer.

Glaser, B. G., & Strauss, A. (1967). *The discovery of grounded theory: Strategies for qualitative research*. New York: Aldine.

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The Qualitative Report, 8*(4), 597-607.

Gott, R., & Duggan, S. (1995). *Investigative work in the Science curriculum*. Buckingham: Open University Press.

Graham, C., & Hill, M. (2003). *Negotiating the transition to secondary school.* Retrieved from http://www.scre.ac.uk/spotlight/spotlight89.html

Gredler, M. E. (1997). *Learning and instruction: Theory into practice*. Upper Saddle River, NJ: Prentice-Hall.

Gredler, M. E., & Schwartz, L. S. (1997). Factorial structure of the self-efficacy for self-regulated learning scale. *Psychological Reports, 81*, 51-57.

Green, P. (1997). The journey from primary to secondary school: The literacy-related demands in transition. *Australian Journal of Language and Literacy, 21*. Retrieved from http://findarticles.com/p/articles/mi_hb3336/is_n2_v21/ai_n28707084/

Greene, J.C., Caracelli, V.J. & Graham, W.F. (1989). Toward a conceptual framework for mixed-method evaluatin designs. *Educational Evaluation and Policy Analysis 11*(2), 255-274.

Hamida binti Abd. Halim.(2003). *Tahap penguasaan kemahiran asas makmal di kalangan pelajar tahun akhir di Fakulti PendidikanUniversitiTeknologi Malaysia.* Unpublished thesis, Universiti Teknologi Malaysia, Skudai.

Hargreaves, L., & Galton, M. (Eds.). (2002). *Transfer from the primary classroom*. London, UK: RoutledgeFalmer.

Harlen, W. (2006). *Teaching, learning and assessing science 5-12*. London, UK: Sage.

Harrow, A. J. (1972). *A taxonomy of the psychomotor domain.* New York, NY: David McKay.

Hawk, K., & Hill, J. (2004, April). *Transition traumas, traps, turning points and triumphs: Putting student needs first*. Paper presented at The Way Forward for Secondary Education Conference, Wellington, New Zealand.

Heinrich, R., Molenda, M., Russell, J., & Smaldino, S. (1996). *Instructional media and technologies for learning* (5th ed.). Upper Saddle River, NJ: Pearson Merrill Prentice Hall.

Hodgson, C. (2005). *Laboratory manual for Bio 102, Principles of modern Biology, 6th Ed.* Courtenay, Canada: North Island College.

Hodson, D. (1990). Assessment of practical work: Some considerations in philosophy of science. *Science & Education, 1*, 115-144.

Hoese, W. J., & Casem, M. L. (2007). Drawing out misconceptions: Assessing student mental models in biology. Retrieved from http://bioliteracy.colorado.edu/Readings/papersSubmittedPDF/Hoese%20and%20Casem.pdf

Hofstein, A. (2004). The laboratory in chemistry education: Thirty years of experience with developments, implementation and evaluation. *Chemistry Education Research and Practice, 5*, 247-264.

Hofstein, A., Ben-Zvi, R., & Samuel, D. (1976). The measurement of interest in and attitude to laboratory work amongst Israeli high school students. *Science Education, 60*, 401-411.

Hofstein A., & Lunetta V. N. (2004). The laboratory in science education: Foundation for the 21st century. *Science Education, 88*(1), 28-54.

Hofstein, A., & Mamlok., R. (2007). The laboratory in science education: the state of the art. *Chemistry Education Research and Practice, 8*(2), 105-107.

Holt, R. W. (2002). Communicating skills: Science drawing. *Holt Science and Technology*. Retrieved from http://go.hrw.com/hrw.nd/gohrw_rls1/pKeywordResults?HS5%20SW-TOC

Howard, S., & Johnson, B. (2000). *Transition from primary to secondary school: possibilities and paradoxes*. New South Wales: University of South Australia.

Howe, A. C., & Jones, L. (1993). *Engaging children in science*. New York, NY: Macmillan.

Hurd, P. D. (2000). *Transforming middle school science education.* New York, NY: Teachers College Press.

International Association for the Evaluation of Educational Achievement (IEA). (2012). *TIMSS 2011 International Science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grade.* Boston, MA.

Isman, A. (2011). Instructional design in education: New model. *Turkish Online Journal of Educational Technology, 10*(1), 136-142.

Isman, A., Abanmy, F. A., Hussein, H. B., & Al Saadany, M. A. (2012). Effectiveness of instructional design model (Isman-2011) in developing the planning teaching skills of teachers college students' at King Saud University. *The Turkish Online Journal of Educational Technology*, *11*(1), 71-78.

Jafri Mohd Saad, Lanita Md Yusof, & Syed Najmuddin. (2006). *Science practical book Form 1*. Kuala Lumpur, Malaysia: Cerdik.

Johnson, R. A. (1992). *Biology* (3rd ed.). St. Louis: Mosby.

Johnstone, A. H. & Al-Shuaili, A. (2001). Learning in the laboratory: Some thoughts from the literature. *University Chemistry Education, 5,* 42-51.

Jyh, C. L., & Chin, C. T. (2010). Relational analysis of college science-major students' epistemological beliefs toward science and conceptions of learning science. *International Journal of Science Education, 32*(17), 2273-2289.

Kantanis, T. (2000*). Same or different: Issues that affect mature age undergraduate students' transition to university*. Paper presented at the 6th Pacific Rim, First-Year in Higher Education Conference, Christchurch, New Zealand.

Kempa, R. F. (1986). *Assessment in Science*. Cambridge: Cambridge University Press.

Kempa, R. F., & Buckley, J. G. (1971). Practical work in sixth form chemistry. *School Science Review*, *53*(182), 24-36.

Kirkpatrick, D. (1992). *Student perceptions of the transition from primary to secondary school*. Paper presented at the Australian Association of Research in Education, Geelong: Australia.

Kirkpatrick, D. (2004). *Making the change: Students' experiences of the transition from primary school.* Retrieved from http://edoz.com.au/educationaustralia/archive/features/make.html

Lawton, M. (1997). Hands-on science gets thumbs up from students. *Education Week, 16*(30), 12.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage.

Liu, X., & Lesniak, K. M. (2005). Students' progression of understanding the matter concept from elementary to high school.*Science Education, 89*(3), 433–450.

Lord, S. E., Eccles, J. & McCarthy, K. A. (2004). Surviving the junior high school transition: Family processes and self-perceptions as protective and risk factors. *Journal of Early Adolescence, 14*, 162-199.

Lunetta, V. N., Hofstein, A., & Clough, M. (2007)**.** Learning and teaching in the school science laboratory: an analysis of research, theory, and practice. In N. Lederman & S. Abel (Eds.), *Handbook of research on science education* (pp. 393-441). Hillsdale, NJ: Lawrence Erlbaum Associates.

Malaysia Examination Board. (2008). Assessment guide for Science Practical Work Assessment (PEKA). Ministry of Education, Malaysia. Retrieved from http://apps2.moe.gov.my/lpm/files/PBS/BukuPanduanPEKASainsUPSR2008.pdf

Mariam Faridah Che Muda. (2007). *Penguasaan kemahiran manipulatif dalam makmal sains dalam kalangan pelajar Tingkatan Empat*. Unpublished master's thesis, University of Malaya, Kuala Lumpur.

Marton, F. (1982). Phenomenography: A research approach to investigating different understanding of reality. *Journal of Thought, 21*, 28-49.

Marton, F. (1996). Phenomenography. *The international encyclopaedia of education*. Oxford, UK: Pergamon Press.

McGee, C. (1987). *Executive report: The linkages project- Transition from primary to secondary school in New Zealand*. Wellington, New Zealand: Research and Statistics Division, Department of Education.

Merriam, S. B. (1998). *Qualitative research and case study applications in education: Revised and expanded from case study research*. San Fransisco, CA: Wiley.

Merriam, S.B. (2009). *Qualitative research: A guide to design and implementation*. San Francisco, CA: Wiley.

Merton, R. K., Fiske, M., & Kendall, P. (1956). *The focused interview*. Glencoe, IL: Free Press.

Miles, M., & Huberman, A.M. (1994). *Qualitative Data Analysis*. Thousand Oaks, CA: Sage.

Ministry of Education, Malaysia (2000). *Annual report*. Kuala Lumpur.

Ministry of Education (2006). *Integrated Curriculum for Secondary Schools Curriculum Specifications: Science Form 1*. Kuala Lumpur: Dewan Bahasa dan Pustaka.

Ministry of Education. (2008). *Assessment guide for Science practical work assessment (UPSR)*. Ministry of Education of Malaysia: Malaysia Examination Board.

Mizelle, N. B. (1995, April). *Transition from middle school into high school: The student perspective*. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, USA.

Mizelle, N. B., & Irvin, J. L. (2000). Transition from middle school to high school. *Middle School Journal, 31*(5), 57-61.

Mohd Anuar. (2000). *Meningkatkan kemahiran manipulatif pelajar tahun 5 semasa menjalankan eksperimen*. Unpublished thesis. Universiti Sains Malaysia, P. Pinang.

Moni, R. W., Hryciw, D. H., Paronnik, P., Lluka, L. J., & Moni, K. B. (2007). Assessing core manipulative skills in a large, first-year laboratory. *Advances in Physiology Education, 35*(1), 266-269.

Morris, P. E. (1973). In Denzin, N. K., & Lincoln, Y. S. (2005). *The handbook of qualitative research*. Thousand Oaks, CA: Sage.

Morse, J. M. (1998). Designing funded qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Strategies of Qualitative Inquiry.* London: Sage.

Noraini Zainal Abidin. (2009). *What do we mean by transition at secondary school for students with special educational needs: A case study in the Federal Territory, Kuala Lumpur, Malaysia.* Unpublished doctoral thesis, University of Warwick, United Kingdom.

OECD. (2006). *Assessing Scientific, Reading and Mathematical Literacy: A Framework for PISA 2006.* Paris, France: OECD.

Osborne, J., & Simon, S. (1996). Primary science: Past and future directions. *Studies in Science Education, 27*, 99-147.

Patton, M. Q. (2002). *Qualitative evaluation and research methods* (3rd ed.). Thousand Oaks, CA: Sage.

Piaget, J. (1985). *Equilibration of cognitive structures.* Chicago, IL: University of Chicago Press.

Reid, A. (1997). The meaning of music and the understanding of teaching and learning in the instrumental lesson. In A. Gabrielsson (Ed.), *Proceedings of the Third Triennial ESCOM Conference*. Uppsala, Sweden: Uppsala University.

Reid, A., & Petocz, P. (2002). Students' conceptions of statistics: A phenomenographic study. *Journal of Statistics Education, 10*(2). Retrieved from http://www.amstat.org/publications/jse/v10n2/reid.html

Ritchie, J., & Spencer, E. (1994). Qualitative data analysis for applied policy research. In A. Bryman & R. G. Burgess (Eds.), *Analyzing qualitative data*. London, UK: Routledge.

Rohaida Mohd Saat. (2003). *Learning primary science in a web-based learning environment*. Unpublished Ph.D. thesis, Universiti Putra Malaysia, Serdang, Selangor.

Rohaida Mohd Saat. (2010). Issues in maintaining continuity and progression of students' science learning. In A. Hussain & N. Idris (Eds.), *Dimensions of education* (pp. 275-291). New Delhi, India: Gyan.

Rohiza Hussain. (2008). *Penguasaan kemahiran memerhati dan kemahiran meramal dalam matapelajaran sains di kalangan pelajar tahun lima daerah Johor Bahru*. Unpublished thesis, UniversitiTeknologi Malaysia, Skudai.

Romiszowski, A. (1999). *The development of physical skills: Instruction in the psychomotor domain.* Mahwah, NJ: Lawrence Erlbaum Associates.

Rose Amnah Abdul Rauf, Abd Rashid Johar, Lilia Halim, & Siti Rahayah Ariffin. (2004). Pemupukan kemahiran proses sains di kalangan pelajar tingkatan dua di sekolah bestari. *Jurnal Teknologi, 40,* 19–32.

Ryan, P. (2001). The school-to-work transition: A cross-national perspective. *Journal of Economic Literature, 39*(1), 34–92.

Saldana, J. (2003). Longitudinal qualitative research. New York, US: Alta Mira Press.

Sayre, H. M. (2010). *A world of art*. Upper Saddle River, NJ: Prentice Hall.

Schnepf, S. (2002). A sorting hat that fails? The transition from primary to secondary school in Germany. *School Journal, 31,* 57–61.

Silverman, D. (2001). *Interpreting qualitative data: Methods for analyzing talk, text, and interaction* (2nd ed.). London, UK: Sage.

Seels, B., & Glasgow, Z. (1990). *Exercises in instructional design.* Columbus OH: Merrill.

Simpson, E. (1972). *The classification of educational objectives in the psychomotor domain: The psychomotor domain.* Washington, DC: Gryphon House.

Siti Mariam bt.Hamzah. (2006). *Tahap penguasaan kemahiran manipulatif pelajar tingkatan 4 dalam pengendalian alat radas di makmal*. Unpublished thesis, Universiti Pendidikan Sultan Idris, TanjungMalim.

Sjoberg, S. (2005, March). *Young people and science: Attitudes, values and priorities. Evidence from the ROSE project*. Paper presented at the EU's Science and Society Forum 2005, U.Kingdom. Retrieved from http://roseproject.no/network/countries/norway/eng/nor-sjoberg-eu2005.pdf

Smaldino, S., Russell, J., Heinich, R., & Molenda, M. (2005). *Instructional technology and media for learning*. Upper Saddle River, NJ: Pearson Merrill Prentice Hall.

Speering, W., & Rennie, L. (1996). Students' perceptions about science: The impact of transition from primary to secondary school. *Research in Science Education*, *26*(3), 283-298.

Stevens, D. D., & Levi, A. J. (2005). *Introduction to rubrics: An assessment tool to save grading time, convey effective feedback and promote student learning*. Sterling, VA: Stylus Publishing.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Grounded theory procedures and Technique.* Newbury Park, CA: Sage.

Strauss, A., & Corbin, J. (2008). *Basics of qualitative research: Grounded theory procedures and techniques* (3rd ed.).Newbury Park, CA: Sage.

Suzariman bin Ismail. (2000). *Aras penguasaan kemahiran manipulatif di kalangan pelajar tingkatan empat dalam matapelajan sains tulen*. Unpublished thesis, Universiti Teknologi Malaysia, Skudai.

Taatgen, N. A. (1999). *Proceeding of The Twenty-first Annual Conference of the Cognitive Science Society: A model of learning task-specific knowledge for a new task.* Mahwah, NJ: Erlbaum. Retrieved from http://actr.psy.cmu.edu/papers/344/nat_1999_a.pdf

Tesch, R. (1990). *Qualitative research: Analysis types & software tools.* Bristol, PA: Falmer Press.

Thurston, A., Topping, K. J., Tolmie, A., Christie, D., Karagiannidou, E., & Murray, P. (2010). Cooperative learning in Science: Follow-up from primary to high school. *International Journal of Science Education*, *32*(4), 501-522.

Tiberghien, A., Veillard, L., Jean-François, L.M., Buty, C., & Millar, R. (2001). An analysis of lab work tasks used in science teaching at upper secondary school and university levels in several European countries. *Science Education*, *85*(5), 483–508.

Tilleczek, K. (2007, Jan). *Fresh Starts/false starts: A review of literature on the transition from elementary to secondary school*. Paper presented at the Ontario Education Research Symposium, Toronto: Ontario Ministry of Education.

Tilleczek, K., & Ferguson, B. (2007). *Transitions from elementary to secondary school: A review and synthesis of the literature.* Community Health Systems Resource Group, Ontario Ministry of Education, Toronto: Canada.

Tobin, K. G. (1990). Research on science laboratory activities; In pursuit of better questions and answers to improve learning. *School Science and Mathematics, 90*, 403-418.

Trigwell, K. (2000). A phenomenographic interview on phenomenography. In J. A. Bowden & E. Walsh (Eds.), *Phenomenography*. Melbourne, Australia: RMIT Publishing.

