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The effects of Performance-based Assessment to Enhance Teaching and Learning Science (ForPS) Model on science process skills and science concepts understanding of secondary students in Kinta District of Perak.

Eftah Moh Hj Abdullah, Othman Lebar and Abd. Aziz Abd. Shukor
Sultan Idris Education University, Malaysia

Four classes of Form One students of four schools in Kinta district, State of Perak, Malaysia participated in a five weeks intervention designed to enhance teaching and learning science with Performance-based Assessment to Enhance Teaching and Learning Science (ForPS) Model. Teachers in intervention classrooms were implemented an assessment approach that incorporated the use of instructions based on curriculum-specifications from Ministry of Education and the performance-based assessment module into individual and classroom instructional planning. During the intervention period, control groups continued to use of instruction based on a curriculum-specifications from Ministry of Education and the use of a memory-based traditional testing procedures adopted by the school, which included the use of the assessment of learning developed by the subject teachers'. Intervention groups demonstrated significant improvements on some dimensions of performance as measured by the Integrated Science Process Skills and Science Concepts Understanding, whereas control groups exhibited no significance change. Implications for practice are discussed.

Key words: ForPS; intervention; process skills; science concepts understanding.

Introduction

"A school based assessment system may be used to replace an exam-oriented education system in the country" said Deputy Prime Minister Tan Sri Muhyiddin Yassin (Bernama, 2010). Muhyiddin, who is also Education Minister, said the Examination Board would determine the type of questions that could be used by teachers for such assessment in schools. "We will replace exams with an assessment system. It has not been finalized but a study was done and found acceptable because such a system was used in many countries". Numerous researchers also found that assessment practices impact strongly upon what students learn, and the approach adopted toward study. Students altered their approach to learning in line with the perceived requirements of the learning context (Treagust, Jacobowitz, Gallagher, & Parker, 2001; Ramsden, 1992; Trigwell & Prosser, 1991). Indeed, Elton and Laurillard (1979) write of “something approaching a law of learning behaviour for students; namely that the quickest way to change student learning is to change the assessment system” (p100). Continuous improvements and reforms in education have focused on enhancing the understanding and developing skill mastery in students. Traditional techniques do not prove effective for the expanded concept of learning that requires students to demonstrating higher-level thinking skills (Trowbridge, Bybee & Powell, 2004; Hein & Lee, 2000). Treagust, et al. (2001) emphasized that traditional tests evaluated a limited number of cognitive functions and skills related only to memory, and students’ ability to recall material learned out of context. A carefully planned assessment can have direct influence on students learning and students are actively involved in science and not a reactive reading or listening. Performance-based assessment is an alternative strategy for assessing students’ concepts and skills in science, and it prepares students for a productive future within a technologically complex world. The method also fits the nature of science, that is, the study of active structures, and often changing natural phenomena (Ainley, Hidi, & Berndorff, 2002; Atkin, Black, & Coffey, 2001; Collins, 1997; Guy & Wilcox, 2000; Shavelson, 1994). Since performance-based assessment occurs over a period of time, it provides an opportunity for students to individually achieve the highest level of learning (Baker, 1996). Unlike the memory-based traditional testing procedures, performance-based assessment is authentic assessment, because it involves doing performance of tasks that were valued in their own right, it were situated in a real world context, and it could mirrorr real tasks implemented by professionals (Jorgensen, 1994; Linn et al., 1991; Mabry, 1999). These characteristics of performance-based assessment allow students to engage with meaningful problems that foster significant educational experiences (Garbus, 2000; Kulieke et al., 1990; Linn et al., 1991). Assessment for learning and assessment of specific tasks are two basic approaches of performance-based assessment adopted in this study.

In the treatment classrooms’, performance-based assessment approaches has value for students and teachers. For students, performance assessment provides a realistic approaches to science, reinforces the inquiry skills of science that facilitate the use of process skills for individual and group experiments, and also for individual to conduct the investigations. For teachers, the methodology provides timely information on the learning needs of their students, and thus the teaching methods they employ (Corcoran, Dershimer, & Tichenor, 2004). Assessment for learning and task based performance assessment provides a student with quality information’s they can use in order to improve their skills and allows further learning from the process of the assessment itself. The method of demonstrating tasks that were designed to assess a student’s progress at the end of each unit are carefully design so that it has a direct correlation between the forms of performance assessment and the final science examination. This is because these tasks should be demonstrated individually to give a valid indicator of students’ progress. This finding is consistent with the results of Gallant (2005), who concluded that “a curriculum-embedded performance assessment can be used to predict students’ performance on a state’s criterion-referenced assessment in a later grade” (p. 106).

