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UNIVERSITI SAINS MALAYSIA

LAPORAN AKHIR PROJEK PENYELIDIKAN JANGKA PENDEK

Tajuk Penyelidikan:

Assessing Competency in Integrated Science Process Skill and its relation with Science Achievement

Oleh

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6. **Abstrak Penyelidikan**

(Perlu disediakan di antara 100 - 200 perkataan di dalam **Bahasa Malaysia dan juga Bahasa Inggeris.** Abstrak ini akan dimuatkan dalam Laporan Tahunan Bahagian Penyelidikan & Inovasi sebagai satu cara untuk menyampaikan dapatan projek tuan/puan kepada pihak Universiti & masyarakat luar).

Abstract of Research

(An abstract of between 100 and 200 words must be prepared in Bahasa Malaysia and in English). This abstract will be included in the Annual Report of the Research and Innovation Section at a later date as a means of presenting the project findings of the researcher/s to the University and the community at large)

Abstract: This study was conducted in two stages. The first stage was to develop and validate the Test of Integrated Science Process (TISP), a paper-and-pencil objective test that has been developed specific to the science content defined in the Malaysian school science curriculum. TISP assessed pupils' performance on a set of integrated science processes associated with planning investigations. These include formulating hypotheses, defining variable operationally, identifying and controlling variables as well as interpreting data. The TISP consists of 36 multiple-choice items. Evidence of content validity, construct validity, and reliability showed that the test has sound psychometric properties. The second part of the study aims to investigate development in the process skills with relation to science achievement among secondary school students. The TISP, is used to measure acquisition in the processes of science. However, science process skills are subjects specific. These skills operate in conjunction with specific knowledge. Items in the TISP contain conceptual materials on science as well as requiring the application of component integrated process skills. An objective science test that required application of the science concepts in the TISP is used to assess science academic achievement. Students' ability in science process skills and science content knowledge is calibrated using BILOG-MG based on the Item Response Theory. These measures obtained are compared using a scatter plot. The psychometric properties of these two tests were compared to assess difficulty of the tests. Pupils' performance in science process skill and science achievement is also compared based on the ability calibrated.

Abstrak: Kajian ini dilaksanakan dalam dua peringkat. Peringkat pertama membina dan mengesahkan Ujian Kemahiran Proses Sains Bersepadu (UKPSB), iaitu satu ujian yertas dan pensel berbentuk objektif yang dibina khusus untuk isi kandungan sains untuk kurikulum sains sekolah menengah. UKPSB menilai prestasi pelajar dalam kemahiran proses sains bersepadu yang diperlukan untuk menrancangkan penyiasatan. Proses ini termasuk membentuk hipótesis, mendefinisi istilah secara operasi, mengenal pasti dan mengawal pembolehubah serta mentafsir data. UKPSB mengandungi 36 item pilihan pelbagai. Bukti untuk kesahan isi kandungan, kesahan gagasan dan kebolehpercayaan menunjukkan ujian mempunyai ciri-ciri psikometrik yang baik. Bahagian kedua kajian bertujuan untuk mengkaji hubungan perkembangan kemahiran proses dengan pencapaian sains di kalangan pelajar sekolah menengah. UKPSB digunakan untuk menentukan perolehan proses sains. Namur, kemahiran proses sains berkait dengan subjek. Kemahiran proses sains beroperasi dengan pengetahuan spesifik. Item-item dalam UKPSB memerlukan konsep sains dan juga kemahiran proses sains. Satu ujian sains berbentuk objektif yang memerlukan aplikasi konsep sains dalam UKPSB digunakan untuk menilai pencapaian akademik sains. Kebolehan pelajar dalam kemahiran proses sains dan pengetahuan isi kandungan ditentukur dengan BILOG-MG yang berasaskan Teori Respons Item. Ukuran yang diperoleh dibanding mengguna lakaran taburan. Selain itu, cirri-ciri psikometrik kedua-dua ujian dibanding dari segi kesukaran ujian. Prestasi pelajar dalam kemahiran proses saian dan pencapaian sains juga disbanding menggunakan kebolehan yang ditentukur.

7. Sila sediakan laporan teknikal lengkap yang menerangkan keseluruhan projek ini.
[Sila gunakan kertas berasingan]
Applicant are required to prepare a Comprehensive Technical Report explaning the project. (This report must be appended separately)

Introduction

Good science teaching is defined as that geared toward developing an attainable form of high scientific literacy (Anderson 1987). To be scientifically literate, a person needs to have knowledge of concepts and theories of science, and, in addition, to have some understanding of how this knowledge has been obtained in the past and is still being learned today. Padilla (1990) called these ways of investigating in science as the process skills. Other terms such as the scientific method, scientific thinking and critical thinking are terms used at various times to describe these skills. Today the term "science process skills" is most commonly used. Science educators (Gagne, 1965) have argued that acquisition of the science process skills should be a major goal of science instruction as most curricula also aim to develop students' ability of the scientific approach to enquiry.

Science process skills are defined as an understanding of methods and procedures of scientific investigation (Bilgin, 2006). Harlen (1999) described science process skills include abilities relating to identifying investigable questions, designing investigations, obtaining evidence, interpreting evidence in terms of the question in the inquiry, and communicating the investigation process. Process skill learning has become an important component of science curricula at all levels. Acceptance of this view is reflected in curricula developed in recent years with an emphasis on the science process skills. Although science process skill has been introduced in the United States since 1960s, it was not given much emphasis in Malaysia. During the nationwide science curriculum review in the year 2002 for both primary and secondary schools (Kementerian Pendidikan Malaysia, 2001), explicit teaching of the science process skill was necessary with an introduction of a paper-and-pencil test to assess acquisition of these skill (Lembaga Peperiksaan Malaysia, 2002).

The Importance of Integration Science Process Skills

Science – A Process Approach (SAPA) grouped process skills into two types - basic and integrated (Livermore, 1964). The basic science process skills provide a foundation for learning the more complex integrated science process skills (Padilla, 1990). Processes such as observing, classifying and recording data, which are typically taught in primary schools, act as prerequisites for integrated processes. Examples of integrated science processes include skills such as formulating hypotheses, operationally defining, controlling, and manipulating variables, planning investigations, and interpreting data (Livermore, 1964).

Many science curriculum guides and textbooks have cited important outcomes on the acquisition of integrated science process skills. These processes are rooted in the simple processes and seem necessary to the aim of acquiring a scientific approach to knowledge. This is because process skills represent the rational and logical thinking skills used in science. These process skills are intellectual skills used in collecting and analyzing data so as to solve problems. Students can use process skills to formulate responses to questions, to justify points of view, to explain events or procedures, and to interpret or describe data.

