PRIMARY SCHOOL PUPILS' ACQUISITION OF SCIENCE PROCESS SKILLS VIA HANDS-ON ACTIVITIES AND AUTHENTIC ASSESSMENT

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Abstract

This study is about the acquisition of science process skills by primary school pupils by means of hands-on teaching and learning, and authentic assessment method. Their interest and motivation in science were also inquired. The participants for the 5 months study consisted of 24 year-five pupils in one primary school in Selangor, Malaysia. The instruments used were an observation checklist, sets of science process skills achievement test, and interviews. Data collected from observation and achievement tests were analysed using rubrics, while information from interviews are analysed using NVivo 2.0. Findings from this study showed that the acquisition of science process skills among the pupils has increased tremendously and their interest and motivation in science were high. They were also able to apply the knowledge gained from hands-on learning to solve authentic problems. Therefore it is suggested that hands-on science teaching and learning as well as authentic assessment are used in schools.

Keywords *Science process skills, authentic assessment, observation, motivation, interest.*

Abstrak

Kajian ini ialah mengenai penguasaan kemahiran proses sains di kalangan murid sekolah rendah yang menjalani proses pengajaran dan pembelajaran secara melakukan-sendiri dan ditaksir secara autentik. Di samping itu minat dan motivasi terhadap sains turut dikaji. Murid-murid yang terlibat dalam kajian selama 5 bulan ini terdiri daripada 24 orang murid di sebuah sekolah rendah di Selangor, Malaysia. Instrumen kajian ialah pemerhatian, beberapa set ujian pencapaian kemahiran proses sains dan temubual. Data yang dikutip melalui pemerhatian dan ujian pencapaian dianalisis menggunakan rubrik manakala maklumat daripada temubual dianalisis menggunakan NVivo 2.0. Dapatan kajian ini menunjukkan penguasaan kemahiran proses sains di kalangan murid-murid telah meningkat dengan mendadak dan minat serta motivasi terhadap sains adalah tinggi. Mereka didapati dapat menggunakan pengetahuan yang dipelajari melalui pembelajaran melakukan-sendiri untuk menyelesaikan masalah yang bersifat autentik. Oleh kerana itu dicadangkan pengajaran dan pembelajaran secara melakukan-sendiri dan pentaksiran secara autentik dilaksanakan di sekolah-sekolah.

Kata kunci *Kemahiran proses sains, pentaksiran autentik, pemerhatian, motivasi, minat.*

INTRODUCTION

One of the main and pervasive goals of schooling is to teach children to think. Achieving this goal is of immense importance for all subjects taught in schools. However, teaching children science could pave this path-way, as science itself is unique. Science contributes its unique skills, with its emphasis on hypothesising, manipulating the physical world and reasoning from data. Science processes, often designated as inquiry skills are embodied in exploring and investigating activities in science teaching.

Science processes, the scientific method, scientific thinking and critical thinking have been terms used at various times to describe today's term "Science process skills". It was popularised by the curriculum project named, A Process Approach (SAPA). These scientific skills are defined as a set of broadly transferable abilities, appropriate to many science disciplines and reflective of the behaviour of scientists (Padilla, 1990). He re-emphasised that science processing includes both basic and integrated skills. Basic processing involves: observing, inferring, measuring, communicating, classifying, and predicting. Integrated science process skills require controlling variables, defining terms operationally, formulating hypothesis, interpreting data, experimenting, and formulating models. Both basic and integrated skills are needed to be scientifically literate (Keil et al., 2009).

Science process skills are not only important for those pursuing careers in science, but most jobs in this new millennium involve using these skills (Rillero, 1998). Through science teaching children understand the importance of science and have the tendency to involve deeper in the fields of science, positively perceived, responsible, as well as science and technology literate. Equipped with the ability to read and write scientifically is important to survive in the high technology world (Atware, 1995). While an exhaustive knowledge of science content is impossible, mastery of science process skills enables students to understand at a much deeper level, the content they do know and equips them for acquiring content knowledge in the future. In Malaysia, acquisition of science process skills is greatly emphasised in the science curricula across disciplines and grade levels (Curriculum Development Centre, 2002). However acquisition of science process skills are found to be rather low and unsatisfactory, as shown by research findings by Ismail (2001), Abu Hassan and Rohana, (2003), and Kiu Ling Feng, (2006).