In this study, performance-based assessment methodologies were used formatively, and within a cooperative environment. Performance-based assessment approaches has a greater possibility of positive outcomes than the use of traditional tests such as multiple-choice and true or false, particularly with secondary school pupils. Assessment for learning or sometimes called as formative assessments used specifically to enhance learning processes or performances. Research evidence and theoretical points claimed that effective formative assessment could raise student achievement and improved learning in many subjects (Harlen, 2003). There are also compelling research results indicating that the practice of formative assessment may be the most significant single factor in raising the academic achievement of all students and especially that of lower-achieving students (Black & Wiliam, 1998a).

The intervention approach in this study relied on the use assessment aligned with the curriculum specification from Ministry of Education and a specific Performance-based Assessment to Enhance Teaching and Learning Science (ForPS) which is generated based on three teaching models. The principles that guided the creation of the assessment model, basically is one model of how assessment can be incorporated into the classroom teaching and learning process. In designing the embedded assessment model the main principle focuses on the "match" between what is taught and what is assessed. A different types of assessment were extracted from three different types of models that is 4-E learning cycles (Renner & Marek, 1988, March & Cavallo,1997), the mirror model (Bybee et al., 1990), and models based on problems solving CRESST (Delacruz, Crowly & Bewley, 2003).The information and application of different types of assessment gathered from the three models was then used to develop the ForPS modules and the ForPS assessment tool designed to assess children's development and learning across the topic Matter. The intervention study was restricted to the topic matter in science form one. The science content and objectives of the units of matter in the study program for the experimental groups were aligned to the science curriculum and were conducted as part of the regular timetable. The implementation of the ForPS was guided by the use of module ForPS. This module is activity-based protocols which was included tasks based assessment, individual and groups experiments and unguided individual investigations. Performance-based assessment module could help this process not only by making available proven approaches, but also by providing resources and access to the researcher. Modules also embed development of knowledge, tasks and skills relating to formative assessment for teacher to use it in the classroom. Teachers used different assessment types to collect data in the classrooms (see Figure 1). Additionally, portfolios were developed for all of the children that are guided by ForPS Module. The portfolio was a compilation assessments data from formative assessments, individual experiments and individual unguided investigations. After each stages of assessment, teachers used child assessments' data to guide curriculum planning in the classroom.

The entire view of the model development of ForPS was based on assessment embed learning links up with constructivism philosophy towards whole view of the origin of knowledge. Piaget's view that the mental processes to make sense of the information that we receive from our environment is the process development of a system for organizing mental structures. Piaget and Inhelder (1969) call these small mental structures is "schemes". As one develops more and more schemes they were integrated into cognitive structures. He gives the name "assimilation" to the process of incorporating data into existing structures. It is with the process of assimilation that knowledge construction begins and is comparable to the exploration phases of the learning cycle (Marek & Cavallo, 1997). Piaget maintains that a mismatch between one's mental structures and what one has assimilated creates disequilibrium. If disequilibrium continues, then the learner must adjust, modify, or create new mental structures. This adjustment is known as "accommodation" and is parallel to the term introduction phase of ForPS model. Together, assimilation and accommodation cause the learner to adapt her thinking. Such adaptation requires that the new mental structure be organized within the existing mental structures, thus giving rise to the organization function of the cognitive development process much like the phase two of the ForPS model known as explanation, discovery, and creativity. Piaget, Vygotsky, Bruner, and other theorists, who have observed changes in knowledge as a person goes through the process of intellectual development, have all devised similar concepts to explain how this process occurs. The work of Piaget, Vygotsky, and Bruner werecharacterized as constructivist (Driscoll, 2000). As such it supports the use of learning cycle models to promote the intellectual development of the individual. Bruner's (1961) discovery learning model supports all phases of the learning cycle models especially the exploration phase. Bruner defined discovery as "all forms of obtaining knowledge for oneself by the use of one's own mind" (p. 22). Driscoll (2000) interprets this as the transformation or reorganization of evidence to go beyond an individual's present knowledge to new insights. John Dewey saw knowledge as always unfinished, derived from judgment and beliefs, and made explicit (discovered) through active participation, through doing and making. He was a strong advocate of inquiry in education, rationalizing against absolute answers. His educational views was supplemented and supported by the findings of Piaget (Piaget & Inhelder, 1967) who thought that learning occurs developmentally through interactions between the individual and the environment. In terms of practice, the Piagetians ("constructivists") and Deweyans ("progressive educators") advocate inquiry as central to the teaching and learning process. While Kuhn saw that knowledge does not grow in linear fashion. It does not move gradually toward the truth. It makes great jumps that he claimed as a leap a scientific revolution. To some extend students would propose, giving explanation and find solution that different with what they always believed. They will take more drastic action to change their preconception and realize the changes of their understanding.