The modern science curriculum includes what scientists have found out (content) and what they do to find out (process). Concepts, explanations, understanding, and theories constitute the content of science. Through science process skills, scientists collect knowledge, put experiments together, analyse data, and formulate results (Bilgin, 2006). Some science educators have argued that the scientific approach to enquiry can be thought of as a set of science process skills. The process skill approach (Chiappetta & Koballa, 2002) is argued as one teaching method that could be employed by teachers in the effort to teach science as inquiry. This is because science process skills are very important for meaningful learning; to find, interpret, and judge evidence under different conditions. Therefore, it is essential for students to be provided with science process skills (Harlen, 1999).

The process skill approach focuses on teaching broadly transferable abilities that are appropriate to many science disciplines and are reflective of the behavior of scientists (Padilla, 1990). Chiappetta (1997) states that "the acquisition and frequent use of theses skills can better equip students to solve problems, learn on their own, and appreciate science". Science process skills have been portray as a set of discrete 'thinking skills', which can be practiced and developed separately before being combined to tackle more demanding problems.

Problem Statements

The science process skills, along with the knowledge those skills produce, and the scientific values and habits of mind define the nature of science. Science includes both the process of inquiry about natural phenomena and the content derived there from. Unfortunately, the teaching and learning of science does not always reflect the true nature of science. Most science lessons emphasized either science content or science processes. Before the emphasis of science processes in the curriculum, most teachers view of science education as being concerned only with the development of scientific concepts and knowledge (Tobin et al., 1990). Students memorise scientific laws and knowledge to pass examination. At the end of the science programs, students merely possess chunks of discrete science knowledge.

Some science educators, however, have argued that explicit teaching about the methods of science is necessary and have the opinion that an understanding of science processes (or science method) is more important than the knowledge content (Millar,1990). With the emphasis on the science process skill, some teachers now practice science education where the process of doing science becomes almost the sole focus. Science learning was primarily in terms of the development of pupils' process skill. They did not realize that the process is the tool through which knowledge is acquired, but it alone is not science (Hinman, 1998). Though the major thrust of the science program is to develop the pupil's skills in using science processes, science content should not be neglected. While it is true that without processes, the content of science would become static or even decay. The content of science is the accumulated and ever-expanding body of knowledge in any discipline to which scientific inquiry can be applied. By overemphasizing process, teachers may not be preparing students properly for continuing science learning to the higher level. According to Livermore (1964), both the processes as well as content are important. Students use science process to learn science content. The integrated process skills are involved when conducting investigation or experiments; formulating a hypothesis, identify and control variables in designing an experiment, and making generalizations after collecting data. (Padilla & Okey, 1983).

The National Science Educational Standards (National Research Council, 1996) also emphasize the importance of scientific content when it states, "An essential aspect of scientific literacy is greater knowledge and understanding of science subject matter" (p21). In fact not all science knowledge can be learned through the process approach. A good part of the content of science, especially in the higher grade, must be learned through more traditional methods such as lectures, textbooks, and systematic memorization. The factual and conceptual content is so rich that just to understand it, not to mention master it, requires rigorous, intensive study.

Students' ability to use process skills depend on the extent of their knowledge of the contexts they are asked to work on (Millar, 1990). This is explained by the finding (Song and Black, 1991; Lock, 1993) that performance of tasks requiring these process skills is strongly content-dependent. There is a problem of how to integrate content and process of science. Science process skills always exercised in relation to some science content, and have a crucial role in the development of learning with understanding (Harlen, 1999). Teachers need to capitalize on opportunities in the activities normally done in the science classroom to emphasize science process skills. Students conducting these activities are expected to develop such skills as stating hypotheses, operationally defining variables, designing investigations, and interpreting data in addition to mastering the content of the courses.

Purpose of the Study

Science education for primary and secondary schools emphasize the ability of students to use the processes of science. Process skill learning has been included as a component of science curricula. The development of curricula which emphasize the process of science created a need for reliable and valid instruments capable of evaluating achievement in these skills. There are several reputable tests available that claim to measure the processes of science. The Individual Competency Measures are probably the most valid of all tests of the science processes because the students must actually perform the process in question under the supervision of a trained observer. However, evaluation of the skills requires individual testing, which pose a problem of time management for the classroom. The Test of Integrated Process Skills (TIPS), a paper and pencil multiple-choice test to measure the acquisition of the integrated science process skills, was developed by Dillashaw and Okey (1980) for a non-curriculum specific process skills test for middle and secondary students. The TIPS was designed to assess the proficiency in the science process skills associated with planning, conducting, and interpreting results from investigations. Burns, Okey & Wise (1985) revised TIPS and developed TIPS II to measure five component of integrated process skills: that is, identifying variables, identifying and stating hypotheses, operationally defining, designing investigation and graphing and interpreting data. In Malaysia, Ismail and Zurida (1996) translated TIPS II to the Malay language. Using the Malay version of TIPS II, Zurida reported (1998) that acquisition of Integrated Process

Skills was not satisfactory. This may due to the content of the test being general in nature and does not match the Malaysian school science curriculum. In addition, at the time these skills were measured, the teaching of the science process skill was not carried out explicitly in the science classroom.

For students to demonstrate the integrated process science skills, assessment using hands-on procedures to determine skill acquisition by groups of students deem most appropriate. In the Malaysian school science, this is being implemented by the practical work, which is known as PEKA in the school science curriculum. The Ministry of Education required teachers to conduct school base science practical, PEKA, to assess students' acquisition of the science processes. The PEKA assess more nearly actual samples of the kind of behavior in the integrated science process skills. Yet, the administration of the PEKA, which requires students to actually performed the task concerned has the same problems like the Individual Competency Measures, are very time consuming and require a trained observer. The problem of using such procedure can be a burdensome task to teachers as it is common to have 40 or so students per class in the science classroom. Besides, the question of reliability and validity of such big scale assessment is of big concern. Thus science teachers need a means of measuring process skill competency that can be administered efficiently and objectively. Therefore, a decision was made to utilize a paper-and-pencil group testing format.

In line with the emphasis of the teaching of integrated process skills for the secondary school science curriculum, the Malaysian Examination Board has revamped the standardized tests. Beginning with the year 2003 (Ministry of Education, 2002), the assessment of integrated process skill in a written format is introduced in the public examination besides the school based laboratory assessment, PEKA. Items in this test required students to plan and design an investigation which involves the use of all the integrated process skills in science. To answer items correctly, students must possess all components of integrated process skill as well as knowledge in science. Students who are weak in the content area may not be able to apply these skills at all. A test which can measure each component skill will provide better understanding on students' acquisition of the integrated process skills.