Assessing process skills is not as common as assessing content knowledge, but it can be done (Harlen, 1999). Several instruments used for testing science process skills are developed. One of them is the multiple-choice items instrument developed by Burns, Okey and Wise (1984). Others are training guides which involve the use of one or more process skills that can be assessed by applying them to a series of laboratory station activities. Primary schools in Malaysia implement a program known as science PEKA (Penilaian Kerja Amali) or *Experimental-Work Evaluation.* Through science PEKA, seven elements in scientific skills: observing, classifying, measuring using numbers, communicating, using space/time relations, defining terms operationally, and experimenting are assessed (Malaysia Examination Syndicate, 2008). However, controlling variables, formulating hypothesis, and interpreting data, are embodied in the element, experimenting.

Although science process skills are inseparable from the practice of science and play a key role in both formal and informal learning of science content, more often than not, driven by the pressure of performance on high-stakes testing, many science curricula unfortunately over emphasise content knowledge. Less time are allocated by science teachers to teach science "hands-on" and "minds-on". Wrutheran et al. (2001) reported an average of 25% of teaching time was used for doing experiments among science stream students and 10% among arts stream. This has implications on students' interest in pursuing career in fields of science. In a study where an environmentally based education was implemented by the National Environmental Education and Training Foundation, Glenn (2000) reported that environmentally based education improved performance in science and social studies, developed students' abilities to transfer knowledge to new contexts, enabled students to "do science" rather than just "learn about science", decreased classroom discipline problems, and provided all students with the opportunity to learn at a higher level.

Assessing teaching and learning is as important as the teaching itself. Nowadays, much emphasis is given towards classrooms assessments (Zhang & Burry-Stock, 2003). This is because of classrooms being the centre of teaching and learning session (Chan & Gurman, 2010). Assessment is defined as all the systematic ways teachers use to collect information in classrooms (Airasian, 2001). It involves all methods teachers apply to get data for making decisions, from scores in paper-pencil tests, products, portfolios, systematic performance, formal/informal observation, and interviews (Hanna & Detmer, 2004). Traditional assessment mainly revolves around paper-pencil while others are alternative assessment often known as authentic assessment or performance assessment. Authentic assessment is also known as continuous assessment (Carlson et al.; 2003). What is common between the different terms used is that the assessment taking place in natural environment. Children are assessed throughout the learning process. Authentic assessment should have variation in measures, methods, and criteria. They should be appropriate to children's learning experience. Assessing attitude and motivation toward science is not as common as assessing achievement, but it can be done through authentic assessment rather than traditional assessment. According to Mc Millan (2007), teachers should assess children continuously and give useful feedbacks. Specific feedbacks are meaningful and motivate children to learn on their own and indirectly increase their self–confidence. Motivation depends on feedbacks from assessment and the integration of assessment into learning.

The objective of this study is to examine year-5 (grade 5) pupils' acquisition of science process skills after going through hands-on science learning and a series of authentic assessment, as well as to identify their interest and motivation in learning science.

METHOD

Research Design and Sampling

Based on the objectives of the study, a qualitative research design was implemented. In trying to understand social reality, the focus of the research should be to understand the subjective and specific experience of the individuals. This is to understand the individuals' meaning making of their experience from their own perspectives (Bryman & Bell, 2003). The acquisition level of science process skills is measured authentically using various methods based on observation and documents. The participants were 24 year- five pupils from one rural primary school in Malaysia, aged 11 years. Eight were boys and 16 were girls.