Control groups in this study followed the same curriculum specifications from Ministry of Education with teachers used the assessments they develop themselves without specific guidance or according their normal practices. Conceptually, Models ForPS was designed to be a eight-week intervention; the first week involved collecting pre-test data, one week teachers' training session, the five week implementation of Model ForPS and the another one week involved collecting Post-test data. This study outlines the findings of ForPS Model and control groups, examining the effects on science process skills and concepts understanding.

Research Questions

The study was guided by the following research questions;

1. What are the differences between the mean of science concepts achievement by the implementation of performance-based assessment model and traditional testing methods?
2. Are student science process skills affected by performance based assessment model?

Methods

Participants

ForPS Model was developed and implemented in secondary schools of Kinta district of Perak. Four form one classes with the students age between twelve to thirteen years old were selected in the study. A quasi-experiment with non-equivalent control groups design involved 63 samples of interventions' group and 73 samples of controls' group.

Description of the Intervention

Intervention and control group's teachers attended of three hours formal training on the ForPS model. Training was followed by weekly technical assistance visits throughout the five weeks of the intervention. The content of the training sessions was designed and delivered by the investigators. Teachers received instruction and practice on use of the ForPS Model through module that is containing the activity-based protocols designed specifically for the intervention in this study. Teachers were also trained to interpret assessment results for developing children's individualized guiding plans. Training on the use of a ForPS Module involved a process of connecting Learning Outcomes Framework from Ministry of Education with individual assessment results (see Figure 1 and Figure 2). Additionally, teachers were trained to develop a portfolio system for documenting children's ongoing progress which is a compilation of individual formative tests data, individual experiments and individual investigations reports. Weekly visits consisted of a variety of supports, including motivation and feedback, provision of materials to support implementation of the model and troubleshooting.

Procedures for Data Collection

Intervention and control groups were assessed with Integrated Science process Skills Test (ISPST) and Understanding Science Concepts Test (USCT) at the beginning and end of the eight-week. The science concepts pre-test was conducted at the first week of the study to examine similarity between groups. The test included 30 items related to a topic matter of science form one prior to this intervention ForPS Model. These items were prepared by the researcher, subjects teachers and validate by expert teachers were designed for students to complete within 40 minutes. The science concepts post-test was a same measure from the pre-test measure was conducted immediately after the intervention period. The content was limited to the matter units that were covered in this research. The data of pilot test for the Understanding science Concepts Tests was analyzed to determine reliability by evaluating the Crombach alpha coefficient. For the pilot test, the Cronbach alpha coefficient was .82, (N=53), Nunnaly (1978) has indicated 0.7 to be an acceptable reliability coefficient, so that Cronbach's reliability coefficients for the science tests are acceptable. The integrated science process skills were adapted from Test of Integrated Science Process skills (Vantipa Roadrangka, Muhamad Nor Ahmad, Said Manap, 1996). ISPST consists 28 items with internal consistency, Cronbach alpha 0.78 (N=53). The data were collected by the teachers involved in the study. Data were entered into SPSS 11.5 for analysis.