The purpose of this study is to develop is to develop a paper and pencil objective test of the integrated processes of science suitable for the Malaysian science curricula. This test assesses components of integrated process skills separately so as to prevent the occurrence of non-mastery of certain skills that hamper students from demonstrating other skills that they already knew. Test items which can assess each component of the integrated process skills with different test items will be useful for diagnostic purposes. Teachers can use this test to identify weaknesses and strength of the components integrated process skill for a student.

With the implementation of the new science curricula which emphasize the teaching of science process skills systematically in both the primary as well as the secondary schools, integrated science processes became the instructional objectives in the Malaysian secondary schools science program. Science educators should be aware of the important aspects of students' competency levels in integrated process skills and their abilities in using these integrate process skills to obtain science knowledge. As such, data is needed to provide information regarding students' development of the process skills in relation to science academic achievement. Research studies showed that there were positive relationships between the students' science process skills and their achievement in science (Bybee, 2000; Padilla, 2004). Further study of process skills by Doran & Sellers (1978) investigated relationships between students' mental ability, gender, biology achievement and science process achievement. The achievement measures contained items on experimenting, predicting, and concluding. The authors reported that mental ability was related to the process achievement. The relationship was not strong, however, as biology achievement and mental ability together accounted for only nine percent of the variance in process skill achievement.

This study also aims to compare acquisition of science process skill, focusing on integrated science process skill and science achievement using item response theory. The relationship between students' acquisition of integrated process skills and their ability to acquire science knowledge, that is, achievement in science was also examined.

Methodology

Test of Integrated Science Process (TISP)

This instrument, TISP measures how competent students are in the processes of science. Science process skills are not subject specific. However, these skills operate in conjunction with specific knowledge. There has to be a task, some information to be absorb or a problem to solve so that these skills can be applied. The TISP developed in this study purports to be specific to the science content defined in the Malaysian school science curriculum. The items contain conceptual materials on science as well as requiring the application of component integrated process skills. The objective of the test is the evaluation of process skills that are related to the science content. The Test of Integrated Process Skill II by Burns, Okey & Wise (1985) was non-curriculum specific and is not suitable to be adopted for this study.

Clearly, it is not valid to assess process skills in tasks which require conceptual understanding not available to the student. It is important to assess process skills only in relation to content where the conceptual understanding will not be an obstacle to using process skills (Harlen, 1999). With this in mind, TISP was constructed specific to the science content defined in the Malaysian school science curriculum. The items in TISP contain conceptual materials on science as well as requiring the application of component integrated process skills. The objective of the test is the evaluation of process skills that are related to the science content.

The researcher, with the help of a chemistry teacher and a biology teacher, developed a collection of objective test items that met the criterion of face validity. The development of test items followed the normal procedure of writing and revising with the input of expert opinion, until the researchers were confident that the retained items exhibited face validity. As some of the tasks involve fairly complex situations, which require elaborate description. The text rich item may become difficult as the examinees may encounter problems of comprehension and interpretation which changes the purpose of the test. To make the test free of the confounding factor of reading ability, items and items distracters have supplementary visual illustrations such as diagrams, tables to help in the clarification of ideas.

TISP is a multiple-choice written test. The use of written tasks for assessing science process skills enable more questions, covering a range of subject-matter, can be asked more quickly and reduce the problem of bias (Harlen, 1999). Therefore, a decision was made to utilize a paper-and-pencil group testing format. The purpose of the TISP was skill evaluation. The items were based on concept and principles of science knowledge which are assumed to be familiar to Form IV students. This will not confound skill performance with the students' background.

Besides assessing application of science process skills, answering test items required conceptual understanding of science content as well. The construct being measured is confounded by knowledge of science content. As such, response format, reading level, and item context were important consideration considered in developing TISP. In addition, four criteria guided the development of the TISP:

1. Items were referenced to specific integrated science process related to planning an investigation
2. Multiple opportunities were provided to demonstrate competency for each process
3. Items were based on the review science program for secondary schools
4. The test was to be suitable for group administration within 40 minutes

The integrated science processes selected for testing are those associated with planning investigations. They include formulating hypotheses, operationally defining variable, identifying and controlling variables, design suitable experiment as well as interpreting data. The TISP consisted of 36 multiple-choice items with 16 on controlling variables, three on interpreting data, seven on formulating hypotheses, three on designing experiment and seven on operationally defining variable. 12 items of multiple-choice questions were generated for each of the science area; biology, physics and chemistry. The number of item for each component integrated process skills are listed in Table 1.

Table 1: Number of items for each component of integrated process

Process Skill	Item Number	Number of Items
Formulating Hypotheses	4, 9, 14, 20, 25, 32, 35	7
Controlling Variables	1,2,3,5,6,11,15,16,18,19,24,26,28,29,31,34	16
Defining Operationally	8, 12, 13, 17, 23, 27, 30	7
Interpreting Data	7, 22, 33	3
Design Experiment	10, 21, 36	3

For the purpose of content validation and critique, three experienced science educators reviewed the initial test draft. For each item the reviewers were asked to indicate the following: (a) the correct answer, (b) the process skill to which the item was keyed, and (c) suggestion for modifications where appropriate

Science Achievement Test (SAT)

The second instrument, SAT consists of 30 items. There are 10 items each for biology, physics and chemistry. These items required recalled and understanding of the science concepts and principles as well as application of the science knowledge which required higher cognitive levels. Science content knowledge in the SAT items are those required in the TISP.

Sample

Ten secondary schools of different locations, both rural and urban were selected randomly from Penang and Perak. There were Five schools from Perak and five schools from Penang involved in this study. For each school chosen, 2 intact classes were randomly administered the tests. The average number of students from each school is about 60. This method of sampling was done to help in controlling the factor of teaching method and teachers' characteristics. Some science teachers did not emphasized on the acquisition of integrated science process in their classroom activities. The subjects involved were all Form IV students who had undergone the revised science syllabus. Altogether 609 students sat for the TISP and 611 students took the SAT test. Due to some students did not complete both tests, their responses were not used in the final analysis. Finally, a total of 575 students' responses for each test were analysed. It is important to select a sample that has undergone the program and was familiar with the terminology used. All subjects of this study had been given focused instruction on integrated process skills under the review science curriculum which required the systematic teaching of integrated science processes.