The study began with teaching and learning taking place in a science room involving all 24 pupils and a female teacher. The pupils worked in small groups of four once a week for 60 minutes during science periods as provided in the school time-table. Ten different hands-on experimental-based activities were carried out. Each activity was completed within the 60 minutes of science period allocated in actual school time-table except for one activity which took 180 minutes to complete i.e. within 3 weeks. While the pupils worked themselves, the teacher observed, went around asking probing questions to the groups. Besides doing the experiments and writing science reports, the pupils need to complete five folios from five topics selected by the teacher. After undergoing hands-on science teaching and learning, six pupils were selected and took science process skills achievement test authentically and later were interviewed.

Instruments, Assessment and Data Analysis

The instruments used to assess science process skills were observation: direct observation, document analysis, model making, folios writing and sets of practical achievement test. The instrument used to identify pupils' interest and motivation was a 13- questions interview protocol adapted from Gogolin and Swartz (1992); Lilia and Kamisah (2006). The structured interview protocol was piloted and improvement was made before it was used for this study.

Purposely for assessing the process skill of experimenting, the teacher designed 10 different activities. All ten of the activities required each pupil to write a complete science experiment report, but one activity required them to build a model as well as writing the report. Each activity took 60 minutes each time each week except for the activity involving building a model which was completed in three consecutive weeks with a total time of 180 minutes. The teacher assessed the pupils' science process skills acquisition using 10 sets of analytical rubrics adapted from Ujian Penilaian Sekolah Rendah (UPSR) or *Primary School Evaluation Test* PEKA Guides Book (Malaysia Examination Syndicate, 2008). In addition to the ten activities, the pupils' acquisition of the process skills of classification, observation, and defining terms operationally were assessed using a rubric specially designed for the five folios the pupils had completed. Another rubric was designed to assess the planning, sketching and completed models by the pupils.

After going through the teaching and learning process, six pupils were selected to sit for the science process skills achievement test comprising of three different instruments designed to apply the knowledge learnt to solve real-life problems. This practical test was carried out on a Saturday and the duration of the test was three hours. This process skills achievement test was assessed using rubrics for practical achievement test.

The six pupils were also interviewed to examine their interest and motivation after going through authentic learning. Their answers were written down in the interview forms and also audio-recorded. The data were transcribed, coded and later analysed using NVivo 2.0.

RESULTS

Acquisition of Science Process Skills Through Hands-on Science Learning

Based on observation and document analysis, the acquisition of science process skills is tabulated in Table 1. In the first activity, "Moulding Bread", the science process skills: identifying variables, formulating hypothesis, stating the objective of the experiment, and listing procedure of the experiment yielded low percentages of achievement. Higher achievement percentages were shown in the process skills: communication, observation, using space/time relations, and carrying out the experiment scientifically. In the second activity, "Making Dough", the same science process skills yielded lower percentages than the rest as in the first but higher percentages than the first activity. Generally, all science process skills increased in achievement percentage except for activity 3, "menthol brightness" where all the science process skills except listing procedure of the experiment yielded perfect/nearly perfect acquisition. Even though the pupils did well in activity 3, the same observation could not be determined in activity 4, "Series and Parallel Circuits".

Overall, all ten hands-on teaching and learning activities, the percentage increase in acquisition of science process skills was observed. A tremendous increase was observed for the science process skills: identifying variables, formulating hypothesis, stating the objective of experiments, and listing procedures of experiments. The more easy processes: Listing apparatus and materials, carrying out experiments scientifically, defining terms operationally, observation, communication, using space/time relations, measuring using numbers, and classifying were maintained or increased to near perfection/perfection.