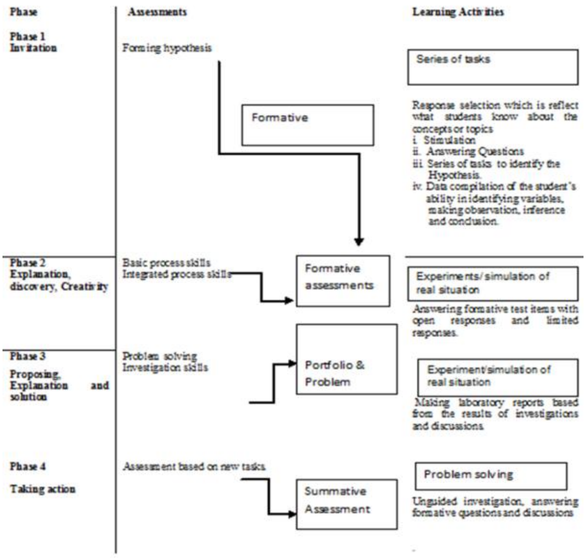

Figure 1 : Performance-based Assessment for Teaching and Learning Science (ForPS) Models' Framework

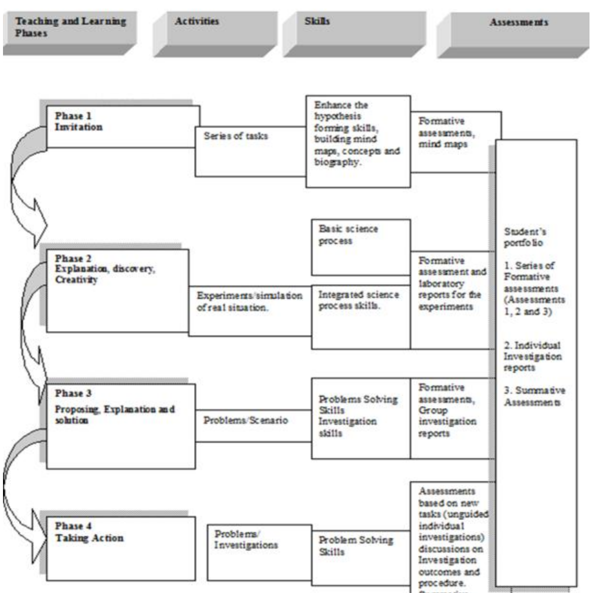

Figure 2; Performance-based Assessment for Teaching and Learning Science (ForPS) Module Framework

Results

Descriptive analyses were conducted for both groups. Table 1 outlines the means and standard deviations for the pre-test and post-test scores for the two groups (intervention and control).

Table 1. Group statistics

Variable	**Pretest Mean *M* (*SD*)**	**Posttest Mean *M* (*SD*)**
Intervention Group (*n* = 63)		
USCT	13.06 (5.50)	18.06(4.71)
ISPST	13.29 (4.71)	19.43(2.83)
Control Group (*n* = 73)		
USCT	13.19 (3.11)	15.36(4.59)
ISPST	13.05 (5.15)	14.26 (6.61)

Research question 1

The first research question concerned the effects of the performance-based assessment model (ForPS) on students' Understanding Science Concepts achievement levels compared to those taught by traditional assessment methods (Control group).

The question is: What are the differences between the students' Understanding Science Concepts achievement levels that can be achieved by the implementation of ForPS Model and traditional testing methods?

> Ho1: There is no significant difference between the experimental and control groups in the USCT post-test.

To test the null hypothesis that emanates from Question 1, the independent sample t test was applied. The result revealed significant statistical differences in the USCT post-test scores between the experimental (N= 63, M = 18.06, SD = 4.71), and control (N= 73, M = 15.36, SD = 4.59) groups, t (134) = 3.387, p = .001 <.01 (see Table 2). Therefore, the null hypothesis is rejected.

Table 2. Independent samples t-test for USCT Post-test

Group	Mean	SD	df	t value	P
Experiment/ Intervention	18.06	4.71	134	3.387	.001
Control	15.36	4.59			

Research question 2

The second research question investigated the effect of the ForPS model on the students' process skills: Does performance-based assessment model have an effect on students' science process?

> Ho2: There is no significant difference in the means of scores between the experimental and control groups in the students' science process skills.

