Exploring the influencing factors in students' acquisition of manipulative skills during transition from primary to secondary school

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Abstract

This paper discusses the contributing factors that influence students' acquisition of manipulative skills. Incompetence in manipulative skills in science at a primary level may impede science learning at secondary school. Thus, to confront these issues, an in-depth study was conducted. The research involved 10 primary school students who were interviewed again in secondary school. This paper gives an account of the factors that influence students' manipulative skills during transition from primary to secondary school, namely the teacher, the performance of the students, teaching and learning aspects and the physical environment of the laboratory. The results suggest several issues to be considered when teaching manipulative skills. Primary school students need to be exposed to these skills in using scientific apparatus so that when they enter secondary school, attention can be given in improving and strengthening those skills.

Keywords: practical work, transition from primary to secondary school, manipulative skills, science teaching

Introduction

For centuries, people have realized the role of science as a catalyst in unveiling the secrets of nature and the resources it is endowed with, transforming them into beneficial products and services through human creativity and innovations in science and technology. With the advent of information technology and knowledge-based economies, mastery of science and technology among school students has become vital to the production of knowledgeable and competent human capital with adequate capabilities and creativity. Science curriculums in Malaysia are aimed at producing students who are able to master scientific knowledge and technological competency. The government has realized that science subjects are crucial and students at early age must be made familiar with it. Thus science has become one of the core subjects in Malaysia primary and secondary schools. Science has been taught to students as early as Year 1 (7 years old) at primary school till upper secondary school, as a compulsory subject (Grade 7 – Grade 11).

Scientific skills are essential part of scientific investigation. Among the skills required for scientific investigation at primary and secondary schools are the science process skills, manipulative skills and thinking skills. Science process skills enable students to carry out investigations systematically. Students can formulate questions and carry out experiments to get answers empirically. Manipulative skills in scientific investigations are psychomotor skills that enable students to use and handle science apparatus, laboratory substances and specimens in an approved manner. Thinking skills, on the other hand, act as a foundation for thoughtful learning that can be developed through students' active participation in the process of teaching and learning (Ministry of Education, 2006).

One of the most distinctive features of science that can ignite students' interest is practical work (Sorgo & Spernjak, 2012). Practical work in this context is defined as any scientific activity in which learners need to be actively involved, hands-on and minds-on, to observe physical phenomena (Allen, 2012). One of the aims of practical work is to develop practical skills that include science manipulative skills. Manipulative skills play an important role in science education, especially in higher level sciences (e.g., biology, chemistry and physics) and these skills can only be obtained through 'hands-on' practical work. According to past studies (e.g. Ferris & Aziz, 2005; Trowbridge, Bybee & Powell, 2000), however, manipulative skills are generally given the least amount of attention in the course of academic instruction even though important aspects of learning can occur in this area. According to Delargey (2001) and Buffler, Allei and Lubben (2001), student progression to the more advanced levels of skills acquisition depends on their progression in the lower levels. Thus it is clear that developing these skills is a worthy goal for students to attain.

Manipulative skills during transition

A student's ability to manipulate scientific apparatus is an important issue. A study conducted in United Kingdom found that students not only lack appropriate manipulative skills but also lack confidence in conducting practical work due to a lack of practice (Abrahams, Reiss & Sharpe, 2013). Reading about skills and concepts is not sufficient, thus students need to manipulate scientific apparatus in the laboratory (Hofstein & Mamlok, 2007; Lunetta et al., 2007). Consequently a lack of student exposure to hands-on activities at the primary level could lead to a deficiency in manipulative skills. Students will carry this problem to the secondary school level and possibly to higher levels of education, as Ferris and Aziz (2005) claim. In their research on students' manipulative skills at tertiary level institutions, Ferris and Aziz (2005) found that students displayed a lack of skills during practical work, while even those who performed well in examination did not show competency in manipulative skills.

The challenges in acquiring manipulative skills become greater during the transition between primary and secondary school, where students are growing in the physical, intellectual, social and emotional aspects of their adolescent life. This transition is not only a period of growth, but also a period of instability and vulnerability. At this stage students are easily influenced by changes in their environment (Hurd, 2000). In this paper, 'transition' refers to the process of moving from primary school (end of Year 6), to secondary school (early Form 1). Transitioning schools is a process of moving from a familiar to an unknown environment, which will be experienced by every student in their educational journey. It is an ongoing process that requires time and effort for students to adjust to. The paper will focus on the acquisition of manipulative skills in science during this time. Studies have shown a significant negative impact on students' attitudes towards and attainment of science education during the transition from primary to secondary school (Braund, Crompton, Driver & Parvin, 2003; Diack, 2009; Thurston et al., 2010); an increased tendency to be negative about school was manifested in the middle of the transition to secondary school. In science subjects, this phenomenon can be demonstrated by the decline in achievement and eroded interest in learning in the middle of the school year following this transition (Braund et al., 2003; Galton, Gray & Ruddock, 2003).