Table 1 Acquisition of Science Process Skills in Percentage from Ten Experiments

Title of Experiments / Science Process Skills	1	2	3	4	5	6	7	8	9	10	% Increment
Experimenting											
Identifying variables	20.8	33.3	100.0	62.5	91.7	79.2	75.0	91.7	87.5	95.8	79.2
Stating the Objective of the Experiment	25.0	33.3	100.0	58.3	91.7	79.2	75.0	87.5	87.5	95.8	75.0
Formulating Hypothesis,	20.8	25.0	100.0	50.0	70.8	75.0	50.0	87.5	66.7	91.7	79.2
Listing Apparatus and Materials	91.7	75.0	100.0	87.5	100.0	70.8	79.2	100.0	83.3	100.0	29.2
Listing Procedure of the Experiment	37.5	33.3	50.0	58.3	66.7	70.8	75.0	91.7	75.0	70.8	58.4
Carrying Out the Experiment Scientifically	83.3	83.3	100.0	62.5	100.0	91.7	95.8	100.0	100.0	100.0	37.5
Defining Terms Operationally	91.7	87.5	100.0	58.3	75.0	75.0	62.5	87.5	70.8	95.8	41.7
Observation	83.3	100.0	100.0	79.2	100.0	95.8	95.8	100.0	95.8	100.0	20.8
Measuring Using Numbers	-	100.0	-	-	87.5	87.5	-	-	-	-	12.5
Communication	75.0	83.3	95.8	79.2	100.0	88.3	83.3	91.7	91.7	91.7	25.0
Using Space/Time Relations	83.3	91.7	-	-	-	87.5	-	-	83.3	-	8.4
Classifying,	-	-	-	-	-	-	95.8	95.8	-	-	4.2

Notes:

1 – Moulding Bread
2 – Making Dough
3 – Menthol Brightness
4 – Series and Parallel Circuits
5 – Factors Affecting Size of Shadows
6 – Temperature Changes
7 – States of Matter
8 - Acidity, Neutrality and Alkalinity of Substances
9 - Appearing of Days and Nights
10 – Constructing a Model Bridge

Table 2 shows the variation in results of the bridge models' strength and stability that the pupils had built in groups of four. The strongest and most stable bridge model had been able to support 110 marbles, followed by 95 marbles and 80 marbles. The weakest model could only support 35 marbles.

Table 2 Bridge Models and Total Number of Marbles Supported

Group Number	Total number of Marbles Supported	Placement
1	95	2
2	35	6
3	80	3
4	70	4
5	65	5
6	110	1

Since the process, "classifying", was tested only twice out of ten experiments, each pupil was asked to make five folios where classifying skill was included in the specified topics. Table 3 showed the acquisition of science process skills: Classification, Observation and Defining Terms Operationally in Percentage from Pupils' Folios. It was seen that all pupils had successfully acquired the science process skills of observation, defining terms operationally, and classifying with minor error.

Table 3 Acquisition of Science Process Skills: Classification , Observation and Defining Terms Operationally in Percentage from Pupils' Folios

Title of Folios / Science Process Skills	Classification of Microorganism	Survival of Animals	Survival of Plants	Eating Habits of Animals	Chemical Characteristics of Substances
Observation	100	100	100	100	100
Classification	79.2	100	100	100	100
Defining Terms Operationally	-	-	-	100	100

Acquisition of Science Process Skills Based on Science Process Skill Achievement Tests

The three instruments used: A (Making and Selling Doughnut on Entrepreneurship Day); B (Light Signals); C (Building a Model for Village Bridge) involved six pupils. Their process skills achievement were assessed using three sets of rubrics for achievement with the following indicators: 4 (excellent); 3 (Good); 2 (Moderate); 1 (Need Guidance). Among the criteria measured were the ability to identify materials and apparatus, ability to list a procedure on doughnut/ circuit/model making, construct effective model and tidiness of working place. The interpretation of the total score for the achievement test is shown on Table 4.

Table 4 Performance Scales for Assessing Science Process Skills Achievement Test

Score	Indicator
16 – 20	Excellent
11 – 15	Good
06 – 10	Moderate
00 – 05	Weak

The authentic assessment of process skills acquisition is shown in Table 5. Both pupils who were assigned to instrument A achieved excellent grades. One of the two who was assigned instrument B achieved excellent grade and the other achieved good grade. For instrument C, one of the pupils achieved excellent grade and another one achieved good grade. Both pupils were able to build bridge models despite their sketches of bridge models were not perfectly scaled.