Trowbridge, L. W., Bybee, R. W & Powell, J. C. (2000). *Teaching secondary school science.* Upper Saddle River, NJ: Prentice Hall.

Ungar, D., Joffe, S., & Kodish, E. (2006). Children are not small adults: Documentation of assent for research involving children. *Journal of Pediatrics*, *149*(1), 31-33.

Wan Dalila Hanum.(2006). *Tahap penguasaan kemahiran manipulatif dalam menjalankan eksperimen Sains di kalangan pelajar tingkatan dua*. Unpublished degree thesis, Universiti Pendidikan Sultan Idris, TanjungMalim.

Wan Noor Izzah Abu Bakar.(2006). *Relationship between students' perception of science laboratory environment and Form 2 students science achievement*. Unpublished master's thesis, University of Malaya, Kuala Lumpur.

Ward, R. (2000). Transition from middle to secondary school: A New Zealand study. *International Journal of Educational Research*, *33*, 365-374.

Wekesa, E. T. (2013). Strategies used by teachers to improve students' mastery of drawing skills and performance in Biology in Bungoma West District, Kenya. *Journal of Emerging Trends in Educational Research and Policy Studies*, *4*(3), 473-479.

Wolfinger, D. M. (2000). Science in the Elementary and Middle School. New York, NY: Longman.

Woolnough, B. E. & Allsop, T. (1985). Practical work in science. Cambridge: Cambridge University Press.

Wrutheran Sinnadurai. (2000). *Amali sains dalam pengajaran dan pembelajaran sains teras dikalangan pelajar tingkatan empat*. Unpublished thesis. Maktab Perguruan Kuala Terengganu.

Wrutheran Sinnadurai, Alyas Mohamad, Rohani Abd. Hamid & Wan Mazlan Wan Muda. (2004). Amali sains dalam pengajaran dan pembelajaran sains teras di kalangan pelajar Tingkatan Empat. *Jurnal Penyelidikan*. Maktab Perguruan Kuala Terengganu.

Wu, W. C., Yang, Y. C., & Chuang, C. P. (2007). *The analysis of Simpson's psychomotor domain educational objectives and its application on the skill evaluation for the department of computer engineering at vocational school.* Paper presented at the Seventh IEEE International Conference on Advanced Learning Technologies (ICALT 2007). Niigata: Japan.

Yager, R. E. (1996). *Science/technology/society as reform in science education*. Albany, NY: State University of New York Press.

Yannis, H. (2001). The role of wonder and romance in early childhood science education. *International Journal of Early Years Education*, *9*(1), 63-70.

Yoong, S., & Aminah Ayob. (2010*). Malaysian Students' Interests in Learning Science and Technological (S&T) Topics, their Attitudes, Perceptions and Priorities towards Important Issues in S&T with International Comparisons*.(ROSE research project). Penang: Universiti Sains Malaysia, Faculty of Education.

APPENDICE

APPENDIX A
LETTER OF CONSENT

Hidayah Mohd Fadzil
No 44 Jln SJ 7,
Taman Selayang Jaya,
68100 Batu caves
Selangor   No telefon: 012-3096366

Kepada,
Ibu bapa/penjaga, pelajar Tahun Enam   12 October 2011

Tuan/Puan,

Memohon kebenaran bagi melibatkan anak Tuan/Puan di dalam projek penyelidikan

Saya Hidayah binti Mohd Fadzil, pelajar Doktor Falsafah (Ph.D) dari Jabatan Pendidikan Matematik dan Sains, Fakulti Pendidikan, Universiti Malaya ingin memohon jasa tuan untuk memberi kebenaran kepada anak tuan bersama dengan rakan kelasnya yang lain untuk menjadi peserta bagi satu penyelidikan bertajuk "Students' Manipulative Skills during Transition from Primary to Secondary School".

2. Kajian ini melibatkan perkembangan kemahiran manipulatif Sains iaitu kemahiran yang melibatkan penggunaan alatan sains di makmal semasa di sekolah rendah (Tahun 6) sehingga ke sekolah menengah (tingkatan 1). Anak tuan akan mengambil bahagian sebagai peserta kajian bermula selepas peperiksaan UPSR sehingga ke Tingkatan Satu. Kajian akan dijalankan di luar waktu pembelajaran agar tidak mengganggu sesi pembelajaran. Semasa sesi di makmal, saya akan menggunakan perakam video dan audio untuk menganalisa kemahiran pelajar dalam menggunakan peralatan Sains di makmal dan pada akhir sesi tersebut mereka akan ditemubual untuk mendapatkan pandangan mereka terhadap proses peralihan ke sekolah menengah. Semua maklumat yang diperolehi akan dirahsiakan dan tidak akan menjadi sebahagian rekod di sekolah. Data dari kajian ini akan digunakan untuk tujuan penulisan tesis dan nama samaran akan digunakan di dalam penulisan.

3. Diharap tuan/puan dapat memberikan jawapan di ruangan yang disediakan di bawah dan dikembalikan kepada guru kelas. Tuan/puan boleh menghubungi saya untuk sebarang pertanyaan berkaitan projek ini.

Sekian, Terima Kasih.

Di sini saya,(nama ibubapa/penjaga)
____, membenarkan / tidak membenarkan (sila gariskan) anak saya (nama pelajar)____________________
_______________________________________ untuk menyertai kajian yang dinyatakan seperti di atas.

Tandatangan ibu bapa,

____
Tarikh:

ASSESSMENT GUIDE

SCIENCE PRACTICAL WORK ASSESSMENT (PEKA)

UJIAN PENCAPAIAN SEKOLAH RENDAH MULAI 2008

LEMBAGA PEPERIKSAAN MALAYSIA
KEMENTERIAN PELAJARAN MALAYSIA

CONTENTS

1.0 INTRODUCTION

The UPSR Science Practical Work Assessment (UPSR PEKA) is a school based assessment that is implemented at school level as part of teaching and learning process.

UPSR PEKA Assessment Guide contains information on the objectives, characteristics and organization of UPSR PEKA. It also outlines the procedures to assess the pupils' practical work as guidelines to teachers as assessors and users of PEKA to carry out the assessment in a coordinated manner.

2.0 OBJECTIVES OF UPSR PEKA

The objectives in conducting UPSR PEKA is to enable the pupils to :

* Master the Scientific Skills
    - Science Process Skills
    - Science Manipulative Skills
* Strengthen the knowledge and understanding on the theories and concepts in Science
* Inculcate the Scientific Attitudes and Noble Values

3.0 THE CHARACTERISTICS OF UPSR PEKA

3.1 Compatibility with the Curriculum Specification

The assessment is designed such that it is compatible with the knowledge, scientific skills, scientific attitudes and noble values to be developed in the teaching and learning process as in the Science Curriculum Specification.

3.2 Pupil-centered

All activities should be carried out by the pupils in a condusive environment and guided by the teacher's teaching plan. The pupils' work should be assessed in accordance to their abilities and readiness.

3.3 Feasible and Systematic

The format of assessment is designed to be practical and manageable. The assessment procedure should be systematic to enable teachers to administer the assessment efficiently.

3.4 Open and Transparent

The assessment should give the pupils the opportunity to be informed on the following aspects :

- The construct to be assessed
- How the construct will be assessed
- When the construct will be assessed
- Where the construct will be assessed

3.5 Variety of Instruments

Pupils are able to use variety of instruments such as folio, project, scrap book, check-list and model to produce evidence that reflects individual's ability and their level of performance.

3.6 Continuous and Formative Assessment

The assessment is to be carried out from Year 3 until Year 6. Throughout the assessment period the pupils are encouraged to acquire knowledge and experience to enable them the opportunity to improve their work and the score obtained.

3.7 Valid and Reliable

The validity of the assessment is determined by the scores that portray relevant information on the constructs assessed. It is ascertained by ensuring the constructs assessed are within the curriculum specification.

The reliability of the assessment refers to the consistency and accuracy of the scores obtained through the process of moderation and monitoring.

3.8 Positive Reports

The scores reported should show that an acquisition of skills that stimulates the pupils to improve on their performance and achievement to a better level of mastering skills, is achieved.

3.9 Continuous Monitoring

The process of generating UPSR PEKA has to be monitored and supervised systematically from time to time to ensure it is carried out in accordance to its objectives and procedures.

4.0 THE ORGANIZATION OF UPSR PEKA

4.1 Planning

The assessment should be planned accordingly which includes aspects such as :

- the pupils to be assessed
- the time / duration to conduct the assessment
- the frequency of the assessment
- the personnel involved
- the type of instrument
- the scoring
- the grading
- the reporting

4.2 Administration

All information regarding the assessment are collected and assessed by teachers responsible in the teaching and learning process of the subject. The teachers are required to manage the evidence produced by the pupils.

4.3 Scoring

Scores are awarded based on the scoring scheme.

Total score for Science Process Skills (SPS) is 30 marks and Science Manipulative Skills (SMS) is 20 marks.

4.4 Reporting

The scores of the pupil are summarized according to the principles and the grading procedures to obtain the pupils' level of mastery.

4.5 Moderation

A mechanism exercised to ensure the pupils are assessed on the similar construct and given the relevant scores. Moderation is an essential procedure to standardize and monitor school based assessments to maintain the validity and reliability of the scores given by the teacher.

5.0 METHOD FOR ASSESSMENT

5.1 UPSR PEKA is carried out as part of teaching and learning process.

5.2 Teachers can assess either one construct/skill or several constructs/skills to a small group of pupils or the whole class.

5.3 Scientific Attitudes and Noble Values should be assessed simultaneously with other skills.

5.4 Teachers assess, give and record the score of the evidence presented by the pupils. All the information regarding the evidence are accessible to the pupils.

5.5 Pupils must submit a complete evidence.

5.6 Pupils who have not mastered any assessed constructs are able to repeat it in another assignment.

5.7 Teachers must plan enough assignments to ensure that all the constructs have been assessed.

5.8 Pupils should be given adequate chances to master the required skills before the assessment is made.

5.9 The assessment should be carried out **at least two times** in each year, from Year 3 to Year 6.
The highest score for each construct could be taken from either year.

6.0 THE FRAMEWORK OF UPSR PEKA

6.1 Learning Area

The learning area comprises of two main elements.

Element 1 : Science Process Skills (SPS)

Element 2 : Science Manipulative Skills (SMS)

Element 1 and Element 2 contain a list of criteria of the skills as performance indicator which are expected to be mastered by the pupils. The criteria are extracted and translated from the Modul Kemahiran Proses Sains - Pusat Perkembangan Kurikulum, 1995.

The Scientific Attitudes and Noble Values are imbedded during the assessment of science process skills and science manipulative skills and must be observed by the teacher / assessor.

The activity code is represented by the following information:

Year / Theme / Learning Objective / Learning Outcomes

(Refer Curriculum Specification)

6.2 Construct, Score and Criteria (Performance Indicator)

6.2.1 Element 1 : Science Process Skills (SPS)

<table>
<tr><th>Construct</th><th>Score</th><th>Criteria</th><th>Remark</th></tr>
<tr><td rowspan="6">SPS 1
Observing</td><td rowspan="3">4</td><td>C1 – State the properties of objects and situations correctly using any of the five senses</td><td rowspan="6">Suggested activity

(i) Field study
(ii) Experiment
(iii) Project

Examples :
3 / 1 / 1.1 / 4
3 / 1 / 1.2 / 1
3 / 1 / 2.1 / 4
3 / 2 / 6.1 / 1
4 / 1 / 3.2 / 1 & 2
4 / 1 / 3.4 / 1 & 2
4 / 1 / 3.5 / 2 & 5
5 / 1 / 1.1 / 3
6 / 1 / 1.1 / 1 - 6
6 / 1 / 1.2 / 1
(Refer Curriculum Specification)</td></tr>
<tr><td>C2 – State the properties of objects and situations correctly using appropriate tools to assist senses</td></tr>
<tr><td>C3 – State the properties of objects and situations based on the sequences occured</td></tr>
<tr><td>3</td><td>C1 and C2</td></tr>
<tr><td>2</td><td>C1 or C2</td></tr>
<tr><td>1</td><td>C1 or C2 (with guidance)</td></tr>
</table>

<table>
<tr><th>Construct</th><th>Score</th><th>Criteria</th><th>Remark</th></tr>
<tr><td rowspan="7">SPS 2
Classifying</td><td rowspan="4">4</td><td>C1 – Grouping objects or events in order into categories based on one common property or criteria</td><td rowspan="7">Suggested activity

(i) Field study
(ii) Experiment
(iii) Project

Examples :
3 / 1 / 1.1 / 1
3 / 1 / 1.3 / 1
3 / 1 / 2.3 / 1
3 / 2 / 1.3/ 1
3 / 2 / 4.1 / 1
4 / 1 / 2.3 / 9
4 / 3 / 1.1 / 1 & 11
5 / 1 / 2.2 / 1
6 / 1 / 3.1 / 2
5 / 3 / 1.1 / 1
6 / 3 / 1.2 / 2
6 / 3 / 2 / 2.1 / 1
(Refer Curriculum Specification)</td></tr>
<tr><td>C2 – State the differences and similarities of the physical properties or criteria</td></tr>
<tr><td>C3 – State the common properties or criteria used in each step of classification</td></tr>
<tr><td>C4 – Grouping objects or events in order into categories based on properties or criteria until the final step or the higher level</td></tr>
<tr><td>3</td><td>C1, C2 and C3</td></tr>
<tr><td>2</td><td>C1 and C2</td></tr>
<tr><td>1</td><td>C1 with guidance</td></tr>
<tr><td rowspan="7">SPS 3
Measuring and Using Numbers</td><td rowspan="4">4</td><td>C1 – Use the correct apparatus to measure quantities e.g. length, volume, mass, time, temperature and speed</td><td rowspan="7">Suggested activity

(i) Field study
(ii) Experiment
(iii) Project

Examples :
4 / 2 / 1.1 / 3 - 4
4 / 2 / 1.2 / 3
4 / 2 / 1.4 / 4 & 5
4 / 2 / 1.5 / 3 & 4
4 / 2 / 1.6 / 4 & 5
5 / 2 / 4.1 / 3
6 / 2 / 2.1 / 1 & 2
(Refer Curriculum Specification)</td></tr>
<tr><td>C2 – Record reading using numbers and correct standard unit (SI)</td></tr>
<tr><td>C3 – Record reading accurately</td></tr>
<tr><td>C4 – State the increase and decrease in a reading</td></tr>
<tr><td>3</td><td>C1, C2 and C3</td></tr>
<tr><td>2</td><td>C1 and C2</td></tr>
<tr><td>1</td><td>C1 and C2 with guidance</td></tr>
</table>

<table>
<tr><th>Construct</th><th>Score</th><th>Criteria</th><th>Remark</th></tr>
<tr><td rowspan="7">SPS 4
Communicating</td><td rowspan="4">4</td><td>C1 – Record data or information from an investigation</td><td rowspan="7">Suggested activity

(i) Field study
(ii) Experiment
(iii) Project

Examples :
5 / 2 / 4.1 / 5
6 / 1 / 1.2 / 2
5 / 3 / 1.3 / 1
4 / 1 / 1.2 / 3
4 / 3 / 1.6 / 2
6 / 4 / 1.1 / 3
(Refer Curriculum Specification)</td></tr>
<tr><td>C2 – Present data or information using appropriate drawing, table or graph</td></tr>
<tr><td>C3 – Explain ideas (oral or written)</td></tr>
<tr><td>C4 – Write experimental report systematically
(With or without guidance)</td></tr>
<tr><td>3</td><td>C1, C2 and C3</td></tr>
<tr><td>2</td><td>C1 and C2</td></tr>
<tr><td>1</td><td>C1 with guidance</td></tr>
<tr><td rowspan="7">SPS 5
Using
Space-Time
Relationship</td><td rowspan="4">4</td><td>C1 – Arrange occurance of phenomenon or events chronologically</td><td rowspan="7">Suggested activity