To test the null hypothesis that emanates from Question 2, the independent sample t test was applied. The result revealed significant statistical differences in the ISPST post-test scores between the experimental (N= 63, *M* = 19.43, *SD* = 2.83), and control (N= 73, *M* = 14.26, *SD* = 6.61). However, the result of Levine's test was significant for ISPST, *F* (1, 100.693) = 39.503, p = .000 <.05. Because equal variances are not assumed, the set of statistics labeled "equal variances not assumed" in the "*t*-test for equality of means" was used. The *p*-value for this version of the *t*-test is *p* =0.000. Since this *p*-value is less than 0.05, the decision would be that there is a significant difference between the two group means (5. 17), groups, *t* (100.693) = 6.062, *p* = .001 <.01 (see Table 3). Therefore, the null hypothesis is rejected.

Table 3. Independent samples t-test for science process Post-test

Group	Mean	SD	df	t value	P
Experiment/ Intervention	19.43	2.83	100.693	6.062	.000
Control	14.26	6.61			

Discussion

The model described in this study is one that allows recommended practices in science assessment to guide these processes while still addressing expected standards in science curriculum. However, the intent of this study was to examine the impact of ForPS model on Understanding Science Concepts Test and the Understanding Science Concepts. Findings from this study suggest that the performance assessment approach have a positive impact on the science process skills and concepts understanding. Differences were found in both the control and intervention group skills.

This study is particularly important in Science disciplines, which are traditionally content-driven. Teachers tend to bemoan the fact that they no longer have time to "cover the entire syllabus" in their science subject. While many dedicated teachers are working tirelessly to transform assessments approaches that aligned with learning outcomes, it is also possible to strategically help them use ForPS model as a teaching and learning without jeopardizing the learning of discipline skills. Assessment practice, more than any other practice in education system, communicates to students the type of learning required of them (Biggs, 1992). Numerous researchers have found that assessment practices impact strongly upon what students learn, and the approach adopted toward study. Students alter their approach to learning in line with the perceived requirements of the learning context (Ramsden, 1992; Trigwell & Prosser, 1991). The outstanding implication of these studies is that assessment with careful design and considerable thought, be used to encourage and expand space of learning activities for students to develop appropriate process skills, in addition to knowledge and understanding. The assessment-based model design include not only what tasks the students need to do, but also how they are expected to do it. Teachers put considerable thought into the tasks especially investigation tasks, which enable them to assess student performance on central concepts and skills in the curriculum. Unguided individual investigation tasks did not provide detail procedure, most were able to critically use their process skill, plan and carry out investigation that would have better achieved their objectives. The process skills were demonstrated to have been achieved by most of the ForPS students.

Teachers in the experiment group used performance assessment formatively. They provided students with information in different ways such as making comments on student's work or within conducting an experiment, and students used this information as feedback to improve their learning. The embedded assessment in ForPS was give opportunities for teachers to assess student progress in the classroom activities. The need to embedded assessment into the instruction process has been emphasized by a number of researchers (e.g., Brown, et al, 1992; Glaser, 1987; Resnick and Resnick, 1992). The positive results of this study reflected in students' outcomes in science do not focus on performance assessment as a test method, that is, students merely practicing science for later examination. Instead these results encompass a holistic approach to learning, based on the theoretical framework of performance-based assessment model, which is different from the traditional approach of assessing and teaching science. The approach contains interactive factors in learning, teaching and assessing, based on constructivist learning theories, as has been described in the theoretical framework of the model. In this approach, performance-based assessment required the learners to adopt higher order thinking, engage in problem-solving for a period of time, and the vitalization of teaching methods that encourage active participation. These activities occur within a social constructivist learning environment where students are able to work cooperatively, and reflect on their work (Roth, 1995; Lorrie Shepard, 2000).

Conclusion

Recognizing the importance of developing science skills in elementary school and carefully defining and organizing those skills are necessary, but not sufficient, for implementing change. A wide body of research suggests that learning to solve problems in a variety of contexts fosters the development of a general problem-solving ability that can be transferred to new contexts. Without practice in applying science skills in real problem-solving situations, transfer is unlikely to happen. A major stumbling block is our focus on designing tasks to challenge student's ability and skills and teaching science skills which represent their real world applications. Teachers responsibilities shift include enhancing individual knowledge with the instructions theories, actively involved and practiced with new assessments approaches and plays an active role as a facilitator.

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