Issues that arise during transition have been considered global phenomena. Substantive progress has been achieved by developed countries in formulating and implementing specific programs to ensure a smooth progression during transition. For instance, in the United Kingdom, Braund et al. (2003) reported that the erosion of student interest was rooted in their high expectations for science prior to transfer, the lack of curriculum continuity and non-harmonisation of teaching approaches. In New Zealand, Hawk and Hill (2004) reported that students found their school transition very stressful, and that it got worse as students went along. Campbell (2001) found that U.S. students reflected less positively on their experience in science education because their expectations, i.e. that they would learn science through a practical approach, were not fulfilled.

By the time adolescents get to secondary school, a specialization of interest and abilities has often occurred, resulting in the selection of some courses of study and the avoidance of others. Some will prefer subjects such as languages, mathematics, history or science. If students had negative experiences with science before they got to secondary school and during transition, they will cut themselves off from many science-related careers (Braund et al., 2003). According to Howe and Jones (1993), the low interest in science may also lead to the poor scientific understanding needed by every citizen. Thus, poor opinions about school may lead to negative educational experiences. Saat (2010) found that students entering secondary school were disillusioned with secondary science education. Primary school students were enthusiastic about science because of its distinctiveness and its exciting experiments. After moving to secondary school, however, expectations of continuing to learn science through a largely practical approach were not fulfilled. Teaching and learning at secondary school were similar to primary school approaches, where the students did not get much opportunity to conduct scientific experiments.

Research in manipulative skills is still limited and much can be done to improve students' skills. Despite the national curriculum's that emphasis on the acquisition of scientific skills, students still have difficulty using and handling scientific apparatus during practical work (Fadzil & Saat, 2013). Thus, this research focuses on the factors contributing to the poor performance of manipulative skills during the transition from primary to secondary school. This study will therefore address the following research question: what are the factors influencing the acquisition of manipulative skills among students during transition?

Methodology

This study is part of a larger study that explores and investigates the acquisition of students' manipulative skills during the transition from primary school to secondary school. 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 are defined as Form 1 (equivalent to Grade 7) students (age 12 to 13). Duration of the study involves 3 stages during school transition which are the early, mid and late transition. Early transition 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. Mid-transition is defined as a period when students start the first year at secondary school (Form 1, age 12-13). Mid-transition refers to the first two months of secondary school and late transition is the period after the second months of secondary school until the middle of Form 1.

The study tracked 10 students through their transition from two different primary schools to two secondary schools in Kuala Lumpur. Purposive sampling technique has been used in order to obtain suitable participants for the study who would give their comprehensive views and insights that will enable us to obtain maximum understanding of the phenomenon (Merriam, 2009). The main criteria in selecting participants were they should be articulate and have the ability to express their opinion. 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). 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. This study utilized a qualitative research paradigm and took 11 months for data collection. The findings were based on analysis of verbal data from interviews with the ten primary and secondary school students as well as six Year 6 and Form 1 teachers, and also from laboratory observations.

According to Saldana (2003) a preliminary study is worthwhile as a preparatory stage before the actual research begins in order to assess the effectiveness of data collection. The data collection of this study involves laboratory observations and interviews. Two primary and two secondary schools were chosen as research sites in preliminary study. Through preliminary study, the skills and technique in observing the students during experiments were sharpen 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. Interview protocols for Year Six and Form One students were reconstructed and organized systematically, before the actual study was conducted.

The first phase of this research was conducted at two primary schools. Video and audio recordings were used during the interviews and during the observation of students and science teachers. The second phase of this study followed the same students during their transition to secondary school. Students were re-interviewed to explore their experiences at secondary school. All the video and audio recordings were transcribed and analysed iteratively, where the researchers repeated the process of data collection and analysis back and forth until the saturation point of the data had been reached.