(i) Field study
(ii) Experiment
(iii) Project

Examples :
5 / 4 / 2.1 / 2
6 / 4 / 1.1 / 3
6 / 4 / 1.2 / 2
5 / 2 / 3.1 / 4
(Refer Curriculum Specification)</td></tr>
<tr><td>C2 – State the relationship between the distance travelled and the time taken</td></tr>
<tr><td>C3 – State the quantity of changes based on the rate of changes</td></tr>
<tr><td>C4 – Explain changes in location, size, shape and direction, with time</td></tr>
<tr><td>3</td><td>C1, C2 and C3</td></tr>
<tr><td>2</td><td>C1 and C2</td></tr>
<tr><td>1</td><td>C1 and C2 with guidance</td></tr>
</table>

Construct	Score	Criteria	Remark
SPS 6 Defining Operationally	**4**	C1 – State concepts by describing what should be observed	Suggested activity (i) Field study (ii) Experiment (iii) Project *Examples* : 6 / 2 / 1.3 / 7 5 / 3 / 2.1 / 1 6 / 1 / 1.2 / 2 6 / 3 / 1.2 / 2 6 / 5 / 1.2 / 2 (Refer Curriculum Specification)
		C2 – State concepts by describing what should be done	
		C3 – State variables by describing what should be observed	
		C4 – State variables by describing what should be done	
	3	C1 and C2 or C3 and C4	
	2	C1 and C2	
	1	C1 or C2 with guidance	
SPS 7 Experimenting	**6**	C1 – State the hypothesis (relationship between what to change and what to measure)	*Examples* : 5 / 3 / 2.1 / 3 5 / 2 / 2.2 / 6 5 / 2 / 3.1 / 4 5 / 2 / 4.1 / 1 6 / 2 / 1.3 / 8 6 / 2 / 2.1 / 1 (Refer Curriculum Specification)
		C2 – State the variables i.e. what to change, what to measure and what to keep constant in an experiment	
		C3 – Identify the apparatus in an experiment	
		C4 – State the steps in an experiment (oral or written)	
		C5 – Carry out an experiment to test the hypothesis by controlling variables in a coordinated manner	
		C6 – Present the result in the form of drawing, table, graph or other means	
	5	C1, C2, C3, C4 and C5	
	4	C1, C2, C3 and C4	
	3	C1, C2 and C3	
	2	Any two criteria (C1 , C2 , C3)	
	1	C1 or C2 or C3 with guidance	

6.2.2 Element 2 : Science Manipulative Skills (SMS)

<table>
<tr><th>Construct</th><th>Score</th><th>Criteria</th><th>Remark</th></tr>
<tr><td rowspan="7">SMS 1
Use and handle science apparatus and substances</td><td rowspan="4">4</td><td>C1 – Use at least 5 apparatus correctly and carefully</td><td rowspan="7">Example

Use ruler, hand lens, measuring cylinder, microscope, thermometer, bunsen burner, stop watch, test tube, stethoscope and retort stand

Note
SPS and SMS can be carried out together</td></tr>
<tr><td>C2 – Handle apparatus and substances correctly and carefully</td></tr>
<tr><td>C3 – Set up the apparatus or prepare the substances in an orderly manner</td></tr>
<tr><td>C4 – Carry out the experiment following the correct procedures</td></tr>
<tr><td>3</td><td>C1, C2 and C3</td></tr>
<tr><td>2</td><td>C1 and C2</td></tr>
<tr><td>1</td><td>C1 with guidance</td></tr>
<tr><td rowspan="7">SMS 2
Handle living and non-living specimens</td><td rowspan="4">4</td><td>C1 – Handle living specimens correctly and carefully</td><td rowspan="7">Example

Living specimen
(i) Young plants
(ii) Insects

Non-living specimen
(i) Stick
(ii) Water
(iii) Stone
(iv) Soil</td></tr>
<tr><td>C2 – Handle non-living specimens correctly and carefully</td></tr>
<tr><td>C3 – Caring for living specimens</td></tr>
<tr><td>C4 – Use non-living specimens without waste</td></tr>
<tr><td>3</td><td>C1, C2 and either C3 or C4</td></tr>
<tr><td>2</td><td>C1 and C2</td></tr>
<tr><td>1</td><td>C1 or C2 with guidance</td></tr>
</table>

Construct	Score	Criteria	Remark
SMS 3 Draw specimen, apparatus and substances	**4**	C1 – Draw neatly	
		C2 – Label drawings correctly	
		C3 – Draw what is observed	
		C4 – Draw using correct scales	
	3	C1, C2 and C3	
	2	C1 and C2	
	1	C1 with guidance	
SMS 4 Clean apparatus	**4**	C1 – Clean apparatus using the correct method	Assessed after carrying out an experiment (fair test). Holistic and continuous assessment.
		C2 – Dispose waste using the correct method	
		C3 – Clean apparatus **(frequently)**	
	3	C1 and C2 Clean apparatus **(sometimes)**	
	2	C1 and C2 Clean apparatus **(rarely)**	
	1	C1 and C2 with guidance	

Construct	Score	Criteria	Remark
SMS 5 Store apparatus and substances	**4**	C1 – Store apparatus and substances correctly and safely	Assessed after carrying out an experiment (fair test). Holistic and continuous assessment.
		C2 – Store apparatus and substances correctly and safely**, (frequently)**	
	3	C1 and Store apparatus and substances **(sometimes)**	
	2	C1 and Store apparatus and substances **(rarely)**	
	1	C1 with guidance	

7.0 SCORING PROCEDURE

The marks / scores obtained from each construct (skills / values) assessed is recorded in the Individual Score Form (ISF).

7.1 Individual Score Form (ISF)

Refer Appendix 1 : Year 3
Appendix 2 : Year 4
Appendix 3 : Year 5
Appendix 4 : Year 6

(i) Tick the highest score in the relevant cell with reference to the scoring scheme.

(ii) Write the highest score obtained for each construct in the respective cell.

7.2 Final Individual Score Form (ISF)

Refer Appendix A.
Write the highest score obtained for each construct.
The highest score for each construct could be taken from either year.

7.3 Procedures in Managing ISF

(i) ISF is used to record the scores of each pupil during the assessment based on the construct assessed.

(ii) ISF should be used by teachers / assessors and moderators.

(iii) ISF must be completed in two copies:
- (a) the original copy is kept by the teacher / assessor
- (b) the second copy is kept in the pupils PEKA record book

(iv) ISF must be certified by the school headmaster at the end of the assessment period.

(v) If a pupil transfers to another school, an updated copy of the ISF should be enclosed together with the personal file to be submitted to the new school.

8.0 REPORTING PROCEDURE

8.1 School Report

The school final report should be in the form of a certificate issued by the school and authorised by the school headmaster. The certificate shows the highest score obtained for each construct.

8.2 Master Score Form (MSF)

At the end of the assessment period (Year 6), the highest score for every construct must be transferred to the MSF. Teachers must sum up the total score for every construct to obtain the total score for PEKA.

The completed MSF must be submitted to Lembaga Peperiksaan Malaysia according to the scheduled date.

Refer **Master Score Form** : Appendix B.

Appendix 1

SCIENCE PRACTICAL WORK ASSESSMENT (PEKA) - UPSR
INDIVIDUAL SCORE FORM
YEAR 3

SCHOOL : ....

Name .... **Class** ....

Date	Activity Code	SPS 1				SPS 2			
		1	2	3	4	1	2	3	4
Highest Score									

Remarks

Date	Activity Code	SMS 1				SMS 2				SMS 3				SMS 4				SMS 5			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Highest Score																					

Evaluated by **Authorised by**

Appendix 2

SCIENCE PRACTICAL WORK ASSESSMENT (PEKA) - UPSR
INDIVIDUAL SCORE FORM
YEAR 4

SCHOOL : ……………………………………………………………

Name ………………………………………………………………………………………………… **Class** ………………………………..

Date	Activity Code	SPS 1				SPS 2				SPS 3				SPS 4			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Highest Score																	

Remarks

Date	Activity Code	SMS 1				SMS 2				SMS 3				SMS 4				SMS 5			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Highest Score																					

Evaluated by **Authorised by**

Appendix 3

SCIENCE PRACTICAL WORK ASSESSMENT (PEKA) - UPSR
INDIVIDUAL SCORE FORM
YEAR 5

SCHOOL : ………………………………………………………………

Name ……………………………………………………………………………………………………… **Class** ………………………………..

Date	Activity Code	SPS 1				SPS 2				SPS 3				SPS 4				SPS 5				SPS 6				SPS 7					
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	5	6
Highest Score																															

Date	Activity Code	SMS 1				SMS 2				SMS 3				SMS 4				SMS 5			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Highest Score																					

Evaluated by **Authorised by**

Appendix 4

SCIENCE PRACTICAL WORK ASSESSMENT (PEKA) - UPSR
INDIVIDUAL SCORE FORM
YEAR 6

SCHOOL : ……………………………………………………………….

Name ………………………………………………………………………………………………………. **Class** ………………………………..

Date	Activity Code	SPS 1				SPS 2				SPS 3				SPS 4				SPS 5				SPS 6				SPS 7					
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	5	6
Highest Score																															

Date	Activity Code	SMS 1				SMS 2				SMS 3				SMS 4				SMS 5			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Highest Score																					

Evaluated by **Authorised by**

Appendix A

SCIENCE PRACTICAL WORK ASSESSMENT (PEKA) - UPSR

FINAL INDIVIDUAL SCORE FORM

SCHOOL : ....

Name .... **Class** ....

	SPS 1	SPS 2	SPS 3	SPS 4	SPS 5	SPS 6	SPS 7	Total SPS
Maximum Score	4	4	4	4	4	4	6	30
Highest Score								

	SMS 1	SMS 2	SMS 3	SMS 4	SMS 5	Total SMS
Maximum Score	4	4	4	4	4	20
Highest Score						

Total Score	/ 50

Evaluated by **Authorised by**

Appendix B

SCIENCE PRACTICAL WORK ASSESSMENT (PEKA) - UPSR
MASTER SCORE FORM (MSF)

SEKOLAH			TAHUN	
NEGERI			KOD PUSAT	

BIL.	ANGKA GILIRAN / NO. SURAT BERANAK	NAMA	SPS								SMS						JUMLAH SKOR PEKA
			1	2	3	4	5	6	7	JUMLAH	1	2	3	4	5	JUMLAH	

Signature of Assessor

Signature of Headmaster

APPENDIX C
PHASE 1 - TASK 1

University of Malaya

DEPARTMENT OF MATHEMATICS AND SCIENCE EDUCATION

FACULTY OF EDUCATION

UNIVERSITI OF MALAYA (UM)

STUDENTS' MANIPULATIVE SKILLS DURING TRANSITION FROM PRIMARY TO SECONDARY SCHOOL

MANIPULATIVE SKILLS IN TRANSITION TASK (MSTT)

TASK 1: HEAT

YEAR 6

Name: ____

School: ____

Your answer will be treated as confidential.

Thank you very much for your cooperation.

Investigating Force and Energy

Heat

Learning objective : Understanding that temperature is an indicator of degree of hotness
Objektif pembelajaran : Memahami bahawa suhu digunakan untuk mengukur darjah kepanasan

Learning outcome : To measure the temperature of water when it is heated
Hasil pembelajaran : Untuk mengukur suhu air apabila dipanaskan

Apparatus and materials that you need:
Radas dan bahan yang diperlukan:

- Water
  Air
- Thermometer
  Termometer
- Bunsen burner
  Penunu Bunsen
- Measuring cylinder
  Silinder penyukat
- Beaker
  Bikar
- Tongs
  Penyepit
- Stopwatch
  Jam randik
- Tripod stand
  Tungku kaki tiga
- Wire gauze
  Kasa dawai
- Lighter
  Pemetik api
- Glass rod
  Rod kaca
- **Candle**
  Lilin

What should you do?
Apa yang anda perlu lakukan?

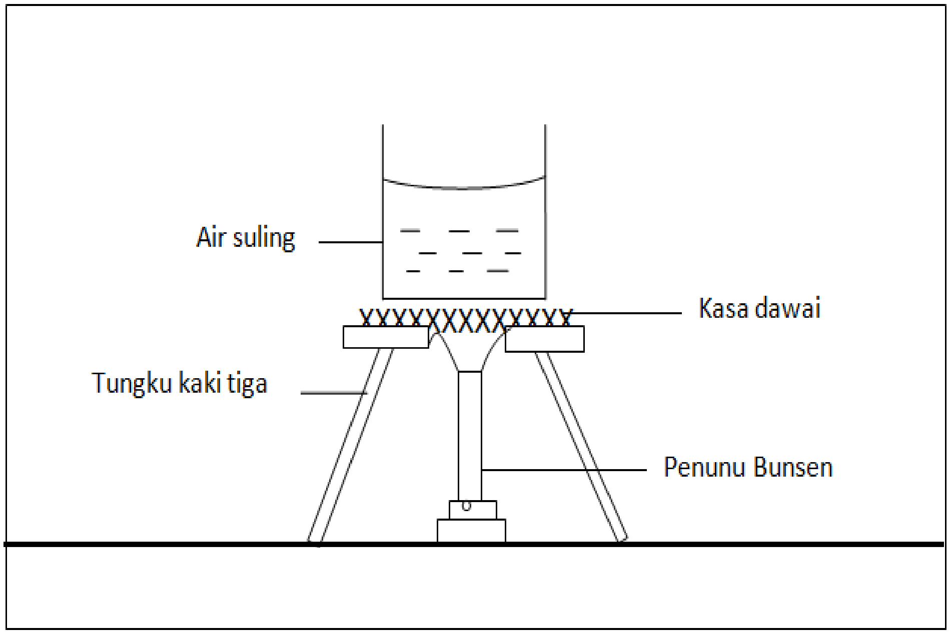


Figure 1

1. Set up the apparatus as shown in figure 1.

   Sediakan radas seperti yang ditunjukkan dalam rajah.

2. Measure 200 ml water and pour into a beaker.

   Sukat 200 ml air dan tuangkan air ke dalam bikar

3. Measure the initial temperature of the water (time = 0 minute) and record it in Table 1.

   Sukat suhu awal air (masa = 0 minit) dan catatkan dalam jadual 1

4. Light the Bunsen burner.

   Nyalakan penunu Bunsen

5. Start the stopwatch and heat the water at the same time.

   Mulakan jam randik dan panaskan air pada masa yang sama.

6. Stir the water from time to time.

   Kacau air dari masa ke semasa.

7. Measure the temperature every 2 minutes for 6 minutes.

   Sukat suhu air setiap 2 minit untuk 6 minit.

8. Record your observations in table 1.

Rekod pemerhatian dalam jadual 1.

Your result:

Keputusan anda:

Time (min) *Masa (min)*	**0**	**2**	**4**	**6**
Temperature of water when heated (°C) *Suhu air yang dipanaskan (°C)*				

Table 1

Conclusion:

Kesimpulan:

____

____

____

THANK YOU

APPENDIX D
PHASE 1 – TASK 2

University of Malaya

DEPARTMENT OF MATHEMATICS AND SCIENCE EDUCATION
FACULTY OF EDUCATION
UNIVERSITI OF MALAYA (UM)

STUDENTS' MANIPULATIVE SKILLS DURING TRANSITION FROM PRIMARY TO SECONDARY SCHOOL

MANIPULATIVE SKILLS IN TRANSITION TASK (MSTT)
TASK 2: INVESTIGATING LIVING THINGS
YEAR 6

Name:____

School: ____

Your answer will be treated as confidential.
Thank you very much for your cooperation.