Validating TISP

The preliminary version of the TISP was pilot tested and administer to a group of pre-service secondary school science teachers. The respondents consisted of 85 chemistry major and 21 physics major 3rd year B. Sc. Education students. The test was administered at the beginning of the semester during the physics method II and chemistry method II course. These students have learned about the science process skill in the Science method I course. The students were given 40 minutes to complete the test. Data collected was also used to investigate test reliability and validity.

The reliability for the test was provided for by the use of index coefficient of Cronbach Alpha. Item indices were examined for the purpose of item revision. Item analysis was performed in order to determine item difficulty and discrimination. Items with correlation above 0.30 were considered to have a satisfactory power of discrimination.

Administration of Tests

The tests were administered at the end of the school year to ensure that all subjects have undergone approximately one year of learning integrated process skill in the secondary science program. To minimize disruption of teaching in the classes involved and to avoid fatigue as a result of taking two tests successively, the two tests were administered on two different days. As a result, data loss occurred when students were not present to take the second tests or were not present when the first test was administered.

The two tests were administered at two different teaching periods but during the same week. This is to minimize the effect of learning that will occur in between the administration of the two tests. Each test required 40 minutes administration time. The order of administration of TISP and SAT was randomly given to cancel out the effect of familiarity with the content of science in the test items.

Reliability and Validity of TISP

The mean and standard deviation for all students on the 36 items TISP were 23.7 and 3.35 respectively. Score range from 16 to 36. Besides the values for TISP, the mean and standard deviation for each component skill is also included in Table 2.

Table 2: Descriptive statistic of the test and its component skills

	Formulating Hypotheses	Controlling Variables	Defining Operationally	Interpreting Data	Design Experiment	Total test
N	106	106	106	106	106	106
Range	5	10	6	2	3	20
Minimum	2	6	1	1	0	16
Maximum	7	16	7	3	3	36
Mean	4.68	11.23	3.85	2.28	1.70	23.7
Standard Deviation	.97	2.31	1.27	.61	.81	3.35
Skewness	-.14	-.027	.062	-.25	-.17	.253

Reliabilities for the total test and subtests , using Cronbach's alpha , are listed in Table 3. Total test reliability was measured at 0.47.

Table 3: Subtests reliabilities

Subtest	Number of Items	Reliability
Formulating Hypotheses	7	0.04
Controlling Variables	16	0.49
Defining Operationally	7	0.28
Interpreting Data	3	-0.065
Design Experiment	3	0.079
Total Test	36	0.47

Correlations between subtests and total test were computed and shown in Table 4.

Table 4: Correlation between subtests and total test

	Formulating Hypotheses	Controlling Variables	Defining Operationally	Interpreting Data	Total Test
Controlling Variables	-0.035				0.84**
Defining Operationally	-0.23*	0.323*			0.61**
Interpreting Data	-0.23*	-0.02	0.10		0.18
Design Experiment	0.09	0.18	0.23*	0.14	0.48**

- *Correlation is significant at the .05 level (2-tailed)
- ** Correlation is significant at the .01 level (2-tailed)

Indices of item difficulty and item discrimination were computed, using BILOG-MG V3.0, for each item on the TISP. Due to the small sample size, 106, the 2-parameter model is chosen. Guessing was assumed to be zero. Four items, item 4, 20, 33 and 35 with biserial correlation less than -0.15 were not calibrated.

The range of item difficulty indices range from -1.380 (the easiest item, that is, item 27) to 2.320 (the most difficult items, that is, item 22). There were 11 items with item difficulty greater than 1; they are. items 2, 3, 7, 12, 13, 14, 16, 21, 22, 24 and 31. Six items have item difficulty indices less than zero. These are item 11, 18, 23, 27, 30 and 36. However, the item discrimination indices has a smaller range; between 0.252 (item 25) to 1.002 (item 2). 30 of the 36 items have item discrimination > 0.3 which is appropriate for the purpose of the test.

Analysis of Data

The parameter of test items obtained using 2-parameter Item Response Theory was analysed by BILOG-MG. The difficulty estimate for TISP range from -2.73 to 6.36 while for SAT it ranges from -1.17 to 7.50. The mean value and standard deviation is as shown in Table 5.

Table 5: Mean item parameter for TISP and SAT

Parameter	Mean	S.D.
TISP		
Discrimination	0.531	0.32
Difficulty	-0.039	2.108
SAT		
Discrimination	0.539	0.297
Difficulty	0.489	2.19

The ability estimates for all subjects was computed with BILOG-MG for both TISP and SAT. A summary of the ability distribution for the two tests is given in Table 6. The mean value for TISP is found to be slightly higher than that of SAT. The distribution for TISP was negatively skew while SAT has a more symmetrical distribution. This indicated the majority of the ability for TISP is at the upper end of the distribution. Both the ability distributions for TISP and SAT have negative kurtosis values, suggesting that the distributions are platykurtic. The ability calibrated spread out across most of the scale with TISP spread over a bigger range as evidence from the minimum and maximum values obtained.

Table 6: Descriptive statistics for ability in TISP and SAT

Statistics	TISP ability	SAT ability
Mean	.0065	.0044
S.D.	.8992	.9239
Skewness	-.322	.090
Kurtosis	-.136	-.579
Minimum	-2.50	-2.28
Maximum	2.21	2.24

To classify the subjects to the different ability levels with average of ability as logit of zero, the number of subjects as well as percentage in each category is as shown in Table 3. For both TISP and SAT, the majority of the ability range clustered around the mean ability of zero; 72.6% for TISP and 70.5% for SAT. Most of the subjects are not proficient in the Integrated process skills, only 12.4% are above the logits of 2. As for the science knowledge, it is slightly better, with 13.9% considered as proficient in science. 15% were considered as weak in the integrated science process skills, and 15.7% as not mastering the science content.

Table 3: Ability Levels for TISP and SAT

Ability Levels θ in logits	TISP	SAT
θ>2.0	3 (0.5%)	7 (1.2%)
2.0 > θ >1.0	69 (11.9%)	73 (12.7%)
1.0 > θ >0.0	237 (41.2%)	206 (35.8%)
0.0 > θ >-1.0	180 (31.4%)	199 (34.6%)
-1.0 > θ >-2.0	72 (12.6%)	86 (15%)
-2.0 > θ	14 (2.4%)	4 (0.7%)
N	575	575

To determine the relationship between students' science process ability and science achievement, Pearson correlation coefficient is computed and was found to be 0.51. This showed that there is a moderate relationship between science process skills and science achievement

To assess whether there is a statistically significant difference between means ability in TISP and SAT, the paired t-test is used. The value of t (574) =-0.056 is not significant at the 0.05 level. This indicated that competency in Integrated science process skill is not higher than the science achievement even though students have been learning these skills in all the three disciplines of science; that is, physics. chemistry and biology.