Constant comparative method of analysis (Glaser & Strauss, 1967) was used in this study. It involved the process of coding, categorizing and developing themes from information that emerged from the collected data, themes that best describe the ways students experience transition in science education. Refining the thematic framework involves logical and intuitive thinking in making sure that the research objectives are being addressed appropriately (Glaser & Strauss, 1967; Ritchie & Spencer, 1994). The validity and reliability of the interview protocol were done through peer review. Themes and categories that emerged during data analysis were also checked by peer review. Two science education experts were involved in the peer review. Peer review is regarded as one of the most reliable techniques used to enhance the credibility and trustworthiness of qualitative research because of its use of external experts in a given field of study (Merriam, 2009).

Findings and discussion

In this study, four (4) main factors emerged during the analysis of the data. The factors are the role of the teacher, the performance of the students, teaching and learning aspects and the physical environment of the laboratory (Figure 1).

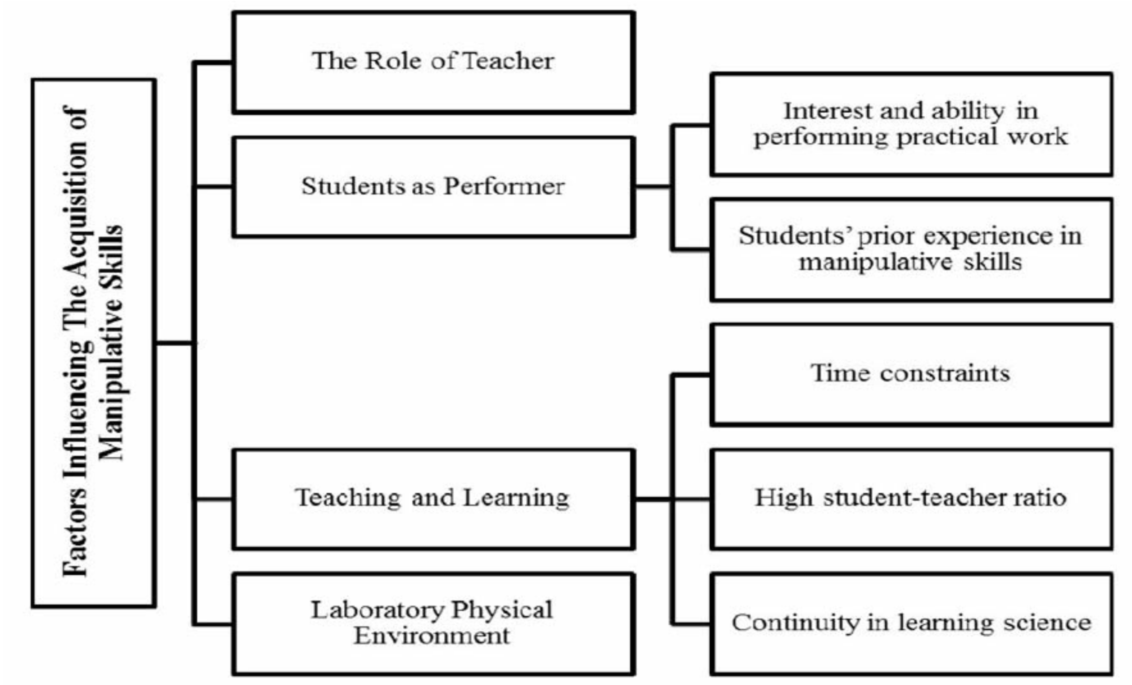

Figure 1. The influencing factors in acquisition of manipulative skills.

The role of the teacher

This research has shown that teachers play the role of experts and instructors in the learning of manipulative skills. As experts, teachers should have a comprehensive and authoritative knowledge of science that includes a mastery of manipulative skills. From classroom observations, the researchers noticed that teachers play a major part in instructing the students in the correct handling of scientific apparatus and materials. Instruction in this context can be defined as a structured process that is concerned with the development of manipulative skills through guided practical experience, assessment and regular feedback in order for students to master the skills in question. Proper guidance based on the specific science curriculum prepared by the Ministry of Education can lead students to a better acquisition of the intended skills. For instance, through demonstration, a teacher ensures that students obtain correct and proper techniques in using apparatus. During practical work in groups, teachers assist the students, correcting and guiding students who encounter difficulties in handling the given task. This is in line with Bandura's observational learning theory (Bandura, 1989), which states that each individual learns from their observation of others' behavior. The cognitive processing of events will guide learners' behavior and performance in manipulative skills. From interviews conducted with secondary school teachers during transition, most of them were disappointed with the students' low capability in handling apparatus:

- Secondary school students (Form 1 students) skills are very weak. Many of them are not even aware that there are science laboratories in their (primary) schools. (ST1, Ss, Ln.45-46)

Primary school students claim that they did not conduct many experiments in primary school, a claim supported by primary school teachers: "from my experience as a science teacher, experiments are rarely conducted," (ST6, Ps, Ln.152-153). Thus, the teachers' positive attitudes toward experiment and practical work play a major role in students' acquisition of manipulative skills during transition. This claim is also supported by secondary school teachers:

- Teachers must possess the initiative to assess whether his/her students have the sufficient manipulative skills. It is all boils down to the teacher. If we are unmotivated, we can just leave them. But a responsible teacher will put more effort in. Maybe not 100%, but we try. At least we do our part. (ST5, Ss, Ln.113-118)

From the interviews and observations, the researchers found that primary school teachers were very protective over their students and defensive about safety issues in the laboratory. During the interviews and laboratory observations, primary school students admitted that they felt intimidated by the teacher's attitude and some of them seemed rather afraid to work with the Bunsen burner. Teachers did not realize that by doing this they have limited the students' opportunity to practice the necessary skills of manipulating the apparatus and restricted the development of scientific skills. Teachers should be more positive. They need to guide the students in the proper techniques of handling the apparatus, but should always be reminded to observe appropriate safety measures that should be taken during practical activities. According to Hamza (2013), students need to work with scientific apparatus to help with their future learning. Thus the experiences in science class can be used fruitfully in other settings. This claim was supported by Wickman and Ostman (2002), who demonstrated that students learn science by using previous science experiences in school successively. If students do not get much of an opportunity to perform experiments, they may encounter difficulties in future because of their lack of skills and experience.

Students as performers

The second factor is an internal factor which derives from the student themselves as a performer of these skills. It involves students' interests and abilities to perform practical work and their prior experience with manipulative skills.

Interest and ability in performing practical work. Almost all of the students in this study expressed their interest in the subject of science. To them, science is an interesting subject because of its distinct features, which are practical work and scientific apparatus. The students had been aware of the significance of conducting practical work since primary school. Students with an exam-oriented mentality explained that laboratory skills were important for them in order to excel in examination. For instance, Student 5 claimed that, "conducting experiments helps your understanding, and when you really understand a topic, you can score in your examination" (Ln. 23-24, S5a).

For others, practical work served as a platform to learn and improve their skills in using apparatus, as suggested by Student 6,"it is important to train our skills, such as how to use the microscope to observe microorganisms and how to measure the temperature with a thermometer. When we are sufficiently trained, this would save our time during experiment" (Ln. 59-61, S6a). Practical work also taught them to practice scientific values, as explained in the following quote, "conducting experiments teaches us how to work as a team…" (Ln 34-35, S1a).

During laboratory observation, however, the researchers noticed that some students were not interested in practical work. The term 'cohesiveness' has been coined by Lightburn and Fraser (2007) to explain student supportiveness in the laboratory environment. In this study, a lack of student cohesiveness was observed. These students were passive; they preferred to have their group members prepare the slides and merely observed the final results or copied the result from their friends. This was acknowledged by secondary school teachers during the interview sessions:

They can do it, but sometimes I see the same few students doing everything in the group. Some just cannot be bothered, and they are mere passengers in their group. (ST5, Ss., Ln.126-128)

This teacher also shared her experience in teaching manipulative skills to Form 1 students with different achievement levels in science. She admitted that good students were given freedom while conducting experiments, with the teacher as facilitator. This differed for the weaker students, who needed constant supervision. The acquisition of manipulative skills during transition also depends on the individual student's ability, as suggested by Teacher 5, "some are able to understand just by observing once, and then they know what to do in an experiment. But some are a bit slow and they need to be personally tutored. No other way. Even for simple experiments" (ST5, Ss, Ln.16-22). Teacher 4 admitted that the objectives of conducting practical work could not be achieved with weak students and are just a waste of time because "the weak students usually conduct experiments without being able to relate them to the lesson. They merely do it for fun. This can be identified when they are unable to answer questions on the topic after conducting the experiment" (ST4, Ss, Ln.102-105).