Investigating Living Things

Microorganisms

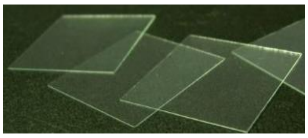
Learning objective : Understand that microorganism is a living thing
Objektif pembelajaran : Memahami bahawa mikroorganisma adalah benda hidup

Learning outcome : To see if microorganisms move
Hasil pembelajaran : Untuk melihat adakah mikroorganism berupaya untuk bergerak

Apparatus and materials that you need:
Radas dan bahan yang diperlukan:

Microscope

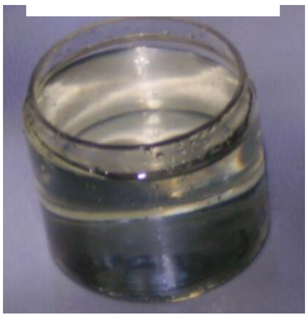
Mikroskop



Glass slide cover
Penutup slaid kaca

Glass slide
Slaid kaca

Dropper
Penitis



Pond water sample
Sampel air kolam

What should you do?
Ape yang anda perlu lakukan?

1. Prepare the apparatus and materials.
   Sediakan alatan dan bahan.

2. Slowly, place a drop of pond water on a clean, dry glass slide by using the dropper as shown in diagram 1.
   Secara perlahan, letakkan setitis air kolam ke atas slaid kaca yang bersih dan kering dengan menggunakan penitis seperti rajah 1.

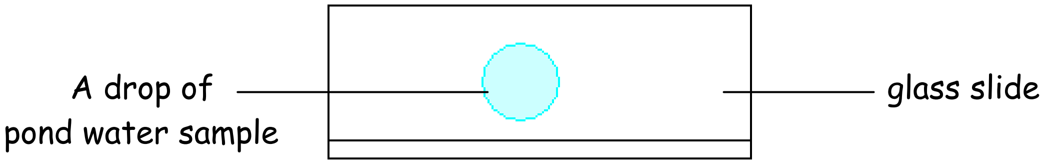


Diagram 1

3. While holding the glass slide cover upright, carefully place one edge of the glass slide cover next to the water. Place the cover over the water by holding the cover at a 45 degree angle and slowly lowering the cover slip onto the water.
   Dengan memegang penutup slaid kaca secara menegak, letakkan sebelah bucu penutup slaid kaca di sebelah kawasan berair. Letakkan penutup slaid ke atas air dengan memegang penutup pada sudut 45 darjah (seperti rajah 2) dan secara perlahan rendahkan penutup ke atas air.

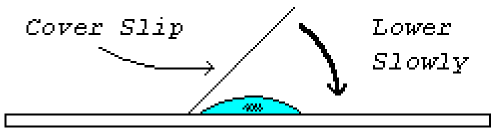


Diagram 2

4. Observe the slide under the microscope.
   Perhatikan slaid di bawah mikroskop.

5. Observe any movement of the microorganism.
   Perhatikan pergerakan mikroorganisma.

6. Draw the microorganisms that you observed.
   Lukis mikroorganisma yang diperhatikan.

Observation:
Pemerhatian:

Do the microorganisms move?
Adakah mikroorganisma bergerak?

____

What do you conclude?
Apakah kesimpulan anda?

Microorganisms are living things because they
Mikroorganisma adalah benda hidup kerana ia

THANK YOU

APPENDIX E

PHASE 1 – TASK 1

DEPARTMENT OF MATHEMATICS AND SCIENCE EDUCATION

FACULTY OF EDUCATION

UNIVERSITI OF MALAYA (UM)

STUDENTS' MANIPULATIVE SKILLS DURING TRANSITION FROM PRIMARY TO SECONDARY SCHOOL

MANIPULATIVE SKILLS IN TRANSITION TASK (MSTT)

TASK 1: MATTER IN NATURE

FORM 1

Name: ____

School:____

Your answer will be treated as confidential.

Thank you very much for your cooperation.

Matter in Nature

Task 1

Your Task:

To understand how the presence of salts affects the boiling point of water
Untuk memahami bagaimana kehadiran garam akan mempengaruhi takat didih air

Apparatus and materials that you need:
Radas dan bahan yang diperlukan:

- Beaker
  Bikar
- Thermometer
  Termometer
- Bunsen burner
  Penunu Bunsen
- Measuring cylinder
  Silinder penyukat
- Tripod stand
  Tungku kaki tiga
- Wire gauze
  Kasa dawai
- Lighter
  Pemetik api
- Glass rod
  Rod kaca
- Candle
  Lilin
- Tongs
  Penyepit
- Distilled Water
  Air suling
- Table Salt
  Garam
- Spatula

Procedure:

1. Set up the apparatus as shown in Figure 1.
   Sediakan radas seperti yang ditunjukkan dalam rajah 1.

2. Measure 200 ml water and pour into a beaker.
   Sukat 200 ml air dan tuangkan ke dalam bikar.

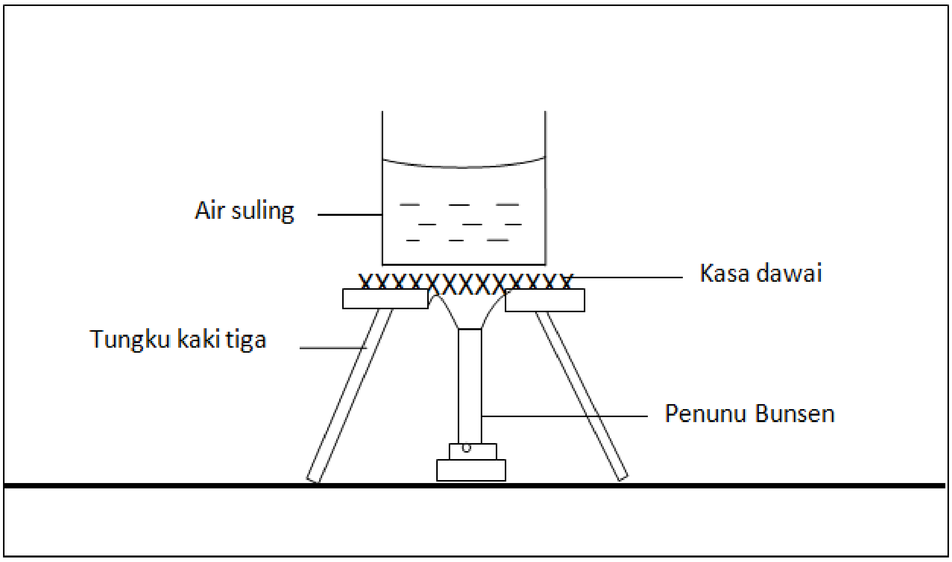


Figure 1

3. Light the Bunsen burner and boil the distilled water.
   Nyalakan penunu Bunsen dan didihkan air suling.
4. Measure the temperature of boiling water and record the highest temperature reading in the data table provided.
   Ukur suhu air didih tersebut dan rekod bacaan suhu tinggi di dalam jadual data yang disediakan.
5. Add two tablespoon of table salt using the spatula, stir and bring to boil.
   Tambah dua sudu garam ke dalam bikar menggunakan spatula, kacau dan biar hingga mendidih.
6. Measure the temperature in of the boiling water. Record the highest temperature reading in the data table.
   Ukur suhu air mendidih. Catatkan bacaan suhu tertinggi ke dalam jadual data yang disediakan.

Results:

Keputusan:

	Highest Temperature (°C) Suhu tertinggi (°C)
Boiling distilled water *Air suling mendidih*	
Boiling distilled water + salt *Air suling mendidih + garam*	

Conlusion:

Kesimpulan:

____

____

-Terima kasih-

APPENDIX F

MSTT PHASE 2- TASK 2

University of Malaya

DEPARTMENT OF MATHEMATICS AND SCIENCE EDUCATION
FACULTY OF EDUCATION
UNIVERSITI OF MALAYA (UM)

STUDENTS' MANIPULATIVE SKILLS
DURING TRANSITION FROM PRIMARY TO SECONDARY SCHOOL

MANIPULATIVE SKILLS IN TRANSITION TASK (MSTT)
TASK 2: MAN AND VARIETY OF LIVING THINGS: CELL AS A UNIT OF LIFE
FORM 1

Name: ____

School: ____

Your answer will be treated as confidential.
Thank you very much for your cooperation.

Man and variety of Living Things: Cell as a unit of life

Learning objective : Understanding cell
Objektif pembelajaran : Memahami sel

Learning outcome : To understand that organisms are built from the basic units of life
Hasil pembelajaran : Untuk memahami organisma terbina dari unit asas kehidupan

Apparatus and materials that you need:
Radas dan bahan yang diperlukan:

- Onion
  Bawang
- Iodine solution
  Larutan iodin
- Scalpel
  Pisau lipat
- Forceps
  Forsep
- Mounting pin
- Glass slide
  Slaid kaca
- Filter paper
  Kertas turas
- Glass slide cover
  Penutup slaid kaca
- Microscope
  Mikroskop

Procedure:
Prosedur:

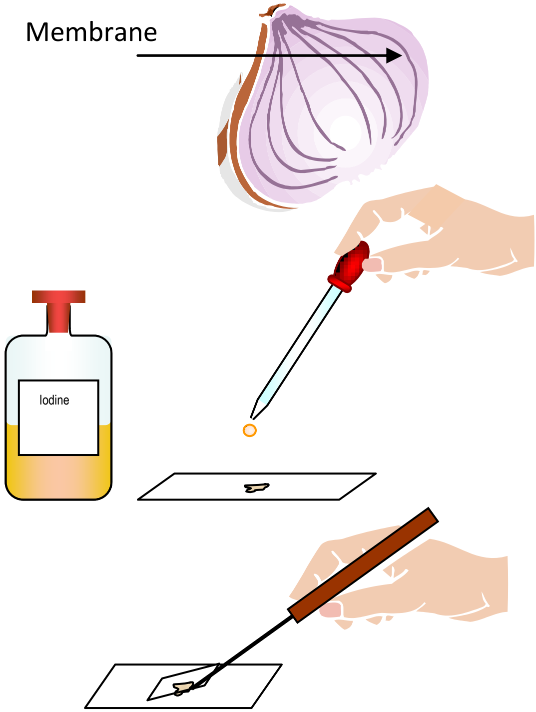


Diagram 1

1. Cut an onion vertically using a scalpel and peel off the inner epidermal membrane from the scale using a forceps.
   Potong sebiji bawang secara menegak menggunakan pisau lipat dan dapatkan membran epidermis dalam pada bawang menggunakan forsep.

2. Spread out the membrane flat on the surface of a clean glass slide. Add 1 drop of iodine solution at the specimen and leave it for two to three minutes.
   Letakkan lapisan membran secara rata pada permukaan sekeping slid kaca yang bersih. Tambahkan setitis larutan iodin pada spesimen dan biarkan selama dua hingga tiga minit.

3. Place a slide cover over the slide carefully. Make sure there are no air bubbles (refer to diagram 1)
   Letakkan penutup slaid kaca dengan berhati-hati. Pastikan tiada gelembung udara terbentuk. (rujuk rajah 1)

4. Put the slide onto the stage of the microscope. Observe the onion cell.
   Letakkan slaid pada pentas mikroskop. Perhatikan sel kulit bawang.

5. Draw and label your observation.
   Lukis dan label pemerhatian anda.

Observation:
Pemerhatian

Conclusion
Kesimpulan:

____

____

APPENDIX H

INTERVIEW PROTOCOL – YEAR 6

DEPARTMENT OF MATHEMATICS AND SCIENCE EDUCATION

FACULTY OF EDUCATION

UNIVERSITI OF MALAYA (UM)

INTERVIEW PROTOCOL:

STUDENTS' MANIPULATIVE SKILLS

DURING TRANSITION FROM PRIMARY TO SECONDARY SCHOOL

(YEAR 6)

INTRODUCTION: Students lack exposure in "hands-on" activities at primary school lead to insufficient manipulative skills and they may carry this problem with them to secondary school. Although most of the pupils are able to adapt to their new learning environment, some found transition difficult and problematic.

PURPOSE: To explore and investigate the acquisition of students' manipulative skills during the transition from primary school (Year Six) to secondary school (Form One).

Your reply will be treated as confidential.

Thank you very much for your cooperation.

Prepared by:

Hidayah Mohd Fadzil

PhD candidate in Science Education

University of Malaya

Part A: Respondent's Particulars

Name :____

School :____

Time & Date :____

Phone Number:____

(A) INTRODUCTION

A1. Thank the student for his/her cooperation to be part of this research

Ucapan terima kasih kepada peserta kajian kerana terus menyertai kajian ini.

A2. Explain briefly the purpose of the interview

Menjelaskan secara ringkas tujuan temubual

(B) TRANSITION

B3. Can you share your feeling since you will be ending your academic pursue at primary school this year?

Bagaimana perasaan adik apabila bakal menamatkan persekolahan di sekolah rendah tidak lama lagi?

Adik tahu adik akan ke sekolah mana tahun hadapan?

B4. How do you feel as you will continue your schooling at secondary school next year? What are the challenges that you think you have to deal with at secondary school? Can you explain.

Bagaimana perasaan melangkah ke sekolah menengah tahun hadapan? Bersedia atau tidak?

Apa cabaran atau masalah yang adik jangka akan hadapi?

Mengapa adik rasa begitu?

B5. Do you think there is any difference in the learning environment between primary and secondary school?

Pada pendapat adik, adakah terdapat perbezaan antara sekolah rendah dan sekolah Menengah?

C) PEMBELAJARAN SAINS

C6. Do you have any interest in science subject at primary school?

Adakah adik meminati/tidak meminati matapelajaran sains di sekolah rendah?

C7. Why do you like/did not like science?

Mengapa adik meminati/tidak meminati sains?

C8. Can you share your experience in learning science at primary school?

Boleh adik ceritakan pengalaman adik belajar matapelajaran sains di sekolah rendah ini?

C9. What are your expectations in learning science subjects at secondary school?

Apakah harapan adik tentang matapelajaran sains di sekolah menengah nanti? Perbezaan yang adik harapkan di sekolah menengah?

D) EXPERIMENTING

D10. What do you think about scientific experiment? Explain your answer.

Apa pandangan adik tentang eksperimen dalam matapelajaran sains? Apa tanggapan adik tentang kepentingan menjalankan eksperimen sains?

D11. Have you been given any opportunity to conduct science experiment? How often?

Di sekolah rendah adik diberi peluang untuk buat eksperimen sains? Berapa kerap?

D12. Can you share about your experience in conducting science experiments at primary school?

Did you have the opportunity to carry out experiments on your own or by teacher demonstration?

Boleh adik ceritakan pengalaman adik dalam menjalankan eksperimen sains di sekolah rendah? Adakah adik berpeluang menjalankan eksperimen sendiri atau demonstrasi oleh guru?

D13. Do you have any expectation about science experiment at secondary school?

Apa jangkaan adik tentang eksperimen sains di sekolah menengah nanti?

E) KEMAHIRAN MANIPULATIF

E14. Can you give the example of apparatus that you used during your learning a primary school?

Adik biasa mengendali alatan sains di sekolah ini? Boleh adik terangkan sedikit alat apa?

E15. Do you have the confidence to operate the apparatus?

Adakah adik yakin dengan kemahiran adik mengendalikan alat/ radas tersebut?

E16. How can your skills in using the apparatus be improved? Can you give some suggestion.

Bagaimana kita nak tingkatkan kebolehan adik dalam menggunakan alatan/radas tersebut? Boleh adik berikan cadangan.

E17. If I give you a Bunsen burner, can you tell me what is the function of the apparatus? Can you show me how to use it?

(Ask the students about the function of each part of apparatus and ask her/him to demonstrates the way of using the apparatus)

Jika adik diberikan penunu Bunsen, boleh adik terangkan fungsi alatan ini?

(Pengkaji meminta pelajar mendemonstrasi penggunaan peralatan berikut)

- Penunu Bunsen
- Termometer
- Silinder penyukat
- Mikroskop

THE END

APPENDIX I

INTERVIEW PROTOCOL – FORM 1

DEPARTMENT OF MATHEMATICS AND SCIENCE EDUCATION

FACULTY OF EDUCATION

UNIVERSITI OF MALAYA (UM)

INTERVIEW PROTOCOL:

STUDENTS' MANIPULATIVE SKILLS
DURING TRANSITION FROM PRIMARY TO SECONDARY SCHOOL
(FORM 1)

INTRODUCTION: Students lack exposure in "hands-on" activities at primary school lead to insufficient manipulative skills and they may carry this problem with them to secondary school. Although most of the pupils are able to adapt to their new learning environment, some found transition difficult and problematic.