Table 5 Science Process Skills Achievement Test Results

Assignment / Topics Criteria	Making and Selling Doughnut on Entrepreneurship Day	Light Signals	Building a Model for Village Bridge
Ability to identify materials and apparatus	Pupil 1 : 4 Pupil 2 : 4	Pupil 3 : 4 Pupil 4 : 4	Pupil 5 : 4 Pupil 6 : 4
Ability to list a procedure on doughnut/ circuit/model making	Pupil 1 : 4 Pupil 2 : 3	Pupil 3 : 3 Pupil 4 : 3	Pupil 5 : 4 Pupil 6 : 3
Ability to sketch electric circuits/ a bridge model		Pupil 3 : 4 Pupil 4 : 3	Pupil 5 : 2 Pupil 6 : 2
Doughnut turn-out well	Pupil 1 : 4 Pupil 2 : 4		
Produce functional circuits		Pupil 3 : 3 Pupil 4 : 3	
Construct effective model			Pupil 5 : 3 Pupil 6 : 3
Tidiness of working place	Pupil 1 : 3 Pupil 2 : 2	Pupil 3 : 4 Pupil 4 : 2	Pupil 5 : 4 Pupil 6 : 3
Promotion	Pupil 1 : 4 Pupil 2 : 3		
Total Score	Pupil 1 : 19 (Excellent) Pupil 2 : 16 (Excellent)	Pupil 3 : 18 (Excellent) Pupil 4 : 15 (Good)	Pupil 5 : 17 (Excellent) Pupil 6 : 15 (Good)

Pupils' Interest in Learning Science

Pupils' interest in science was determined using seven themes: Interest in science and why; methods of science teaching; interesting science activities; science relations to everyday life; looking forward to science class; allocated science periods; and talking about science to other people.

All six pupils interviewed said their interest in science increased because of the hands- on method of learning, as one pupil said, "… we carried out many experiments. I can hold many science apparatus many times." Referring to the method of teaching, all of them liked and understood science concepts better after experiencing varied hands-on science activities. Quoting one pupil, "Teacher teaches me well…I like learning like this, with a lot of experiments. Excited to do experiment. To do the folios also best. Can search information from the internet..." They expressed their interest in learning science by doing science and learning more new thing. One pupil said, "Yes... (nodding her head). I like carrying out experiments in science laboratory. Learning in science laboratory is exciting" and another said, "Do the model and represent it after that...folio also exciting. Get more knowledge when searching pictures from internet".

About relating science to everyday life, they commented, "We did the bridge model... I used to pass Kuala Selangor Bridge as if climbing hills. The bridge at my grandpa's place is also like that. No wonder strong bridges curved a bit"; "That experiment involving temperature is like boiling water at home. But in the lab we can see the temperature increases in the thermometer and later decreased. That moulded bread l used to see at my grandma's house. Not only bread, rice also sometimes become moulded when grandma throw the rice on the ground. But when doing it with friends in school feel best"; "The circuit that we learn… At home there is one menthol fuse but the rest lighted….because parallel circuit. If in series, all will not light…Now I understand though small circuit is used in school, I can imagine". They were able to relate science that they have learnt in schools to everyday life events.

They also said that they were always looking forward to study science. As one pupil said, "Yes, I can't wait to know more about science". Another said, "Sure... because science is exciting. I know sure we will learn something new or do new experiment. That is what's best". They commented that allocated science time was not enough. They suggested science time be increased so they could explore more. As the pupils say, "Not enough. Because I want to do more experiments"; "Looks like not enough. If can, give science time a little longer"; "If do the experiments... time passed very fast. If longer time given, can try other ways". Pupils also talked about science to other people especially their parents, siblings and relatives. Examples were: "Yes... my mum likes it that I learn making dough in school. She asks me to help her make cakes during holidays…. I also speak to my cousins whenever l go to their homes"; "I told my younger sibling... to my auntie also when I see her sometimes. She is a science teacher and she tells me what experiments that she does".