Regression analysis was run to determine whether integrated science process skill can be a good predictor of the science achievement. It was found that R^2=0.26, this mean it accounts for 26% of performance in science achievement. However, the value of t = 14.2 was found to be significant at p= 0.01. The regression equation can be represented as: SAT = 0.52 TISP + 0.001

Discussion and Conclusions

The intent of this paper is to develop an instrument to measure integrated science process skill achievement with referenced to the Malaysian science curriculum. The

TISP constructed seem to be a reasonably good measure of integrated science process skill which is necessary in conducting scientific investigations. Findings from the analysis showed that improvement is still needed for two of the test items to ensure instrument is reliable and useful. However, this instrument may be limited in its usage as it is specific to the Malaysian science curriculum.

Integrated science process skills are important for students to use the inquiry-centered process to learn the content of science knowledge. These help development of mental habits that are essential for the inquiry process and built on to prepare students for a realistic view of science. Educators promoting content and the inquiry process as the essence of learning science believe firmly that this combined approach in the early years will make a significant contribution to improving scientific awareness in later life.

Even though students learned these abilities repeatedly in the three disciplines of science; biology, physics and chemistry but in the context of the respective content area. The results of this study however showed that there is no significant difference between students' competency in integrated science process skill compared to science achievement. This may be due to science process skill are broad transferable abilities which may not help in ensuring acquisition of content knowledge. A statement of caution here is that competency of integrated science process skills in this study is not measured directly, that is where students are required to demonstrate in hands-on experiment or investigation. Instead the learners are asked to select from a list of choices in stating the hypothesis, define operationally and identify variables. In this case, indirect assessment has the obvious advantages of efficiency. However, the written test may not tell if learners would be able to display the process skill when required. Study has been carried out to teach all of these skills involve in conducting experiment (Padilla, Okey and Garrard, 1984). Their results indicated that these complex process skills cannot be learned via a two weeks unit in which science content is typically taught. Rather, experimenting abilities need to be practiced over a period of time.

In line with the emphasis of the teaching of integrated process skills for the secondary school science curriculum, the Malaysian Examination Board has revamped the standardized tests. Beginning with the year 2003, the assessment of integrated process skill in a written format is introduced in the public examination besides the school based laboratory assessment (Lembaga Peperiksaan Malaysia, 2002). Items in the written test required students to plan and design an investigation that involves the use of all the integrated process skills. To answer items correctly, students must possess all components of integrated process skill as well as knowledge in science. Students who are weak in the content area may not be able to apply these skills. The result of this study showed that mastery of the Integrated Science Process Skill, however, does not ensure acquisition of scientific knowledge. This implied that the teaching of content must take precedent over the training of students on the acquisition of science process skills.

For students to demonstrate the integrated process skills, assessment using hands-on procedures to determine skill acquisition by groups of students is also carried out in the Malaysian science curriculum. This has being implemented by the practical work, which is known as PEKA. The problem of using such procedure can be a burdensome task to teachers as it is common to have 40 or so students per class in the science classrooms. Though, it has been criticized that objective test may be insufficient

TISP constructed seem to be a reasonably good measure of integrated science process skill which is necessary in conducting scientific investigations. Findings from the analysis showed that improvement is still needed for two of the test items to ensure instrument is reliable and useful. However, this instrument may be limited in its usage as it is specific to the Malaysian science curriculum.

Integrated science process skills are important for students to use the inquiry-centered process to learn the content of science knowledge. These help development of mental habits that are essential for the inquiry process and built on to prepare students for a realistic view of science. Educators promoting content and the inquiry process as the essence of learning science believe firmly that this combined approach in the early years will make a significant contribution to improving scientific awareness in later life.

Even though students learned these abilities repeatedly in the three disciplines of science; biology, physics and chemistry but in the context of the respective content area. The results of this study however showed that there is no significant difference between students' competency in integrated science process skill compared to science achievement. This may be due to science process skill are broad transferable abilities which may not help in ensuring acquisition of content knowledge. A statement of caution here is that competency of integrated science process skills in this study is not measured directly, that is where students are required to demonstrate in hands-on experiment or investigation. Instead the learners are asked to select from a list of choices in stating the hypothesis, define operationally and identify variables. In this case, indirect assessment has the obvious advantages of efficiency. However, the written test may not tell if learners would be able to display the process skill when required. Study has been carried out to teach all of these skills involve in conducting experiment (Padilla, Okey and Garrard, 1984). Their results indicated that these complex process skills cannot be learned via a two weeks unit in which science content is typically taught. Rather, experimenting abilities need to be practiced over a period of time.

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Some students in this study do not acquired both integrated science process skills and science content knowledge. Further studies may be needed to investigate what actually happens in the science classrooms to shed some light on the effectiveness of the teaching of science program at the secondary school level.

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Senaraikan kata kunci yang mencerminkan penyelidikan anda:
List the key words that reflects your research:

Bahasa Malaysia	*Bahasa Inggeris*
Kemahiran Proses Sains Bersepadu	Integrated Science Process
Pencapaian Sains	Science Achievement
Penilaian	Assessment
Penyiasatan sains	Science Enquiry
Kesahan	Validity

8. **Output dan Faedah Projek**
Output and Benefits of Project

(a) * **Penerbitan Jurnal**
Publication of Journals
(Sila nyatakan jenis, tajuk, pengarang/editor, tahun terbitan dan di mana telah diterbit/diserahkan)
(State type, title, author/editor, publication year and where it has been published/submitted)

Chapter In Research Book
1. **Ong, Saw Lan**. & Zurida Ismail. (2006). Bridging integrated science process skill and science achievement. (pp. 75-84) In H.S. Dhinda et. Al. (Eds.) Shaping the future of science, mathematics and technical education: ETC – Universiti Brunei Darussalam

Papers published in Proceedings for International Conference
1. **Ong, Saw Lan,** Zurida Ismail & Fong, S.F. (2006). Development and Validation of Test for Integrated Science Processes. Proceeding for 3rd International Conference on Measurement and Evaluation in Education. Penang, Malaysia. 13-15 February 2006. pp 149 – 156

2. **Ong, Saw Lan** (2006) Comparing Acquisition of Science Process Skill and Science Achievement Using Modern Test Theory. Proceeding in International Science Education Conference –Singapore, 22-24 November 2006. pp. 642-650

3. **Ong, Saw Lan.** (2006). Assessing Competency in Integrated Science Process Skill and Its Relation with Science Achievement. Proceedings in XII ISOTE Symposium ,30 July – 4 August 2006. pp474-480