PURPOSE: To explore and investigate the acquisition of students' manipulative skills during the transition from primary school (Year Six) to secondary school (Form One).

Your reply will be treated as confidential.

Thank you very much for your cooperation.

Prepared by:

Hidayah Mohd Fadzil

PhD candidate in Science Education

University of Malaya

Part A: Respondent's Particulars

Name :____

School :____

Time & Date :____

UPSR Result :____

(A) INTRODUCTION

A1. Thank the student for his/her cooperation to be part of this research

Ucapan terima kasih kepada peserta kajian kerana terus menyertai kajian ini.

A2. Can you share your feeling as a new secondary school student in this school?

Bagaimana perasaan belajar di sekolah menengah memandangkan ini bulan ketiga adik disini?

(B) TRANSITION TO SECONDARY SCHOOL

B3. Can you describe your experience as a secondary school student? Do you encounter any difficulties in this school?

Ada menghadapi sebarang masalah ketika mula memasuki sekolah menengah? Boleh adik ceritakan?

B4. What is the hardest thing to adapt to in Form 1? (example: adjustments with friends, Science lessons, new teachers)

Apa perkara yang paling sukar untuk adik sesuaikan diri di tingkatan 1? (*contoh: penyesuaian dengan rakan,pelajaran,guru)*

B5. How do you cope with the environment?

Bagaimana adik menyesuaikan diri dalam jangka masa beberapa bulan ini?

B6. Is there any difference between primary and secondary school? Please explain

Adakah terdapat sebarang perbezaan di antara sekolah rendah dengan sekolah menengah? Boleh adik terangkan?

C) SCIENCE LEARNING

C7. Can you give your view on Science subject at secondary school?

Apa pandangan adik tentang subjek Sains di sekolah menengah?

C8. Are there any differences in the teaching and learning of science at primary and secondary schools? How do you feel about the differences?

Ada perbezaan dari aspek pengajaran dan pembelajaran guru dalam subjek sains di sekolah rendah dan sekolah menengah?Apa perasaan adik tentang perbezaan tersebut?

C9. How about your performance in science at secondary schools? Increased / decreased. Why?

Bagaimana dengan prestasi subjek sains di sekolah menengah ini? Meningkat/menurun. Kenapa?

D) EXPERIMENTING

D10. From the interview at primary school, you have mentioned that you did not get Much opportunity to conduct science experiments. How are things in this school? Did you get more opportunity to conduct experiments now?

Daripada temubual semasa di sekolah rendah, adik banyak menyatakan adik kurang berpeluang menjalankan eksperimen sains. Bagaimana keadaan di sekolah menengah ini? Adakah adik berpeluang menjalankan eksperimen di sekolah menengah ini?

D11. Is there any difference in scientific experiment in primary and secondary schools? Please explain.

Ada perbezaan tentang eksperimen sains di sekolah rendah dan menengah? Sila jelaskan.

D12. How about the opportunity to use scientific apparatus/equipment at secondary school? Do you get to familiarize yourself with the appropriate technique of using the apparatus?

Adakah peluang menggunakan radas/alatan di makmal mencukupi untuk adik membiasakan diri dalam mengendalikan peralatan semasa menjalankan eksperimen?

E) MANIPULATIVE SKILLS

D13. Do you experience any difficulties in using scientific apparatus in secondary schools? If you did, how do you overcome the problem?

Adakah adik menghadapi sebarang masalah mengenal alat/radas di sekolah menengah? Bagaimana adik mengatasinya?

D14. Is there any difference between your skills in handling the apparatus at primary And secondary schools?

Boleh adik bandingkan kemahiran adik mengendalikan alat/ radas tersebut di sekolah rendah dan sekolah menengah ini ?

D15. Can you tell me what are the apparatus that you have used in these 4 months? What is the function of the apparatus? Can you show me how to use the apparatus (Ask the students about the function of each part of apparatus and ask her/him to demonstrates the way of using the apparatus)

Adik biasa mengendali alatan sains di sekolah ini? Boleh adik terangkan sedikit alat apa yang telah digunakan sepanjang tempoh 4 bulan ini? Alat diguna untuk apa?Bagaimana digunakan?

(Pengkaji meminta pelajar mendemonstrasi penggunaan peralatan berikut. Pengkaji akan bertanya tentang fungsi asas setiap peralatan, fungsi setiap bahagian pada peralatan sains tersebut dan teknik yang diguna oleh pelajar semasa mengendalikan peralatan tersebut misalnya teknik yag betul untuk membaca senggatan pada silinder penyukat dan termometer)

- Penunu Bunsen
- Termometer
- Silinder penyukat
- Mikroskop

THE END

APPENDIX J

SAMPLE OF INITIAL CODING
AT
EARLY AND LATE TRANSITION

INITIAL CODING
PRIMARY SCHOOL

Phase 1 – Task 1

Student: Meor Mirza (Primary School B)

Date: 26 October 2011

Time: 9 am (12:02 min)

Episode 1 (0:03)

Meor went to the sink, he turned the pipe and filled the measuring cylinder with the tap water.

He lifted the measuring cylinder and brings it to his eye level.

He poured back some of the content into the sink and walked back to the laboratory table.

Comment [D1]: Difficulty in following instruction

Comment [D2]: Wrong technique in measuring volume

Comment [D3]: Eyes must be parallel to the meniscus

Episode 2 (0:21)

Meor poured the water from the measuring cylinder into the beaker and kept reading the manual.

Episode 3 (0:40)

He picked up the thermometer from the table, took a glimpse at the stem and immersed it for a quick second (letting the bulb to touch the floor beaker) into the water to take the initial temperature.

Comment [D4]: Wrong technique in using thermometer

Meor took out the thermometer from the beaker, brought it closer to his eye and start reading the temperature. *Check his task paper*

Comment [D5]: Initial temperature = 0

Episode 4 (01:16)

Meor lighted the candle with confidence and do not have any problem to light the Bunsen burner as well.

He did not aware to open the air hole.

Comment [D6]: sequencing

Meor placed the thermometer to near to the edge of the table, while waiting for the water to be heated.

Comment [D7]: Safety measures

Episode 5 (03:16)

Meor took the thermometer and immersed into the beaker. This time he read the thermometer without taking it out from the beaker.

He made his eyes parallel to the meniscus and read the temperature. Meor puts the thermometer at the table.

After a short second he picked up the thermometer again and immersed it back, into the beaker.

Comment [D8]: Lack of confidence?

Episode 6 (2:59)

Meor lighted the Bunsen burner every time took the temperature.

Comment [D9]: Improper technique

Episode 7 (5.34)

After 2 minutes he dipped the thermometer into the water, without stirring the solution and once again he let the bulb to touch the bottom of the beaker.

Comment [D10]: Poor skills in handling themometer

Episode 8

He took out the Bunsen burner from under the tripod stand, he hold the gas knob and move the Bunsen burner by the knob.

He turned the gas off and carefully took down the hot beaker.

He waited for the beaker to cool off before taking it to the sink to be washed.

He clean his work place by placing back the apparatuses at the appropriate places

Comment [D11]: Cleaning and storing

Phase 1 – Task 2
Student: Meor (Primary School B)
Date: 21 October 2011
Time: 8.30 am

Episode 1

Meor started the experiment by placing a clean glass slide on the table.
He picked the dropper, gently squeezed the rubber end of the dropper using his thumb and forefinger.
He placed the dropper into the beaker which contained aquarium's water.
He gently squeezed the rubber end of the dropper and put one drop of the liquid in the middle of the slide. He placed the cover slip straight away, without using the correct technique to prevent air bubble.

Comment [D12]: Wrong technique in preparing slide

Episode 2 (01:34)

He picked up the microscope and brought it closer to him
(he held the microscope arm with one hand and moves the glass slide in front of him with the other hand).

Comment [D13]: Dangerous technique in holding microscope

Meor placed the glass slide carefully and put it at the stage.
He used the clip stage to secure the slide from moving.

Comment [D14]: Basic skills in using apparatus

Slowly he adjusted the slide position by manipulating the stage knob.
At this moment the objective lens was already set at the lowest power.

Episode 3 (02:20)

Meor looked through the eyepiece.
Then he turned the coarse adjustment knob with his left hand (should use both hand) carefully, while tilting his head to the side to make sure the objective lens did not hit the glass slide.

Comment [D15]: Incorrect skills

He looked back at the eyepiece and adjusted the knob again.
Meor observed the specimen and keep drawing his observation at the worksheet (he drew small circles on the worksheet which actually are gas bubbles)

Comment [D16]: Drawing skills

Episode 4 (04:15)

He adjusted back the course knob to its initial position (far from stage).
Meor carefully hold the stage clips and removed the slide from the microscope stage.
He removed the glass slide cover carefully and washed the slides, dried them with clean tissue and put it back at the table.

Comment [D17]: Cleaning and storing apparatus

Tarikh: 21/10/2011
Masa: 10.40 pagi
Pelajar:Meor Mirza
cita cita: Doktor

R: Bagaimana perasaan adik apabila bakal menamatkan persekolahan di sekolah rendah tidak lama lagi?
Meor:Perasaan saya takde ape pun. Tapi sedih sedikit..nak tinggalkan kawan-kawan yang lama. Dah enam tahun di sini
R:Adik tahu adik akan ke sekolah mana tahun hadapan?
Meor:SMK Kepong

R:Bagaimana perasaan melangkah ke sekolah menengah tahun hadapan? Bersedia atau tidak?
Meor:berdebar
R: Kenapa rasa berdebar?
Meor: nak belajar pelajaran yang banyak lagi…
R: ada benda lain lagi?
Meor: Tiada sangat risau benda lain. Cikgu tiada cerita apa-apa tentang sekolah menengah

Comment [D18]: No information about secondary school

R: Apa cabaran atau masalah yang adik jangka akan hadapi?
Meor: Untuk dapat kawan baru. Belajar dengan cikgu baru. Rasa cikgu di sekolah menengah lebih garang.

R:Pada pendapat adik, adakah terdapat perbezaan antara sekolah rendah dan sekolah menengah?
Meor: Tiada banyak beza tapi lebih banyak pasal belajar la.

R: Adakah adik meminati/tidak meminati matapelajaran sains di sekolah rendah?
Meor: minat
R: Mengapa adik meminati/tidak meminati sains?
Meor: Sebab cita-cita saya nak jadi doctor jadi kena minat sains la. Boleh belajar

R: Ada adik rasa perbezaan sains dengan mata pelajaran lain?
Meor: sains ni banyak buat eksperimen tidak seperti subjek lain. Kena guna otak banyak lah.

Comment [D19]: Distinct feature of science

R:Boleh adik ceritakan pengalaman adik belajar matapelajaran sains di sekolah rendah ini.
Meor : Selalunya buat aktiviti..menulis..salin nota.selalu belajar di kelas.
cikgu tulis di papan hitam di kelas dan salin nota..cikgu ada suruh lukis gambar macam mikroorganisma

Comment [D20]: Drawing skills

R: Ada buat PEKA?
Meor: Ada
R: Boleh terangkan sedikit?
Meor: Takdelah buat eksperimen. Hanya ikut logik la macamana benda tu jadi eksperimen tu. Banyak menulis.
R: Ada buat eksperimen?Boleh meor terangkan sedikit?
Meor:Kadang-kadang lah…Kertas litmus penah…Selalu buat dalam kumpulan.
R: Macam eksperimen kita buat tadi tu pernah buat?
Meor: Pernah…Cikgu pernah tunjuk…Cikgu lukis di papan hitam dan kita buatlah dalam kumpulan

Comment [D21]: Scientific drawing

R: Apa yang terlintas di fikiran adik bila kita sebut pasal 'eksperimen'?
Meor: Dia best la.Seronok.menarik…
R: kenapa adik cakap macam tu?
Meor: sebab dia...Ia melatih kita lah untuk buat benda macam….ape…nak tengok mikroorganisma. Nak ukur suhu kita guna thermometer.

Comment [D22]: Manipulative skills

R: Ada tak diberi peluang jalankan eksperimen sepanjang sekolah rendah ini?
Meor: kalau…takdelah, tak banyak peluang. Sepanjang tahun 6 ini 2-3 kali sahaja masuk lab.

Comment [D23]: Lack of opportunity

R: sepanjang tahun 4 dan 5?
Meor: 4 5 lebihlah dari darjah 6. Darjah enam banyak buat nota lagi. Cikgu nak cepatlah. Nak terus ke topic lain semua. Kalau dah habis boleh ulang lagi topic-topik untuk exam UPSR.

R: Apakah harapan adik tentang matapelajaran sains di sekolah menengah nanti?
Meor: Di sekolah menengah nanti eksperimen dia lagi…cara dia lagi tinggi la…lagi susah.
Tapi ikut cikgu jugalah. Kalau cikgu beri peluang saya boleh buat lebih bagai eksperimen lagi lah.

Comment [D24]: expectation

R: Adik biasa mengendali alatan sains di sekolah ini? Boleh adik terangkan sedikit alat apa?
Meor: beaker, measuring cylinder, Bunsen burner, kertas litmus…thermometer.
R: Tahu alat diguna untuk apa? (Bunsen burner)
Meor: dia gas nak..kalau kita nak nyalakan api dia tahan lebih lama.

Comment [D25]: Cannot state the exact function

R: Mikroskop pernah guna?
Meor: Tak pernah. Tapi ayah saya ada belilah tapi saya tak tahu nak guna macamana.

R: Di sekolah?

Meor: cikgu tak pernah tunjuk tapi tahu lah itu mikroskop. Pernah belajar dalam buku. Tahu kegunaan dia untuk tengok mikroorganisma.

Comment [D26]: Function of microscope

R: Tahu tak setiap bahagian mikroskop?
Meor: Tak..(gelak). Tapi pernah guna, cikgu pun tak bagi tahu.

Comment [D27]: Recognizing part of apparatus

R: Thermometer pernah guna?
Meor : Pernah Masa tahun 5

R: Bagaimana digunakan?
Meor: Mata kena luruslah masa guna thermometer.
R: Kenapa?
Meor: Supaya dapat bacaan yang betul
Tahu kegunaannya?
Meor: Untuk ukur suhu…air misalnya.
R: boleh adik namakan bahagian2 pada thermometer ini tak?
Meor:Tak pasti la cikgu

Kalau Bunsen burner tahu nama bahagian ini? (menunjuk pada lubang gas)
Meor: tak pasti la cikgu.

R: Adakah adik yakin dengan kemahiran adik mengendalikan alat/ radas tersebut di sekolah menegah nanti?
Meor: saya rasa nanti guna alat ini juga. InsyaAllah...

R: Pada pandangan adik bagaimana kita nak tingkatkan kebolehan adik dalam menggunakan alatan/radas tersebut?
Meor: emmmm…bacalah. Baca nota yang cikgu baca.

INITIAL CODING
SECONDARY SCHOOL

Phase 2 – Task 1
Name: Meor
Date: 10^{th} April 2012
Time: 12.10 pm

Episode 1:
Meor started the experiment by setting the apparatus.
He placed the wire gauze on the tripod stand and reached for the beaker which contained distilled water.
Cautiously he poured the water into a 100ml measuring cylinder.
He stopped before the bottom meniscus reached the 100ml line.
He did not lower his head to check on the meniscus in order to avoid parallax error.
He poured the measured water into an empty beaker and placed it on the tripod stand.

Comment [D28]: Problem in reading meniscus

Comment [D29]: Failed to avoid parallax error

Episode 2
Meor picked up the lighter and started to light up the Bunsen burner.
He twisted the gas knob without hesitation.
His left hand was holding the gas knob and he lighted the Bunsen burner with his right hand. He slowed down the gas a little and he cautiously pushed the Bunsen burner under the tripod stand.
He adjusted the flame again.
He did not open the gas hole. The burner burned with yellow flame.