Pupils' Motivation in Learning Science

Pupils' motivation in learning science is determined through six themes: Finding information about science before science class; doing science assignments; excitement while doing science; evidence/products produced; skills to carry out experiments; and ambitions in science.

All six pupils searched for science information and were motivated to know more about science by reading books. Some pupils said: "Read a little. Mum will always ask me to sleep early. Before going to sleep l read a science book. Many science information with pretty and colourful pictures"; "I do. I read a lot of books and magazines from school library. Because at home there are not many books"; "I do. At home there are many science story books. Last year my dad bought one science experiments book. A lot l haven't done because it's difficult to buy all the things needed. The easy ones can do". About doing the assignments given by the teacher, they said they were able to do the assignments with help from parents, friends and internet. One pupil said, "I like it. I can do the assignments that teacher give. If I don't know, I ask Fateha". About carrying out experiments, most of them were excited and liked to do the experiments. They felt like real scientists and become more confident in doing experiments. As one pupil said, "I feel l become more clever and do not feel awkward any more handling science apparatus".

All six of them were motivated to produce good evidence/products. They worked hard to produce them. They also felt proud when looking back at their products or when shown appreciation by the teacher. As one pupil said, "Looking at the bridge model..feel proud, because teacher exhibits it in the science lab..". Another said, "Best..because l like to do the folio by searching information from internet. Pictures are easy to find. Furthermore if teacher makes it as an example. For a while feel proud (laughing)". About the skills to carry out experiments, they felt confident to be allowed to do experiments by holding and manipulating the apparatus and materials in the science room. They gained experience from doing the experiments and their fear receding after carrying out many experiments. Doing the experiment in small groups give them confidence because they can discuss among themselves. Some examples were: "Quite okay. Because have been doing many times..feel confident and can do"; "I'm delighted to be able to do experiments. I feel I can do it especially when doing in groups. Because can discuss"; "Feel more confident. I like it when l get reading from experiments. We transfer them onto graph papers. I now increasingly know how to make graphs correctly". About their ambitions in science, the pupils were determined to get higher achievement in science. Most of them would like to pursue careers in science. As some of them said, "To know more about science. Firstly, l will complete all work that the teacher gives and finding information from internet. I will study hard so l can get A for science this year"; "I would like to get higher marks in science so that l can become a scientist. I am confident that l can get high marks because l have understood the experiments that have been carried out…"; "Yes. I am determined to know more about science. I will study hard the topics that l have learnt so as to score 100%...I would like to enter science schools and become a scientist".

DISCUSSION AND IMPLICATION

Doing science, hands-on, refer to teaching science involving active participation from pupils. Coupling this method of teaching science with problem-solving is definitely an inquiry-based teaching. In the late 1990s, the notion of teaching science process skills explicitly in science lessons as a necessity to lay ground work for future acquisition of science concepts, has been adopted by Malaysia Ministry of Education into its education policy. However some elements of the official discourse of science education – such as constructivist teaching, authentic assessment, and science process skills hardly entered or partially entered practitioners' thinking. The findings of this study is aimed at providing evidence how practising inquiry-based learning coupled with authentic assessment engaged pupils and highly motivated them to further study in science. And the reason why authentic settings are important is the recognition that the knowledge and skills that learning activities produced are tied to the situation in which they learnt.

From this study, it shows that great improvement had been achieved by the pupils in their acquisition of science process skills. Initially they were rather unable to identify variables (responding, manipulated, fixed); stating the objective of the experiment; formulating hypothesis; and listing procedure of the experiment. After experiencing hands-on and minds-on inquiry-based learning, they acquired the needed science process skills. The other process skills: listing apparatus and materials, carrying out the experiment scientifically, defining terms operationally, observation, measuring using numbers, communication, using space/time relations, and classifying had all increased to perfection or near perfect. "Listing procedure of the experiment" was difficult to many of the pupils because after doing 10 experiments, the group acquisition percentage was 70.8% for the 10th experiment. "Carrying out the experiment scientifically" reached 100% acquisition 5 times including the 10th experiment. This particular skill is reflecting the elements of good values and attitudes.