Papers published in Proceeding for Local Conference
1. **Ong, Saw Lan**. (2005) Assessing Preservice Science Teachers Competency in Integrated Science Process Skill. Proceedings of National Conference on Skills & Competencies in Education 2005. Penang. 29-30 Novvember, 2005. pp.185-194

Paper presented in International Conference without proceeding
1. Ong, Saw Lan. & Zurida Ismail. (2006). Bridging integrated science process skill and science achievement. Paper presented in Elenth Annual Conference, Sultan Hassanai Bolkiah Institute of Education, Universiti Brunei Darussalam, 22-25 th May 2006

LAMPIRAN

1. Development and Validation of Test for Integrated Science Processes.
2. Comparing Acquisition of Science Process Skill and Science Achievement Using Modern Test Theory.
3. Test of Integrated Science Process
4. Science Achievement Test
5. Assessing Competency in Integrated Science Process Skill and Its Relation with Science Achievement.
6. Bridging integrated science process skill and science achievement.
7. Assessing Preservice Science Teachers Competency in Integrated Science Process Skill.

Paper precented at 3rd International Conference on Measurement and Evaluation in Education. Penang, Malaysia. 13-15 February 2006.

I. Development and Validation of Test for Integrated Science Processes

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Abstract: *This paper describes the development and validation of a Test of Integrated process skills specifically for the Malaysian schools. The test assess student performance on a set of integrated science processes associated with planning investigations. They include formulating hypotheses, operationally defining variable, identifying and controlling variables as well as interpreting data. Science process skills are not subject specific. However, these skills operate in conjunction with specific knowledge. Test items were developed so as to be suitable for use with the Malaysian students. The Test of Integrated Science Process consisted of 36 multiple choice items. Evidence of content validity, construct validity, and reliability are presented. This test with sound psychometric properties will be useful in evaluating the progress in the learning of integrated science process skills.*

Introduction

Science education for primary and secondary schools emphasize the ability of students to use the processes of science. Process skill learning has been included as a component of science curricula. The development of curricula which emphasize the process of science created a need for the development of reliable and valid instruments capable of evaluating achievement in these skills. The research reported here is an attempt to develop an objective test of the integrated processes of science. Reliability and time efficiency are the primary reason for such a test. However, a primary consideration must be validity. The test score must provide an accurate assessment of the student's ability to perform the process in question successfully.

There are several reputable tests available that claim to measure the processes of science. The Individual Competency Measures of Science – A Process Approach (AAAS, 1967), the Processes of Science Test by the Biological Science Curriculum Study Group (1962), and the Test of Science Processes by Tannenbaum (1968) are notable examples. However, all these tests have restricted to face validity. Face validity merely requires that a group of experts in the field agree that an item will measure what it intends to measure. The Individual Competency Measures are probably the most valid of all tests of the science processes because the students must actually perform the process in question under the supervision of a trained observer. However, evaluation of the skills requires individual testing, which pose a problem of time management for the classroom.

A number of paper-and-pencil tests have been developed to assess science process skill (e.g. Tannenbaum, 1968; Fyffe, 1971; Riley, 1972; Robinson, 1973; Ludeman, 1975; Dillashaw & Okey, 1980). Burns (1972) developed a paper and pencil multiple-choice test to measure the acquisition of the integrated science process skills by undergraduate elementary education majors. Other tests that were not curriculum specific were developed by Molitor and George (1976) and Tannenbaun (1968). The Test of Integrated Process Skills (TIPS) developed by Dillashaw and Okey (1980) for a non-curriculum specific process skills test was developed for middle and secondary students. The TIPS was designed to assess the proficiency in the science process skills associated with planning, conducting, and interpreting results from investigations. Collectively these are often referred to as the integrated science processes. These include skills such as formulating hypotheses, operationally defining, controlling, and manipulating variables, planning investigation and interpreting data. Burns, Okey & Wise (1985) revised TIPS and developed TIPS II to measure five component of integrated process skills: that is, identifying variables, identifying and stating hypotheses, operationally defining, designing investigation and graphing and interpreting data. In Malaysia, Ismail and Zurida (1996) translated TIPS II to the Malay language. Zurida reported (1998) that acquisition of Integrated Process Skills was not satisfactory. In a similar study, Nordin (1997) found that less tan 40% of the primary school students showed mastery in the Integrated Process Skills. This may be a result of the content of the item being unsuitable to the Malaysian students.

For students to demonstrate the integrated process science skills, assessment using hands-on procedures to determine skill acquisition by groups of students deem most appropriate. In the Malaysian school science, this is being implemented by the practical work, which is known as PEKA in the school science curriculum. The Ministry of Education required teachers to conduct school base science practical, PEKA, to assess students' acquisition of the science processes. The PEKA assess more nearly actual samples of the kind of behavior in the integrated science process skills. Yet, the administration of the PEKA, which requires students to actually performed the task concerned has the same problems like the Individual Competency Measures, are very time consuming and require a trained observer. The problem of using such procedure can be a burdensome task to teachers as it is common to have 40 or so students per class in the science classroom. Besides, the question of reliability and validity of such big scale assessment is of big concern. Thus science teachers need a means of measuring process skill competency that can be administered efficiently and objectively. Therefore, a decision was made to utilize a paper-and-pencil group testing format.

In line with the emphasis of the teaching of integrated process skills for the secondary school science curriculum, the Malaysian Examination Board has revamped the standardized tests. Beginning with the year 2003 (Ministry of

Education, 2002), the assessment of integrated process skill in a written format is introduced in the public examination besides the school based laboratory assessment, PEKA. Items in this test required students to plan and design an investigation which involves the use of all the integrated process skills in science. To answer items correctly, students must possess all components of integrated process skill as well as knowledge in science. Students who are weak in the content area may not be able to apply these skills at all. A test which can measure each component skill will provide better understanding on students' acquisition of the integrated process skills.

Purpose of the Study

The purpose of this study is to develop a test that will assess components of integrated process skills separately. This will prevent the occurrence of non-mastery of certain skills that hamper students from demonstrating other skills that they already knew. Test items which can assess each component of the integrated process skills with different test items will be useful for diagnostic purposes. Teachers can use this test to identify weaknesses and strength of the components integrated process skill for a student. According to Gagne (1968), processes of science are the strategies, the behavioral capabilities, the psychological process used by the individual to deal with the content. Information obtain may be useful to help teachers in designing instructional plan and sequencing instruction effectively in the teaching and learning of science.