Comment [D30]: Ability to manipulate the flame

Comment [D31]: Failure to use the gas hole

Episode 3
He took the thermometer and immersed it in the beaker, letting the bulb to touch the floor of the beaker.
OC: No progression in using thermometer
He lowered his head to take the temperature. “58^{0}C”, he told the researcher.
He read the worksheet while waited for the water to boil.
He saw the air bubble and took another reading of temperature.
He immersed the thermometer inside the beaker and took the reading of the temperature. “90^{o}C”.
He took the glass rod, stirred the water and immersed the thermometer again. “93^{o}C”.
He waited for a while and took the reading again. “It is still 93^{0}C”.
He wrote the temperature at his worksheet.

Comment [D32]: Poor technique in using thermometer

Formatted: Font: Times New Roman, Italic

Comment [D33]: Correct application of apparatus

Episode 4
Meor put a spoonful of salt into the boiling water.
He stirred the solution carefully using the glass rod.
He took the temperature of the boiling solution; he make sure his eyes were parallel to the meniscus.
He stirred the solution again to make sure the salts were fully dissolved.
He took the thermometer and immersed it back in the solution, letting the bulb to touch the bottom of the beaker.
He took the reading and wrote the result at the worksheet.

Comment [D34]: Undeveloped skills

Episode 5

He grabbed a small towel and pick up the hot beaker and put it on the table.
He pulled the Bunsen burner carefully and turned the gas off without hesitation.
Meor poured the hot solution into the sink and washed the beaker.
He placed it beside the sink and did the same thing to the measuring cylinder.
He picked up the thermometer; put it under the running tap water and placed it with the other apparatus.
He checked his worksheet, wrote his name and hand it to the researcher.

Comment [D35]: Good skills in cleansing and storing of apparatus

Phase 2 – Task 2
Student: Meor Mirza (Primary School B)
Date: 10 April 2012

Time: 12.45pm

Episode 1

Meor took time to read the given worksheet. He picked up the onion and scalpel.

Carefully he tried to pull the inner layer of the onion.

The layer is too thin; his hand trembled when he did this step.

He took a small piece of the specimen and placed it at the glass slide.

He took his time to read the manual again.

Meor took the iodine solution and he placed a drop of the solution at the thin layer of onion on the slide.

Episode 2

Carefully he took the slide cover and positioned it on the slide.

He did not apply the correct technique.

He squeezed/pushed the slide cover to readjust its position.

[Difficulty in preparing slide]

He placed the slide on the microscope stage and used the stage clip to hold the slide.

He adjusted the slide position by manipulating a small knob at the microscope stage so the specimen located exactly under the lens.

He started observing the specimen through the eyepiece. He used the highest magnification lens (the microscope has 3 three lenses: 4x, 10x and 40x).

[Using the highest magnification power]

He adjusted the coarse adjusting knob and observed the specimen simultaneously.

Episode 3

Meor asked the researcher how he should draw the cell.

He saw too many cells under through the eyepiece. He ends up drawing a single onion cell on his worksheet.

[Scientific drawing]

Meor turn off the microscope power and pulled the plug.

He took out the slide from the stage and removed the slide cover. He washed the cover and the slide and dried it with a piece of tissue.

He placed it back into the slide box and cleaned his laboratory table.

[Cleaning and storing]

He hand the worksheet to the researcher.

Sofia (Phase 2 Secondary school)

1.45pm

26/4/12

R: Apa perasaan adik belajar di sekolah menengah ini?

Z: Seronok. Seronok belajar kat sini

R: ada hadapi sebarang masalah tak?

Z: tiada. Saya boleh sesuaikan diri dengan sekolah ini. Tapi perbezaannya pelajarannya lebih mencabar.

R: mencabar macamana?

Z; lebih susah sikitlah

R: sains bagaimana?

Z: sains lebih susah lah. Berbanding sekolah rendah dahulu.

Kandungan dia lebih banyak. Dan belajar lebih mendalam

R: bagaimana dengan eksperimen yang dijalankan di sekolah menengah?

Z: dah buat eksperimen pendulum, tengok cells… Dan matter..matter occupy space.

R: Bagaimana pula beza eksperimen di sekolah rendah dan sekolah menengah?

Z: sekolah menegah punya eksperimen lagi best la.

Lagi seronok.

R: dari segi peralatan?

Z: saya tak pernah guna mikroskop untuk tengok sel-sel. Lebih canggih dari peralatan di sekolah rendah. Dulu buat eksperimen boiling water sahaja di sekolah rendah.

Comment [D36]: More opportunity to conduct experiment

R: adik ada masalah gunakan sebarang alatan di makmal?

Z: tiada. Boleh gunakan

R: boleh namakan bahagian ini pada penunu Bunsen? (knob)

Z: suis…(laughing)

Comment [D37]: Recognizing part of apparatus

R: kita panggl dia gas knob.

R: tahu bahagian ini untuk apa? (gas hole)

Z: untuk mengalirkan udara…supaya boleh proses pembakaran.

Kalau tutup udara tak boleh masuk…jadi tak boleh terbakar lah…

Comment [D38]: Understand the principle in using Bunsen burner

R: Kalau tutup bahagian ni nyalaan jadi warna apa?

Z: warna merah.

R: kenapa?

Z: sebab tiada udara

R: kalau buka?

Z: warna biru. Lebih panas.

R: kenapa semasa menjalankan eksperimen adik tidak membuka lubang udara ini?

Z: sebelum ini tak tahu

Comment [D39]: Inability to relate theory and practise

(The amount of air mixed with the gas stream affects the completeness of the combustion reaction. Less air yields an incomplete and thus cooler reaction, while a gas stream well mixed with air provides oxygen in an equimolar amount and thus a complete and hotter reaction. The air flow can be controlled by opening or closing the slot openings at the base of the barrel)

R:Pada pandangan adik, bagaimana cara untuk menjadikan adik dan kawan-kawan adik dapat mahir dalam mengendalikan peralatan ini?

Z: lakukan lebih banyak eksperimen.

APPENDIX K
EXAMPLE OF MATRIX
OF ANALYSIS

<table>
<tr><td colspan="2">2) Non-effective management of time and workplace</td></tr>
<tr><td rowspan="2">(i) Efficiency in using time</td><td>• He made his eyes parallel to the meniscus and read the temperature. Meor put the thermometer down. After a short second he picked up the thermometer again and immersed it back, into the beaker (Obs.1, Ep.2, S6a).
• There was no flame (the burner knob was not turned sufficiently – not enough gas to light the burner). She repeated the step and turned the gas knob some more. This time it worked. (Obs.1, Ep.2, S4a)
• He turned off the Bunsen burner every time he took the reading of temperature (Obs.1, Ep.6, S6a)</td></tr>
<tr><td>• When it reached 100^{o}C he turned off the Bunsen burner, put down the thermometer and wrote his result.(Obs.3,Ep.3,S12b)</td></tr>
<tr><td rowspan="2">(ii) Condition of working area</td><td>• Student 4 poured the water into the measuring cylinder, too fast. The water spilled out from the beaker to the surface of the table. She did not bother to wipes the table and continue with her experiment. (Obs.1, Ep.1, S4a)
• Student 1 placed the beaker on the top of the tripod stand; in the middle of the table, quite far from the end of the table where he stands (Obs.1, Ep.1, S1a)
• Later: “How can I read this?” Student 1 mumbled to himself. It was difficult for him to read the thermometer because the apparatus was se t quite far from the end of his laboratory table. (Obs.1, Ep.3, S1a)
• Meor placed the thermometer on the table while waiting to take his second reading. The thermometer was to near to the edge of the table. (Obs.1, Ep.4, S6a)
• Sofea pours the water from the beaker into the measuring cylinder. The measuring cylinder was placed too near to the edge of the table… Carefully she poured the water into the beaker (the beaker was very near to the end of the table). Sofea moved the beaker further from the table end (it still quite near to the edge). (Obs.1,Ep.1,S9a)</td></tr>
<tr><td>• Cautiously he poured the measured water into an empty beaker until the last drop of the water. He placed it on the tripod stand. He moved the measuring cylinder, empty beaker and the salt container further from his working area. (Obs.4, Ep.1, S7b)</td></tr>
</table>

(iii) Cleansing and storing of apparatus	• Carefully Haziq took out the Bunsen burner from under the tripod stand by holding the Bunsen burner at the knob. Haziq turned the gas off and carefully he took down the hot beaker by using a dry towel and throws the water at the sink. He washed the beaker and measuring cylinder and placed it beside the sink. He went back to his workplace and carefully put back the thermometer inside the plastic casing (Obs.1, Ep.6, S7a) • Batrisyia recorded her last reading on the paper. She lowered and tilted her head, her hand reached for the gas knob. She turned the knob clockwise and counter-clockwise until the fire disappeared from our sight. She held the knob carefully and dragged the Bunsen burner out from under the tripod stand. She picked up the tongs and carefully took down the hot beaker. She held the beaker with a small towel and walk to the sink. She cleaned the beaker and placed it beside the sink. She did the same thing with the measuring cylinder. (Obs.1,Ep.7, S13a) • Amir took out the slide from the stage. Carefully he removed the cover and washed the slide and the cover slip. He dried it with tissue and returned it to near the microscope. (Obs.2, Ep.4, S5a) • He adjusted back the course knob to its initial position (far from stage). Haziq carefully hold the stage clips and remove the slide from the microscope stage. He removed the glass slide cover carefully and wash the slides, dried them with clean tissue and put it back at the table. (Obs.2, Ep.5, S7a)
	• *He grabbed a small towel and pick up the hot beaker and put it on the table. He pulled the Bunsen burner carefully and turned the gas off without hesitation. Meor poured the hot solution into the sink and washed the beaker. He placed it beside the sink and did the same thing to the measuring cylinder. He picked up the thermometer; put it under the running tap water and placed it with the other apparatus. He checked his worksheet, wrote his name and hand it to the researcher (Obs.3,Ep.5, S6b)* • *Meor turn off the microscope power and pulled the plug. He took out the slide from the stage and removed the slide cover. He washed the cover and the slide and dried it with a piece of tissue. He placed it back into the slide box and cleaned his laboratory table. He hand the worksheet to the researcher. (Obs.4, Ep.3,S6b)* • *He turned the gas off and pulled the Bunsen burner from under the tripod stand. He took a small towel to hold the hot beaker and took it to the sink. He ran the tap water to cool it. He washed the*

<table>
<tr><td></td><td>

beaker and placed it beside the sink. He did the same procedure to the other equipment.; beaker, measuring cylinder, spatula and thermometer (Obs.3, Ep.4, S7b)

- *Adam took the glass slide and went to the sink. He washed the glass slide and the slide cover. He wiped the slide and put it back in the box.(Obs.4, Ep.3, S7b)*
- *He picked up the slide, took a forceps and went to the dustbin. He used the forceps to took the specimen and throw it away into the dustbin. He walked to the sink and started to wash the slide, slide cover and the forceps. He used tissue to dried the slide and put it on the table. He cleaned his working area and turned the microscope off.(Obs.4,Ep.3,S8b)*
- *She left the slide on the microscope and hand her worksheet to the researcher. (Obs.4,Ep.3, S1b)*

</td></tr>
<tr><td colspan="2">

3) Safety and Precautionary Measures
(precautionary measure warding off impending danger/damage to avoid injury)

</td></tr>
<tr><td rowspan="2">

(i) Technique in using apparatus

</td><td>

- Student 1 (Irfan) turned the gas knob. The hissing sound from the Bunsen burner can be heard clearly. He reached for the lighter and tried to light up the candle. The smell of the gas lingered on the air (Obs.1,Ep.1, S1a)
- He (student 2) abruptly turned the gas knob with his left hand. He lighted on the lighter and took it near the barrel of Bunsen burner. The sudden burst of yellow flame taken him aback (Obs.1,Ep.1, S2a)
- Dhilan turned the gas on. In the meantime he was busy looking for the lighter and tried to light the candle. The smell of the gas lingered around us. Dhilan did not aware of this situation; he was busy lighting the candle. The researcher has to take action and turned the gas off for safety reason (Obs.1, Ep.1, S10a).

</td></tr>
<tr><td>

- *She waited for the water to boiled (the volume of water was more than 100ml). She immersed the thermometer and let it stay in the beaker during the heating. The thermometer was unstable. She tilted her head to read the meniscus without holding the thermometer. The researcher has to advices her to hold the thermometer before any unwanted accident occurs. (Obs.3, Ep.2, S4b)*
- *He waited for the water to boil. Once in a while he touched the beaker. The researcher asked him to stop doing that in case he injured his fingers (Obs.3, Ep.2, S12b).*

</td></tr>
</table>

	• *He stirred the solution until all the salt dissolved. He observed the boiling water, too near; his face was directly above the beaker. The researcher has to stop him from doing that. He pressed the thermometer bulb at the towel again, repeatedly. (Obs.3, Ep.4, S12b)* • *She slid the Bunsen burner under the tripod stand and turned the gas knob. She took the lighter and brought it close to the barrel and lighted the burner (from beneath the tripod stand). (Obs.3,Ep.2,s14b)* • *She went out to get something from her bag and leave the boiling water.(Obs.3, Ep.2, S14b)*
(ii) Handling of apparatus and specimens (more towards damaging to the apparatus itself)	• Student 2 held the thermometer on his left procedure and the stopwatch in his right hand. "Tap!" he suddenly hit the thermometer bulb to the table. He read the experiment procedure and his left hand was playing with the thermometer, holding it upright and pushed it at the table top (Obs.1, Ep.2, S2a) • Amir held the thermometer while waiting to take his third reading of the water temperature. He held it vertically, at the tip of the stem with his 2 fingers like holding a pen. The thermometer bulb was in contact with the surface of the table (and he did this near to the end of the table). His other hand was holding a stopwatch (Obs.1, Ep.5, S5a). • Haziq picked up the beaker and placed it on the tripod stand. He took the thermometer and placed it in the beaker, the thermometer seemed unstable but it doesn't bother him. (Obs.1, Ep.2, S7a)
	• *He pressed the thermometer bulb to the small towel. (Obs.3,Ep.3,S12b)* • *Carefully he took the slide cover and positioned it on the slide. He did not apply the correct technique. He squeezed/pushed the slide cover to readjust its position. (Obs.4, Ep.2, S6b)* • *He pressed the slide cover to eliminate the air bubbles. He used a filter paper to absorb the remaining iodine solution and kept pressing the glass slide cover (it may crack!)(Obs.4, Ep.1,S8b)*

APPENDIX L
AUDIT TRAIL

No.	Audit Trail	Steps in Audit Trail	Evidence
1.	Preparation for data collection	Prepare: i. Consent letter ii. Observation tasks iii. Interview questions	i. List of participants ii. Manipulative Skills in Transition Tasks: • Year 6 • Form 1 iii. Interview protocol
2.	Data collection	i. Video recording of task observations ii. Audio recording of interviews iii. Observation field notes	i. 46 electronic files from task, each approximately 25 minutes in length. ii. 23 audio tapes came from students' interviews. iii. Field notes
3.	Data analysis	i. Transcription of task observations ii. Verbatim transcription of audio recording	All were transcribed and save into two main electronic files: early transition and late transition. The files have been compiled according to the schools the students' attended.
4.	Producing results	i. All transcripts were coded and categorized in a form of matrix. ii. Categories were revised and collapsed iii. Categories were further revised and collapsed iv. Categories were further	i. 162 open codes emerged from the data (primary and secondary school). ii. The codes were then collapsed into 27 different categories iii. Codes collapsed and

		revised and collapsed v. Data for technical skills were arranged according to apparatus vi. Final revision of themes and categories	reduced into 7 categories and 18 sub-categories arose. iv. Five categories and 11 sub-categories were further refined. v. Two categories with 6 sub-categories emerged. vi. Findings were grouped under two main themes or dimensions (Technical skills and functional aspects of performing laboratory task) with its own categories, elements and sub-elements.
5.	Writing up report		Report

APPENDIX M:

RUBRICS FOR TASK A AND B

SENARAI SEMAK KEMAHIRAN MANIPULATIF (SKM)