Students' prior experience in manipulative skills. Research by Campbell (2001) on students' perceptions of science at primary and secondary schools has shown that primary school students were enthusiastic about science because of its distinctiveness and its exciting experiments. The research also found that students' expectations of science in secondary school were that they would use specialized facilities and apparatus in the laboratory, and this was what they looked forward to most in order to maintain their positive attitudes towards science. This is similar to findings by Campbell (2001), Galton et al. (2003) and Fadzil and Saat (2013), who claim that the teaching and learning of science at the primary level is more about retention of knowledge, where students were involved with too much writing and too little practical work. Insufficient skills cause secondary school teachers to have to re-teach their students the basic skills of using and handling apparatus, as Primary Teacher 3 and Secondary Teacher 6 explained: "most of the students could not use science apparatus appropriately" (ST6, Ps, Ln.32), "the students' abilities are very disappointing" (ST3, Ss, Ln.37-39).

Interviews conducted with Form 1 teachers revealed that some of these teachers were skeptical about students' abilities to use the apparatus. They assumed that students had no experience in using laboratory apparatus. As Teacher 5 said:

Although we know that they should have acquired some skills from primary school, we still need to refresh their knowledge, like how to read the meniscus. Some already know, but sometimes there are those who still do not understand...so we have to teach them all over again. (ST5, Ss, Ln.55-59)

Findings from the interviews showed that secondary school teachers tended to blame primary school teachers for students' lack of abilities:

A few of the students do have the necessary skills in the laboratory. Maybe they were given the chance to use the apparatus from primary school. But majority of them are lacking in the skills. For example, when they are asked to observe the cells of an onion peel, they are not able to use the microscope properly. Maybe they were not exposed to the proper techniques in primary school. (ST4, Ss, Ln.54-58)

It is important for teachers to provide students with sufficient skills, starting in primary school. The knowledge of the skills that were delivered by the teacher gives students a basic understanding of manipulative skills and these skills can be further enhanced during the transition to secondary school (Anderson, 1982). Given the lack of practical work in science, students might have to deal with problems in obtaining specific skills during scientific investigation.

Teaching and learning

Three (3) main issues have emerged in the teaching and learning of manipulative skills during transition: time constraints, high student-teacher ratios and continuity in learning science during transition from primary to secondary school.

Time constraints. Most teachers gave the same response when the issue of practical work was raised by the researchers. Experiments took too much time and preparation due to the lack of a laboratory assistant. This claim was supported by Primary Teacher 6, "we do not have laboratory assistant at primary school. The teacher has to do everything from scratch. That is the main reason we cannot do much experimentation" (ST6, Ps, Ln.152-154). Thus, teaching practice at the primary level tends to use rote memorization, as suggested by Campbell (2001) and Saat (2010).

The claim was also supported by a student during his interview, who told the researchers that he "did not do many experiments at primary school. When I asked my teacher she said we do not have time for it. There are two science laboratories in that school but I rarely went there to carry out experiments" (S5b, Ln. 35-37).

At secondary schools, the teachers expressed their problem with laboratory assistants by saying that "laboratory assistants depend too much on the teacher in preparing apparatus and materials" (ST1, Ss, Ln.15-17). Secondary school teachers also demanded that "we need teaching assistants who can help the students when they are conducting an experiment" (ST3, Ss, Ln.98-101).

High student-teacher ratios. During the implementation of the study, primary and secondary school teachers admitted that they encountered difficulty in assessing students' manipulative skills during practical work. The high number of students in science classrooms makes things more complicated. Students have to conduct practical work in a large group due to the shortage of science apparatus and materials. As this primary school student explained, "we usually carry out the experiment in groups...a group of six" (Ln. 23, S7a). Thus, it is difficult for the teacher to control the classroom and at the same time ensure that each student acquires the intended scientific skills. As Secondary Science Teacher 4 states, "a large class makes it difficult for a teacher to provide attention to each student" (ST4, Ss, Ln.107-108).

Most of the teachers at primary and secondary schools suggested that the number of students in the classroom should be reduced so that experiments can be conducted in smaller groups and each student can have equal opportunity to use the apparatus. The following quote reiterates the significance of reducing the number of students:

- If possible, the number of students in each class must be reduced. I think both primary and secondary schools are facing the same problem. It is impossible to make sure that all 40 odd students acquire the necessary skills. (ST5, Ss, Ln.157-160)

Continuity in science learning. Continuity in science learning is a significant aspect of education that needs to be considered during the transition from primary to secondary school. The problem during school transition is that students have the tendency to assume that science at primary school and science at secondary school are two different subjects. They have difficulty understanding the continuity between learning science at primary school and learning it at secondary school. Secondary School Teacher 2 claims, "students rarely put their skills to practice in secondary school, claiming that the subjects taught are different to what they were taught in primary school" (ST2, Ss, Ln.44-46). Thus, in order to prevent these difficulties and to improve students' manipulative skills during transition, teachers should "ensure the same method is use to acquire scientific data in primary and secondary school so the students are not confused" (ST2, Ss, Ln.95-97).