Beside, the use of objective pencil-and-paper test items will have both cost and time efficiency. Though, it has been criticized that objective test may be insufficient to demonstrate a student's actual ability to perform the processes of science. When a test item is constructed, a student may not be able to abstract from the real situation.

Test of Integrated Science Process (TISP)

This instrument, TISP will measure how competent students are in the processes of science. Science process skills are not subject specific. However, these skills operate in conjunction with specific knowledge. There has to be a task, some information to be absorb or a problem to solve so that these skills can be applied. The TISP develop in this study purports to be specific to the science content defined in the Malaysian school science curriculum. The items contain conceptual materials on science as well as requiring the application of component integrated process skills. The objective of the test is the evaluation of process skills that are related to the science content. The Test of Integrated Process Skill II by Burns, Okey & Wise (1985) was non-curriculum specific and is not suitable to be adopted for this study.

The researcher, with the help of a chemistry teacher and a biology teacher, developed a collection of objective test items that met the criterion of face validity.

36 items were constructed altogether for the test. 12 items of multiple-choice questions were generated for each of the science area; biology, physics and chemistry. The integrated science processes selected for testing are those associated with planning investigations. They include formulating hypotheses, operationally defining variable, identifying and controlling variables, design suitable experiment as well as interpreting data. The number of item for each component integrated process skills are listed in Table 1.

Table 1: Number of items for each component of integrated process

Process Skill	Item Number	Number of Items
Formulating Hypotheses	4, 9, 14, 20, 25, 32, 35	7
Controlling Variables	1,2,3,5,6,11,15,16,18,19,24,26,28,29,31,34	16
Defining Operationally	8, 12, 13, 17, 23, 27, 30	7
Interpreting Data	7, 22, 33	3
Design Experiment	10, 21, 36	3

The development of test items followed the normal procedure of writing and revising with the input of expert opinion, until the researchers were confident that the retained items exhibited face validity. As some of the tasks involve fairly complex situations, which require elaborate description. The text rich item may become difficult as the examinees may encounter problems of comprehension and interpretation which changes the purpose of the test. To make the test free of the confounding factor of reading ability, items and items distracters have supplementary visual illustrations such as diagrams, tables to help in the clarification of ideas.

Besides assessing application of science process skills, answering test items required conceptual understanding of science content as well. The construct being measured is confounded by knowledge of science content. As such, response format, reading level, and item context were important consideration considered in developing TISP. In addition, four criteria guided the development of the TISP:

1. Items were referenced to specific integrated science process related to planning an investigation
2. Multiple opportunities were provided to demonstrate competency for each process
3. Items were based on the review science program for secondary schools
4. The test was to be suitable for group administration within 40 minutes

An initial draft of the TISP consisted of 36 multiple-choice items. 16 on controlling variables, 3 on interpreting data, 7 on formulating hypotheses, 3 on designing experiment and 7 on operationally defining variable. For the purpose of content validation and critique, three experienced science educators reviewed the initial test draft. For each item the reviewers were asked to indicate the following: (a) the correct answer, (b) the process skill to which the item was keyed, and (c) suggestion for modifications where appropriate

Data Collection

The preliminary version of the TISP was pilot tested and administer to a group of pre-service secondary school science teachers. The respondents consisted of 85 chemistry major and 21 physics major 3rd year B. Sc. Education students. The test was administered at the beginning of the semester during the physics method II and chemistry method II course. These students have learned about the science process skill in the Science method I course. The students were given 40 minutes to complete the test. Data collected was also used to investigate test reliability and validity.

The reliability for the test was provided for by the use of index coefficient of Cronbach Alpha.

Item indices were examined for the purpose of item revision. Item analysis was performed in order to determine item difficulty and discrimination. Items with correlation above 0.30 were considered to have a satisfactory power of discrimination.

Results

The mean and standard deviation for all students on the 36 item TISP were 23.7 and 3.35 respectively. Score range from 16 to 36. Besides the values for TISP, the mean and standard deviation for each component skill is also included in Table 2.

Table 2: Descriptive statistic of the test and its component skills

	Formulating Hypotheses	Controlling Variables	Defining Operationally	Interpreting Data	Design Experiment	Total test
N	106	106	106	106	106	106
Range	5	10	6	2	3	20
Minimum	2	6	1	1	0	16
Maximum	7	16	7	3	3	36
Mean	4.68	11.23	3.85	2.28	1.70	23.7
Standard Deviation	.97	2.31	1.27	.61	.81	3.35
Skewness	-.14	-.027	.062	-.25	-.17	.253

Reliabilities for the total test and subtests, using Cronbach's alpha, are listed in Table 3. Total test reliability was measured at 0.47.

Table 3: Subtests reliabilities

Subtest	Number of Items	Reliability
Formulating Hypotheses	7	0.04
Controlling Variables	16	0.49
Defining Operationally	7	0.28
Interpreting Data	3	-0.065
Design Experiment	3	0.079
Total Test	36	0.47

Correlations between subtests and total test were computed and shown in Table 4.

Table 4: Correlation between subtests and total test

	Formulating Hypotheses	Controlling Variables	Defining Operationally	Interpreting Data	Total Test
Controlling Variables	-0.035				0.84**
Defining Operationally	-0.23*	0.323*			0.61**
Interpreting Data	-0.23*	-0.02	0.10		0.18
Design Experiment	0.09	0.18	0.23*	0.14	0.48**

- *Correlation is significant at the .05 level (2-tailed)
- ** Correlation is significant at the .01 level (2-tailed)

Indices of item difficulty and item discrimination were computed, using BILOG-MG V3.0, for each item on the TISP. Due to the small sample size, 106, the 2-parameter model is chosen. Guessing was assumed to be zero. Four items, item 4, 20, 33 and 35 with biserial correlation less than -0.15 were not calibrated. Table 5 shows the indices of the rest of the 32 items sorted according to item difficulty.

Table 5: Item indices of the test items

Item Number	Item Difficulty	Item Discrimination
27	-1.380	0.408
30	-0.624	0.286
18	-0.564	0.281
36	-0.449	0.290
11	-0.421	0.399
23	-0.077	0.489
5	0.003	0.361
10	0.098	0.384
8	0.204	0.419
26	0.238	0.298
17	0.366	0.308
29	0.469	0.293
6	0.639	0.477
1	0.681	0.328
25	0.754	0.252
32	0.827	0.371
9	0.845	0.324
34	0.853	0.416
15	0.926	0.429
19	0.965	0.510
28	0.97	0.518
16	1.038	0.318
21	1.038	0.412
3	1.064	0.751
24	1.066	0.468
2	1.231	1.002
12	1.283	0.424
7	1.359	0.626
13	1.370	0.369
14	1.512	0.381
31	1.517	0.501
22	2.329	0.536
Mean	0.63	0.43

The range of item difficulty indices range from -1.380 (the easiest item, that isitem 27) to 2.320 (the most difficult items, that is, item 22). There were 11 items with item difficulty greater than 1; they are. item 2, 3, 7, 12, 13, 14, 16, 21, 22, 24 and 31. Six items have item difficulty indices less than zero. Theses are item 11, 18, 23, 27, 30 and 36. However, the item discrimination indices has a smaller range; between 0.252 (item 25) to 1.002 (item 2). 30 of the 36 items have item discrimination > 0.3 which is appropriate for the purpose of the test.