Generally after learning science by "doing", the pupils are found to be very excited and confident. Initially many are awkward when handling and manipulating the science apparatus and materials for fear of making mistakes. But with the teacher's facilitation and words of encouragement, their confidence escalated, and later they feel free to work their ideas into the tasks and move about their tables. Their interests in science were obvious by impatiently waiting for the next science class to come. They also tried to read and find relevant information before coming to their science class. High level of engagement of pupils in science practical work/experiment indicate their high interests in authentic activities that they do not notice the passing of time (Nurzatulshima et al.; (2009).

Actual acquisition of science process skills should be measured authentically, just like how it is done in this study. Probably classroom assessment is best done through authentic assessment. Variation in measures, methods, and criteria of authentic assessment are useful and appropriate to pupils' learning experience and come hand in hand with inquiry-based learning. While the pupils are attempting to understand science concepts by "doing" science or carrying out inquiry-based learning, their acquisition of science process skills and knowledge are assessed authentically. Teachers observe and keep record on the pupils development as they go about their tasks in the laboratory or smaller science rooms.

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. Students will engage in selected aspects of inquiry as they learn the scientific way of knowing the natural world, but they also should develop the capacity to conduct complete inquiries (NRC, 1996). Inquiry consists of thinking ability, competencies, and process skills, and how can we assess these? Probably there is no better way than through authentic assessment. In this study, direct observation, document analysis (the pupils' practical reports), making models (Bridge models), writing folios, and practical achievement tests were the various ways used to assess the pupils' acquisition of science process skills. Specific rubrics were then designed and adapted for measurement.

Since it is pertinent for students to become the focus of learning, the inquiry teaching context enabled to explore and construct knowledge by themselves, much akin to scientists. Additionally, the role of the teacher is to guide students, helping them practise critical thinking, promoting their higher-level thinking and problem-solving abilities, guiding them to understand scientific concepts, enhancing their awareness of the role of science process skills, and enhancing their learning motivation (Windschitl, 2003). Teaching and learning is indeed important, however assessing teaching and learning is integral to effective learning. Designing interesting real-life problems to solve in the practical achievement test lends elements of fun to the test. This is hoped to transform learning science as realism. Something that is part of life, that everyone should learn, not just for the elite few who want to pursue science careers, but everyone need to acquire science process skills as most jobs in this millennium use these skills (Rillero, 1998), as well as to be scientifically literate to understand and take part in the discourse of science and technology that affects the world we live in.

Based on the explanation of the nature of inquiry, Tseng, et al. (2012) find that inquiry is embedded in constructivism and social constructivism and helps students appreciate how scientists construct their scientific knowledge through the inquiry process. They suggested that future science teacher education programs should demonstrate varying inquiry-based teaching approaches to teachers beginning to learn inquiry teaching, and science teacher educators should create a long-lasting supporting community to consistently encourage teachers to develop their inquiry-based teaching.

As suggested by Osborne and Dillon (2008), it is critical that science teachers of the highest quality be provided for pupils in elementary and lower secondary schools. Also, emphasis in science education before pupils reach 14 years old should be a priory. Evidence suggested that this is best achieved through opportunities for extended investigative work and hands-on experimentation, not through a stress on the acquisition of canonical concepts. Our study found that the pupils were full of interest to study science because of the hands-on, experimentation and that they were overly excited when they were able to solve tasks given to them. Their self-confidence was nurtured by achievement in accomplishing the given tasks and working with their peers.

CONCLUSION

The pupils' acquisition of science process skills have increased tremendously and their interests and motivation in science were high. They were able to put into application the skills and knowledge gained from hands-on learning to solve and understand real-life problems. Therefore science teachers should perceive hands-on experimentation as a vehicle to capture pupils' interests and favourable attitudes toward science. Science teachers should be trained on how to implement authentic assessment creatively in their classroom assessment.

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