MODUL A

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	**Sederhana**	**Tinggi**
(A) OPERASI KERJA YANG SISTEMATIK **Semasa eksperimen didapati bahawa murid:**				
1.	Kebolehan untuk mengikut peraturan dan arahan secara keseluruhan	Tidak dapat mengikut peraturan dan arahan secara keseluruhan mengikut prosedur yang diberikan	Boleh mengikut peraturan dan arahan secara keseluruhan dengan sederhana, mengikut prosedur yang diberikan	Dapat mengikut peraturan dan arahan secara keseluruhan dengan efektif mengikut prosedur yang diberikan
2.	Pemeriksaan dan pengenalpastian kerosakan pada alatan sebelum penggunaan	Tidak dapat memeriksa dan mengenalpasti sebarang kerosakan/ ralat pada alatan	Memeriksa kebolehgunaannya alatan sebelum menjalankan eksperimen namun tidak dapat mengenalpasti sebarang kerosakan/ralat pada alatan	Dapat memeriksa dan mengenalpasti sebarang kerosakan/ralat pada alatan sebelum menggunakannya
3.	Komunikasi dengan rakan sekumpulan	Tidak berkomunikasi secara efektif dengan rakan sekumpulan	Berkomunikasi secara sederhana dengan rakan sekumpulan	Berkomunikasi secara efektif dengan rakan sekumpulan

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	**Sederhana**	**Tinggi**
B) PENGURUSAN MASA DAN TEMPAT KERJA **Semasa eksperimen didapati bahawa murid:**				
1.	Tempoh masa dalam menjalankan eksperimen.	Memerlukan tempoh masa yang lama untuk menjalankan eksperimen berbanding dengan tempoh masa yang diberi oleh guru.	Memerlukan tempoh masa yang agak lama untuk menjalankan eksperimen tetapi dapat diterima oleh guru.	Dapat menjalankan eksperiman dalam tempoh masa yang diarahkan oleh guru.
2.	Keadaan tempat kerja sebelum, semasa dan selepas eksperimen	Tidak memastikan keadaan tempat kerja dalam keadaan yang bersih dan kemas sebelum, semasa dan selepas eksperimen	Keadaan tempat kerja yang sederhana bersih dan kemas sebelum, semasa dan selepas eksperimen	Dapat memastikan keadaan tempat kerja dalam keadaan yang bersih d an kemas sebelum, semasa dan selepas eksperimen
3.	Pengurusan dan pembersihan peralatan selepas eksperimen	Murid hanya menjalankan kurang daripada dua langkah daripada senarai tersebut: (a) menguraikan radas eksperimen dengan berhati-hati	Murid menjalankan tiga atau empat daripada lima perkara dalam senarai: (a) menguraikan radas eksperimen dengan berhati-hati	Murid menjalankan semua perkara dalam senarai tersebut: (a) menguraikan radas eksperimen dengan berhati-hati

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	Sederhana	Tinggi
		(b) melupuskan bahan buangan dengan kaedah yang bersesuaian (c) membersihkan peralatan dengan teknik yang betul (d) Mengembalikan alatan di tempat yang betul selepas eksperimen dijalankan (e) Membersihkan kawasan sekitar tempat kerja selepas menyelesaikan tugasan	b) melupuskan bahan buangan dengan kaedah yang bersesuaian (c) membersihkan peralatan dengan teknik yang betul (d) Mengembalikan alatan di tempat yang betul selepas eksperimen dijalankan (e) Membersihkan kawasan sekitar tempat kerja selepas menyelesaikan tugasan	(b) melupuskan bahan buangan dengan kaedah yang bersesuaian (c) membersihkan peralatan dengan teknik yang betul (d) Mengembalikan alatan di tempat yang betul selepas eksperimen dijalankan (e) Membersihkan kawasan sekitar tempat kerja selepas menyelesaikan tugas

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	**Sederhana**	**Tinggi**
(C) LANGKAH PENGAWASAN DAN KESELAMATAN **Semasa eksperimen didapati bahawa murid:**				
1.	Penggunaan kaedah yang selamat semasa menjalankan eksperimen	Tidak menggunakan kaedah yang selamat semasa menjalankan eksperimen untuk mengelakkan kecederaan dan kemalangan kepada diri sendiri, rakan lain dan persekitaran	Cuba untuk menggunakan kaedah yang selamat semasa menjalankan eksperimen untuk mengelakkan kecederaan dan kemalangan kepada diri sendiri, rakan lain dan persekitaran tetapi tidak sepenuhnya	Dapat menggunakan kaedah yang selamat semasa menjalankan eksperimen untuk mengelakkan kecederaan dan kemalangan kepada diri sendiri, rakan lain dan persekitaran
2.	Pengendalian peralatan makmal untuk mengelak kerosakan	Tidak mengendalikan peralatan makmal dengan berhati-hati untuk mengelakkan kerosakan pada peralatan yang sensitif	Mengendalikan peralatan makmal secara sederhana dan masih memerlukan bimbingan guru	Dapat mengendalikan peralatan makmal dengan berhati-hati dan efektif untuk mengelakkan sebarang kerosakan
(D) NUMERASI Semasa eksperimen didapati bahawa murid:				
1.	Membuat andaian (Jika berkaitan)	Tidak mengambil suhu awal air dan terus membuat andaian bahawa suhu awal air adalah sifar	Mengambil suhu awal air tetapi masih membuat andaian bahawa suhu awal adalah sifar	Mengambil suhu awal air dengan betul dan tidak membuat andaian bahawa suhu awal air adalah sifar
2.	Kemahiran membaca meniskus ketika mengambil bacaan isipadu cecair	Tidak membaca aras bawah meniskus ketika mengambil bacaan isipadu cecair dengan silinder penyukat	Cuba membaca aras meniskus dengan betul tetapi teknik memerlukan penambahbaikan	Membaca aras bawah meniskus ketika mengambil bacaan isipadu cecair dengan silinder penyukat

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	**Sederhana**	**Tinggi**
3.	Kemahiran membaca meniskus merkuri ketika mengambil bacaan suhu	Tidak membaca aras atas merkuri ketika mengambil bacaan suhu pada termometer	Cuba membaca aras meniscus merkuri dengan betul tetapi teknik memerlukan penambahbaikan	Membaca aras atas merkuri ketika mengambil bacaan suhu pada termometer
(E) KEMAHIRAN TEKNIKAL DALAM PENGGUNAAN ALATAN				
(i) Penggunaan Silinder Penyukat Untuk Menyukat Isipadu Cecair Semasa eksperimen didapati bahawa murid:				
1.	Keperluan untuk mengenali alat dan fungsi alatan ini	Tidak mengenali alat dan fungsi alatan	Hanya mengenali alat atau fungsi alatan	Mengenali alat dan fungsi alatan yang digunakan
2.	Penggunakan silinder penyukat yang bersesuaian	Tidak dapat menggunakan silinder penyukat yang bersesuaian dengan isipadu cecair yang akan disukat	Boleh menggunakan silinder penyukat tetapi masih memerlukan bimbingan guru	Boleh menggunakan silinder penyukat yang bersesuaian dengan isipadu cecair yang akan disukat
3.	Kedudukan silinder penyukat semasa mengambil bacaan	Gagal untuk meletakkan silinder penyukat di permukaan yang rata semasa mengambil bacaan	Cuba untuk meletakkan silinder penyukat di permukaan yang rata semasa mengambil bacaan tetapi tidak bersesuaian	Meletakkan silinder penyukat di permukaan yang rata semasa mengambil bacaan
4.	Kedudukan mata ketika mengambil bacaan	Tidak memastikan kedudukan mata adalah selari dengan aras bawah meniskus cecair untuk mengelakkan ralat ketika mengambil bacaan	Memastikan kedudukan mata selari dengan aras bawah meniskus cecair tetapi mempunyai masalah untuk mengelakkan ralat ketika mengambil bacaan	Memastikan kedudukan mata adalah selari dengan aras bawah meniskus cecair untuk mengelakkan ralat ketika mengambil bacaan

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	**Sederhana**	**Tinggi**
5.	Keberkesanan dalam menggunakan silinder penyukat	Menggunakan silinder penyukat dengan tidak yakin, teragak-agak dan tidak berkesan	Menggunakan silinder penyukat dengan tidak begitu yakin dan sederhana berkesan	Dapat menggunakan silinder penyukat dengan yakin, tidak teragak-agak dan berkesan
6.	Keperluan Bimbingan	Tidak berupaya menggunakan alatan tanpa pengawasan yang sepenuhnya dari guru	Boleh menggunakan alatan dengan sederhana dan masih memerlukan pengawasan oleh guru	Dapat menggunakan alatan dengan baik dan memerlukan pengawasan minimum dari guru
ii) Penggunaan termometer untuk mengukur suhu cecair Semasa eksperimen didapati bahawa murid:				
1.	Kebolehan mengenal alat dan fungsi alatan	Tidak mengenali alat dan fungsi alatan	Hanya mengenali alat atau fungsi alatan	Mengenali alat dan fungsi alatan yang digunakan
2.	Teknik memegang termometer	Memegang termometer dengan teknik yang salah iaitu tidak memegang di bahagian batang kaca	Memegang termometer dengan teknik yang boleh diterima tetapi masih boleh diperbaiki	Memegang termometer dengan teknik yang betul iaitu memegang di bahagian batang kaca dan bukan pada bebuli
3.	Penggunaan bahagian yang betul semasa menyukat suhu	Tidak merendam bahagian hujung berbebuli ke dalam cecair	Merendam bahagian hujung berbebuli ke dalam cecair tetapi masih terdapat kesilapan	Merendam bahagian hujung berbebuli ke dalam cecair dengan baik
4.	Kebolehan dalan memastikan bebuli tidak terkena dasar atau dinding bikar	Tidak memastikan termometer terkena dasar atau dinding bikar ketika mengambil bacaan suhu	Memastikan bebuli tidak terkena dasar atau dinding bikar tetapi kemahiran masih perlu diperbaiki	Dapat memastikan bebuli tidak terkena dasar atau dinding bikar semasa mengambil bacaan suhu

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	Sederhana	Tinggi
5.	Suhu yang stabil	Mengambil bacaan suhu tanpa menunggu suhu stabil dan tidak mengacau cecair sebelum mengambil bacaan	Mengacau cecair menggunakan rod kaca tetapi tidak mengambil bacaan suhu ketika suhunya stabil	Mengambil bacaan suhu secara efektif iaitu ketika suhunya stabil dan menggunakan rod kaca untuk mengacau cecair sebelum mengambil bacaan suhu
6.	Posisi mata ketika mengambil bacaan untuk mengelakkan ralat	Tidak memastikan posisi mata dan bahagian atas meniskus merkuri adalah selari ketika mengambil bacaan untuk mengelakkan ralat	Memastikan kedudukan mata selari dengan aras atas meniskus merkuri tetapi mempunyai masalah untuk mengelakkan ralat ketika mengambil bacaan	Dapat memastikan posisi mata dan bahagian atas meniskus merkuri adalah selari ketika mengambil bacaan untuk mengelakkan ralat
7.	Pengambilan bacaan suhu cecair	Membawa keluar termometer dari larutan apabila mengambil bacaan suhu	Tidak membawa keluar termometer dari larutan tetapi teknik memerlukan penambahbaikan	Tidak membawa keluar termometer dari larutan apabila mengambil bacaan suhu
8.	Keberkesanan dalam menggunakan termometer	Menggunakan termometer dengan tidak yakin, teragak-agak dan tidak berkesan	Menggunakan termometer dengan tidak begitu yakin dan sederhana berkesan	Dapat menggunakan termometer dengan yakin, tidak teragak-agak dan berkesan
9.	Keperluan bimbingan	Tidak berupaya menggunakan alatan tanpa pengawasan yang sepenuhnya dari guru	Boleh menggunakan alatan dengan sederhana dan masih memerlukan pengawasan oleh guru	Dapat menggunakan alatan dengan baik dan memerlukan pengawasan minimum dari guru

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	Sederhana	Tinggi
iii) Penggunaan penunu Bunsen untuk pemanasan Semasa eksperimen didapati bahawa murid:				
1.	Kebolehan mengenal alatan dan fungsi alatan	Tidak mengenali alat dan fungsi alatan	Hanya mengenali alat atau fungsi alatan	Mengenali alat dan fungsi alatan yang digunakan
2.	Kebolehan mengenalpasti setiap bahagian alatan dan fungsinya	Tidak dapat mengenalpasti setiap bahagian alatan dan fungsi alatan	Hanya dapat mengenalpasti bahagian tertentu alatan dan fungsinya	Dapat mengenalpasti setiap bahagian alatan dan fungsi bahagian tersebut
3.	Manipulasi lubang udara sebelum nyalaan	Tidak menutup lubang udara dengan menggerakkan bahagian kolar pada penunu Bunsen	Cuba menutup lubang udara dengan menggerakkan bahagian kolar pada penunu Bunsen tetapi kurang efektif dan boleh diperbaiki	Dapat menutup lubang udara dengan menggerakkan bahagian kolar pada penunu Bunsen
4.	Menyalakan lilin sebelum menghidupkan gas	Menghidupkan gas sebelum menyalakan lilin	Menyalakan lilin sebelum menghidupkan gas tetapi teknik masih perlu diperbaiki	Dapat menyalakan lilin sebelum menghidupkan gas
5.	Manipulasi lubang udara selepas nyalaan	Tidak menghidupkan gas dengan berhati-hati dan tidak membuka lubang udara untuk mendapatkan nyalaan biru	Dapat menghidupkan gas dengan berhati-hati tetapi membuka lubang udara untuk mendapatkan nyalaan biru	Dapat menghidupkan gas dengan berhati-hati dan efisyen dan membuka lubang udara untuk mendapatkan nyalaan biru
6.	Keberkesanan dalam menggunakan penunu Bunsen	Menggunakan alatan dengan tidak yakin, teragak-agak dan tidak berkesan	Menggunakan alatan dengan tidak begitu yakin dan sederhana berkesan	Dapat menggunakan alatan dengan yakin, tidak teragak-agak dan berkesan

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	**Sederhana**	**Tinggi**
7.	Keperluan bimbingan	Tidak berupaya menggunakan alatan tanpa pengawasan yang sepenuhnya dari guru	Boleh menggunakan alatan dengan sederhana dan masih memerlukan pengawasan oleh guru	Dapat menggunakan alatan dengan baik dan memerlukan pengawasan minimum dari guru

SENARAI SEMAK KEMAHIRAN MANIPULATIF (SKM)

MODUL B

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	Sederhana	Tinggi
(A) OPERASI KERJA YANG SISTEMATIK Semasa eksperimen didapati bahawa murid:				
1.	Kebolehan untuk mengikut peraturan dan arahan secara keseluruhan	Tidak dapat mengikut peraturan dan arahan secara keseluruhan mengikut prosedur yang diberikan	Boleh mengikut peraturan dan arahan secara keseluruhan dengan sederhana, mengikut prosedur yang diberikan	Kebolehan untuk mengikut peraturan dan arahan secara keseluruhan
2.	Pemeriksaan dan pengenalpastian kerosakan pada alatan sebelum penggunaan	Tidak dapat memeriksa dan mengenalpasti sebarang kerosakan/ ralat pada alatan	Memeriksa kebolehgunaannya alatan sebelum menjalankan eksperimen namun tidak dapat mengenalpasti sebarang kerosakan/ralat pada alatan	Pemeriksaan dan pengenalpastian kerosakan pada alatan sebelum penggunaan
3.	Komunikasi dengan rakan sekumpulan	Tidak berkomunikasi secara efektif dengan rakan sekumpulan	Berkomunikasi secara sederhana dengan rakan sekumpulan	Komunikasi dengan rakan sekumpulan