This finding is in line with Galton et al. (2003), who conclude that the curriculum discontinuity in science during transition is a factor that causes the erosion of students' interest in studying science. Continuity of curriculum suffers during transition due to the gaps in knowledge that make students lose confidence in their abilities. Greater emphasis on ensuring better curriculum continuity between upper primary and lower secondary levels will improve support for implementing curriculum changes.

The physical environment of the laboratory

The issue of inadequate scientific apparatus and materials in school laboratories is often highlighted during transition. At secondary school this issue is not as critical. Teachers expressed, however, that additional number of apparatus are needed in order for students to be more efficient in the learning of manipulative skills. As Teacher 4 suggests, "ensure the laboratory is equipped with a sufficient supply of apparatus so the experiment can be conducted in smaller groups, for example a group of three. Currently, the ratio of apparatus with the number of students is inappropriate" (ST4, Ss, Ln.117-118).

Primary school teachers claimed that there were insufficient numbers of scientific apparatus, and the student agreed, "the apparatus in primary school is very limited. The Head of Science is more interested in buying workbooks rather than buying scientific apparatus and material." (ST6, Ps, Ln. 79-81)

The interviews indicate that the problem of a lack of apparatus affects the acquisition of manipulative skills at primary school. Thus, it was not surprising that students exhibited poor manipulative skills. In contrast to the responses from interviews with teachers and students, however, the researchers found that the problem was not all because of the absence or lack of scientific apparatus, but because the apparatus was unattended and not taken care of.

The same situation was observed during the preliminary study. The school was new, but student enrolment exceeded the maximum capacity, thus two of its science laboratories had been converted into classrooms. Only one laboratory was available and it was shared with the whole school. The laboratory was very well-equipped, but the science teachers were not able to use it frequently and made this an excuse to not conduct scientific experiments.

Based on the findings discussed, there is a need to provide each primary school with a laboratory assistant to assist the teacher in handling the science laboratory. If no lab assistant is possible, then special courses should be given to primary school teachers in order to assist them in maintaining their apparatus properly and effectively, especially because there is no laboratory assistant provided at primary schools. This suggestion is in accordance with Lightburn and Fraser (2007). Adequate laboratory equipment and material is important for the efficient teaching and learning of science.

Conclusion

Undoubtedly many benefits accrue from engaging students in scientific laboratory activities (Hofstein & Mamlok, 2007; Lunetta et al., 2007), since one of the main aims of practical work is to develop skills in manipulating laboratory apparatus (Trowbridge, Bybee & Powell, 2000). Laboratories can be considered the best place to learn manipulative skills and these skills should be learned as part of a formal instruction in science. The purpose of this study was to explore and investigate the factors affecting the acquisition of students' manipulative skills during the transition from primary school (Year 6) to secondary school (Form 1) by employing a qualitative approach.

Science education has undergone changes in recent years. New pedagogical techniques are constantly being developed, yet the development in the acquisition of manipulative skills tends to be unwieldy. The reason behind this can be explained by exploring the factors that impinge on the process of skills acquisition in the present environment. These factors are the role of the teacher, the students as performers or executers of manipulative skills, issues in teaching and learning, and the laboratory environment. Based on the findings presented above, it is clear that teachers play the role of experts as well as instructors in the acquisition of manipulative skills by students (Bandura, 1989). Teachers can facilitate or hinder students' acquisition of skills, but it all depends on the teacher's attitude toward practical work. The students' abilities to master manipulative skills will serve as a strong basis for them to further enhance these skills at the upper secondary school.

The students' interest in and their prior experience with manipulative skills also plays an essential role during transition.

The ground has been prepared for innovation in practical work. Current practices at most primary schools may impede students' development of manipulative skills during transition, however, and the problems are most likely to be transferred to secondary school. Students should be well trained in core manipulative skills that benefit them in higher learning. To develop manipulative skills progressively, students should be given ample opportunities to practice their skills. Providing more experiences of practical work in primary school will help students see practical skills and procedural knowledge in science as something they can always use and that naturally develops, rather than something that starts again in secondary school.

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