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	**Sederhana**	**Tinggi**
B) PENGURUSAN MASA DAN TEMPAT KERJA Semasa eksperimen didapati bahawa murid:				
1.	Tempoh masa dalam menjalankan eksperimen.	Memerlukan tempoh masa yang lama untuk menjalankan eksperimen berbanding dengan tempoh masa yang diberi oleh guru.	Memerlukan tempoh masa yang agak lama untuk menjalankan eksperimen tetapi dapat diterima oleh guru.	Dapat menjalankan eksperiman dalam tempoh masa yang diarahkan oleh guru.
2.	Keadaan tempat kerja sebelum, semasa dan selepas eksperimen	Tidak memastikan keadaan tempat kerja dalam keadaan yang bersih dan kemas sebelum, semasa dan selepas eksperimen	Keadaan tempat kerja yang sederhana bersih dan kemas sebelum, semasa dan selepas eksperimen	Dapat memastikan keadaan tempat kerja dalam keadaan yang bersih d an kemas sebelum, semasa dan selepas eksperimen
3.	Pengurusan dan pembersihan peralatan selepas eksperimen	Murid hanya menjalankan kurang daripada dua langkah daripada senarai tersebut: (a) menguraikan radas eksperimen dengan berhati-hati	Murid menjalankan tiga atau empat daripada lima perkara dalam senarai: (a) menguraikan radas eksperimen dengan berhati-hati	Murid menjalankan semua perkara dalam senarai tersebut: (a) menguraikan radas eksperimen dengan berhati-hati

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	Sederhana	Tinggi
		(b) melupuskan bahan buangan dengan kaedah yang bersesuaian (c) membersihkan peralatan dengan teknik yang betul (d) Mengembalikan alatan di tempat yang betul selepas eksperimen dijalankan (e) Membersihkan kawasan sekitar tempat kerja selepas menyelesaikan tugasan	b) melupuskan bahan buangan dengan kaedah yang bersesuaian (c) membersihkan peralatan dengan teknik yang betul (d) Mengembalikan alatan di tempat yang betul selepas eksperimen dijalankan (e) Membersihkan kawasan sekitar tempat kerja selepas menyelesaikan tugasan	(b) melupuskan bahan buangan dengan kaedah yang bersesuaian (c) membersihkan peralatan dengan teknik yang betul (d) Mengembalikan alatan di tempat yang betul selepas eksperimen dijalankan (e) Membersihkan kawasan sekitar tempat kerja selepas menyelesaikan tugas

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	**Sederhana**	**Tinggi**
(C) LANGKAH PENGAWASAN DAN KESELAMATAN **Semasa eksperimen didapati bahawa murid:**				
1.	Penggunaan kaedah yang selamat semasa menjalankan eksperimen	Tidak menggunakan kaedah yang selamat semasa menjalankan eksperimen untuk mengelakkan kecederaan dan kemalangan kepada diri sendiri, rakan lain dan persekitaran	Cuba untuk menggunakan kaedah yang selamat semasa menjalankan eksperimen untuk mengelakkan kecederaan dan kemalangan kepada diri sendiri, rakan lain dan persekitaran tetapi tidak sepenuhnya	Dapat menggunakan kaedah yang selamat semasa menjalankan eksperimen untuk mengelakkan kecederaan dan kemalangan kepada diri sendiri, rakan lain dan persekitaran
2.	Pengendalian peralatan makmal untuk mengelak kerosakan	Tidak mengendalikan peralatan makmal dengan berhati-hati untuk mengelakkan kerosakan pada peralatan yang sensitif	Mengendalikan peralatan makmal secara sederhana dan masih memerlukan bimbingan guru	Dapat mengendalikan peralatan makmal dengan berhati-hati dan efektif untuk mengelakkan sebarang kerosakan

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	Sederhana	Tinggi
(D) LUKISAN SAINTIFIK Semasa eksperimen didapati bahawa murid:				
1.	Penggunaan pensel untuk melukis	Tidak menggunakan pensel untuk melukis	Menggunakan pensel yang tumpul dan mejejaskan kejelasan lukisan	Menggunakan pensel yang baik untuk melukis
2.	Kekemasan lukisan	Lukisan tidak kemas dan terlalu kecil berbanding dengan ruang yang telah disediakan	Lukisan secara keseluruhannya sederhana kemas dengan saiz lukisan yang memenuhi ruang	Melukis spesimen dengan kemas dan saiz lukisan memenuhi ruang
3.	Kebolehan untuk menamakan spesimen	Nama spesimen tidak diberitahu	Menulis nama spesimen tetapi tidak lengkap	Dapat menulis nama spesimen dengan betul
4.	Kebolehan melabel lukisan saintifik	Lukisan tidak dilabel sama sekali	Melabel satu atau dua bahagian penting pada spesimen atau alatan dengan betul	Dapat melabel tiga atau lebih bahagian penting dengan betul
5.	Kuasa pembesaran	Tidak menulis kuasa pembesaran yang digunakan untuk melukis spesimen	Menulis kuasa pembesaran yang digunakan tetapi kurang tepat	Menulis kuasa pembesaran yang digunakan untuk melukis spesimen

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	Sederhana	Tinggi
6.	Kejelasan lukisan	Tidak melukis dengan jelas dan betul	Lukisan sederhana jelas dan perlu diperbaiki	Dapat melukis dengan jelas dan betul
7.	Lukisan berdasarkan pemerhatian	Melukis bukan berdasarkan pemerhatian dari mikroskop	Melukis berdasarkan pemerhatian tetapi memerlukan bimbingan	Dapat melukis dengan baik berdasarkan pemerhatian melalui mikroskop
(E) KEMAHIRAN TEKNIKAL DALAM PENGGUNAAN ALATAN (i) Penyediaan slaid Semasa eksperimen didapati bahawa murid:				
1.	Penggunaan pewarna yang betul dengan jumlah yang bersesuaian	Meletakkan pewarna yang salah pada spesimen	Menggunakan pewarna yang betul pada spesimen dengan jumlah yang terlalu banyak atau sedikit	Dapat meletakkan pewarna yang betul dengan jumlah yang bersesuaian untuk mengelak slaid kaca dari terapung
2.	Teknik meletakkan penutup slaid kaca	Tidak menggunakan teknik yang betul ketika meletakkan penutup slaid kaca untuk mengelak gelembung udara	Menggunakan teknik yang betul tetapi memerlukan bimbingan untuk mendapatkan teknik yang lebih baik	Dapat menggunakan teknik yang betul ketika meletakkan penutup slaid kaca untuk mengelak gelembung udara

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	Sederhana	Tinggi
(ii) <u>Penggunaan mikroskop</u> Semasa eksperimen didapati bahawa murid:				
1.	Kebolehan mengenal alatan dan fungsi alatan	Tidak mengenali alat dan fungsi alatan	Hanya mengenali alat atau fungsi alatan	Mengenali alat dan fungsi alatan yang digunakan
2.	Kebolehan mengenalpasti setiap bahagian alatan dan fungsinya	Tidak dapat mengenalpasti setiap bahagian alatan dan fungsi alatan	Hanya dapat mengenalpasti bahagian tertentu alatan dan fungsinya	Dapat mengenalpasti setiap bahagian alatan dan fungsi bahagian tersebut
3.	Kemahiran membawa mikroskop	Tidak dapat membawa mikroskop dengan kaedah yang betul dan merbahaya	Cuba membawa mikroskop dengan dua belah tangan, di bahagian lengan mikroskop dan di dasar mikroskop untuk sokongan, tetapi masih memerlukan bimbingan	Dapat membawa mikroskop dengan betul iaitu dengan dua belah tangan, di bahagian lengan mikroskop dan di dasar mikroskop untuk sokongan
4.	Kebolehan dalam penggunaan kanta objektif	Tidak dapat menggunakan kanta objektif mengikut arahan yang diberikan	Dapat menggunakan kanta objektif berkuasa rendah diikuti kanta berkuasa tinggi tetapi sederhana efisyen	Dapat menggunakan kanta objektif berkuasa rendah diikuti kuasa tinggi semasa pemerhatian spesimen secara efisyen

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	Sederhana	Tinggi
5.	Penyelarasan cermin, kondenser dan diafragma untuk mendapatkan cahaya yang sesuai	Tidak menyelaraskan cermin, kondenser dan diafragma untuk mendapatkan cahaya yang sesuai	Cuba untuk menyelaraskan cermin, kondenser dan diafragma untuk mendapatkan cahaya yang sesuai tetapi memerlukan bimbingan	Berkebolehan untuk menyelaraskan cermin, kondenser dan diafragma untuk mendapatkan cahaya yang sesuai dengan efisien
6.	Penggunakan klip pentas	Tidak menggunakan klip pentas untuk memegang slaid	Mempunyai masalah untuk menggunakan klip pentas dengan baik	Dapat menggunakan klip pentas dengan baik
7.	Penggunakan tombol pelaras kasar	Tidak mempunyai kebolehan untuk menggunakan tombol pelaras kasar	Boleh menggunakan tombol pelaras kasar tetapi dengan kemahiran yang sederhana dan memerlukan bimbingan	Dapat menurunkan kanta objektif secara berhati-hati dengan menggunakan tombol pelaras kasar
8.	Penggunaan tombol pelaras halus	Tidak mempunyai kebolehan untuk menggunakan tombol pelaras halus untuk	Boleh untuk menggunakan tombol pelaras halus dengan kemahiran yang	Dapat menggunakan tombol pelaras halus dengan baik untuk menfokus kepada imej

NO.	KRITERIA	Tahap Kemahiran		
		Rendah	Sederhana	Tinggi
		menfokus kepada imej	sederhana dan memerlukan bimbingan	
9.	Keberkesanan dalam menggunakan mikroskop	Menggunakan alatan dengan tidak yakin, teragak-agak dan tidak berkesan	Menggunakan alatan dengan tidak begitu yakin dan sederhana berkesan	Dapat menggunakan alatan dengan yakin, tidak teragak-agak dan berkesan
10.	Keperluan bimbingan	Tidak berupaya menggunakan alatan tanpa pengawasan yang sepenuhnya dari guru	Boleh menggunakan alatan dengan sederhana dan masih memerlukan pengawasan guru	Dapat menggunakan alatan dengan baik dan memerlukan pengawasan minimum dari guru

APPENDIX N
PARTICIPANT YEAR OF EXPERIENCE IN TEACHING SCIENCE

Teacher (Primary school)	Year of experience in teaching science (Year 6)	Teacher (Secondary school)	Year of experience in teaching science (Form 1)
1.	28	1.	7
2.	18	2.	13
3.	18	3.	32
4.	4	4.	5
5.	10	5.	7
6.	15	6.	16
7.	10	7.	17
8.	13	8.	15
9.	7	9.	5
10.	20	10.	5
11.	23	11.	3
12.	15	12.	8
13.	5	13.	7
14.	29	14.	13
15.	15	15.	10
16.	10	16.	15
17.	17	17.	12
18.	10	18.	17
		19.	21
		20.	15
		21.	18

Average teaching experience = 14 years

Borang Cadangan Penambahbaikan Modul Pengesanan Kemahiran Manipulatif

Arahan: Sila berikan komen anda terhadap MeP dalam ruang yang diberi.

1. Adakah penerangan yang diberi jelas? Sila huraikan.

____
____

2. Adakah aktiviti yang dicadangkan dapat menentukan aras penguasaan kemahiran manipulatif?

____
____

3. Adakah kriteria bagi setiap kategori yang dicadangkan relevan dalam konteks pembelajaran sains di sekolah? Sila huraikan.

____
____

4. Adakah kriteria bagi setiap kategori yang dicadangkan mudah difahami?

____-
____
____

5. Adakah Borang Pengesanan bagi tahap penguasaan mudah digunakan?

____
____
____

6. Adakah modul MeP boleh dilaksanakan di sekolah? Kenapa?

____
____

7. Modul MeP ini akan menjadi lebih berkesan sekiranya cadangan berikut diambil kira:

(i)
____

(ii)
____

(iii)
____

APPENDIX P
MARK SHEET FOR ACTIVITY A

Criteria	Mark		
	Low	Intermediate	High
Systematic operation of tasks:			
1. Following instruction in performing overall operation of task	0	1	2
2. Checking the functionality of apparatus	0	1	2
3. Communication with group members	0	1	2
Total			
Management of time and workplace			
1. Using time	0	1	2
2. Condition of working area before, during and after experiment	0	1	2
3. Cleaning and storing of apparatus and materials	0	1	2
Total			
Safety and precautionary			
1. Safety procedure during experiment	0	1	2
2. Technique in using apparatus in order to prevent unwanted damage	0	1	2
Total			
Numeracy			
1. Making assumption	0	1	2
2. Skill in reading meniscus of measuring cylinder	0	1	2
3. Skill in reading meniscus of thermometer	0	1	2
Total			
Technical Skill			
(i) The use of measuring cylinder to measure volume			
1. Ability to recognize apparatus, its features function	0	1	2
2. Using appropriate measuring cylinder in measuring volume of solution	0	1	2
3. Placement of measuring cylinder	0	1	2
4. Eye position when reading meniscus	0	1	2
5. Efficiency in using measuring cylinder	0	1	2
6. The need for guidance	0	1	2
Total			

(ii) The use of thermometer to measure temperature			
1. Ability to recognize apparatus, its features and function	0	1	2
2. Technique in holding thermometer	0	1	2
3. Using the correct part of thermometer to measure temperature.	0	1	2
4. Ensuring the thermometer bulb did not touch the bottom or the wall of the beaker.	0	1	2
5. To wait for the temperature to be stable by stirring the solution before taking temperature.	0	1	2
6. Eye position when reading meniscus	0	1	2
7. Appropriate way of taking measurement of water temperature (did not take the thermometer out from the solution)	0	1	2
8. Efficiency in using thermometer	0	1	2
9. The need for guidance	0	1	2
Total			
(iii) The use of Bunsen burner			
1. Ability to recognize apparatus and its function	0	1	2
2. Ability to identify parts and features of apparatus and its function	0	1	2
3. Manipulation of gas hole before lighting the Bunsen burner (the collar of the Bunsen burner should be turned so that the air-hole is closed)	0	1	2
4. Light up the candle/lighter before turn on the gas	0	1	2
5. Manipulation of air hole after lighting up the Bunsen burner (Open the air-hole, so that the flame changes to the non-luminous blue flame)	0	1	2
6. Efficiency in using Bunsen burner	0	1	2
7. The need for guidance	0	1	2
Total			

APPENDIX Q
MARK SHEET FOR ACTIVITY B

Criteria	**Mark**		
	Low	Intermediate	High
Systematic operation of tasks:			
1. Following instruction in performing overall operation of task	0	1	2
2. Checking the functionality of apparatus	0	1	2
3. Communication with group members	0	1	2
Total			
Management of time and workplace			
1. Using time	0	1	2
2. Condition of working area before, during and after experiment	0	1	2
3. Cleaning and storing of apparatus and materials	0	1	2
Total			
Safety and precautionary			
1. Safety procedure during experiment	0	1	2
2. Technique in using apparatus in order to prevent unwanted damage	0	1	2
Total			
Scientific drawing			
1. Use pencil to draw	0	1	2
2. Use of neat line drawing	0	1	2
3. Appropriate title of the drawing	0	1	2
4. Correct label of scientific drawings	0	1	2
5. Magnification of drawing is indicated	0	1	2
6. Authentic drawing – base on observation	0	1	2
Total			
Technical Skill			
(i) Slide preparation			
1. The use of correct stain in appropriate amount	0	1	2
2. Technique in using slide cover	0	1	2
Total			

(ii) The use of microscope			
1. Ability to recognize apparatus and its function	0	1	2
2. Ability to identify parts and features of apparatus and its function	0	1	2
3. Handling microscope (technique in holding it and placing in flat surface)	0	1	2
4. The use of stage clips to secure the specimen slide	0	1	2
5. The use of the lowest magnification power objective lens by rotating the nosepiece	0	1	2
6. The ability to coordinate the mirror, condenser and diaphragm in order to get sufficient source of light.	0	1	2
7. Adjustment of the coarse adjustment knob until the specimen is in focus.	0	1	2
8. Adjustment of the fine adjustment knob until the focused specimen is well-defined.	0	1	2
9. Efficiency in using microscope	0	1	2
10. The need for guidance	0	1	2
Total			