An analysis of the options chosen by students is shown in Table 6.

Table 6: Analysis of response of students

	Options						Options				
Item	A	B	C	D	Omit	Item	A	B	C	D	F
1	17	0	79*	10	0	19	15	85*	5	1	0
2	8	84*	3	11	0	20	0	0	106*	0	0
3	2	18	84*	2	0	21	88*	3	1	13	0
4	68	3	5	30*	0	22	103*	1	0	2	0
5	6	8	53*	39	0	23	36	1	50*	18	0
6	76*	16	14	0	0	24	88*	9	4	3	2
7	2	7	92*	5	0	25	2	19	3	82*	0
8	61*	21	8	16	0	26	63*	8	3	32	0
9	8	10	84*	4	0	27	24	21	12*	49	0
10	20	57*	23	6	0	28	2	85*	3	16	0
11	37*	7	51	11	0	29	5	5	24	72*	0
12	1	3	9	93*	0	30	52	8	29*	17	0
13	95*	1	8	2	0	31	6	3	1	96*	0
14	0	9	97*	0	0	32	83*	8	13	2	0
15	5	1	15	85*	0	33	47*	10	6	42	1
16	0	89*	14	3	0	34	19	83*	1	3	0
17	9	68*	22	6	1	35	14*	84	1	7	0
18	16	27	31*	31	1	36	29	35*	30	12	0

The distracters in item 20 are not functioning as all students provide the correct answers. The distracter 'B' in items 35 has attracted the response from most of the students. Theses two questions need to be review and rewrite for its intended purpose.

Conclusions

The purpose of this paper is not to make inferences about pre-service teachers competency levels of science process skills. However, the scores reflect students' abilities in this skill in all content areas of science in biology, physics and chemistry. The intent of this paper is to develop an instrument to measure integrated science process skill achievement with referenced to the Malaysian science curriculum. The TISP constructed seem to be a reasonably good measure of integrated science process skill which is necessary in conducting scientific investigations. Findings from the analysis showed that improvement is still needed for two of the test items to ensure instrument is reliable and useful. However, this instrument may be limited in its usage as it is specific to the Malaysian science curriculum.

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2. Comparing Acquisition of Science Process Skill and Science Achievement Using Modern Test Theory

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Abstract: The science process skills, along with the knowledge those skills produce has been the instructional objectives of science education today. Unfortunately, the teaching and learning of science does not always reflect the expectation of the curriculum. Very often, science instruction inside the science classrooms merely cover vast amounts of abstract science contents. With the emphasis on acquisition of science process, some teachers concentrated on the teaching of these skills while ignoring the content of science. This study aims to investigate development in the process skills with relation to science achievement among secondary school students. The Test of Integrated Science Process, a paper-and-pencil objective test that has been developed specific to the science content defined in the Malaysian school science curriculum is used to measure acquisition in the processes of science. However, science process skills are subjects specific. These skills operate in conjunction with specific knowledge. Items in the Test of Integrated Science Process contain conceptual materials on science as well as requiring the application of component integrated process skills. An objective science test that required application of the science concepts in the Test of Integrated Science Process is used to assess science academic achievement. Students' ability in science process skills and science content knowledge is calibrated using BILOG-MG based on the Item Response Model. These measures obtained is compared using a scatter plot. The psychometric properties of these two tests were compared to assess difficulty of the tests. Performance in Science Process Skill and Achievement is compared based on the ability calibrated for respondents.

Background

Good science teaching is defined as that geared toward developing an attainable form of high scientific literacy (Anderson 1987). To be scientifically literate, a person needs to have knowledge of concepts and theories of science, and, in addition, to have some understanding of how this knowledge has been obtained in the past and is still being learned today.

With the rapid advance in knowledge and technology, the goal for science education (Rezba et. al, 1995) in the nineties and beyond, stress science as ways of thinking and investigating as well as a body of knowledge. Padilla (1990) called these ways of thinking in science as the process skills. Other terms such as the scientific method, scientific thinking and critical thinking are terms used at various times to describe these skills. Today the term "science process skills" is most commonly used. Science educators (Gagne, 1965) have argued that acquisition of the science process skills should be a major goal of science instruction as most curricula also aim to develop students' ability of the scientific approach to enquiry

Science process skills are defined as an understanding of methods and procedures of scientific investigation (Bilgin, 2006). Harlen (1999) described science process skills include abilities relating to identifying investigable questions, designing investigations, obtaining evidence, interpreting evidence in terms of the question in the inquiry, and communicating the investigation process. Process skill learning has become an important component of science curricula at all levels. Acceptance of this view is reflected in curricula developed in recent years with an emphasis on the science process skills. Although science process skill has been introduced in the United States since 1960s, it was not given much emphasis in Malaysia. During the nationwide science curriculum review in the year 2002 for both primary and secondary schools (Kementerian Pendidikan Malaysia, 2001), explicit teaching of the science process skill was necessary with an introduction of a paper-and-pencil test to assess acquisition of these skill (Lembaga Peperiksaan Malaysia, 2002).

The Importance of Integration Science Process Skills

Science – A Process Approach (SAPA) grouped process skills into two types - basic and integrated (Livermore, 1964). The basic science process skills provide a foundation for learning the more complex integrated science process skills (Padilla, 1990). Processes such as observing, classifying and recording data, which are typically taught in elementary grades (primary schools), act as prerequisites for integrated processes. Examples of integrated science include skills such as formulating hypotheses, operationally defining, controlling, and manipulating variables, planning investigations, and interpreting data (Livermore, 1964).

Many science curriculum guides and textbooks have cited important outcomes on the acquisition of integrated science process skills. These processes are rooted in the simple processes and seem necessary to the aim of acquiring a scientific approach to knowledge. This is because process skills represent the rational and logical thinking skills used in science. These process skills are intellectual skills used in collecting and analyzing data so as to solve problems. Students can use process skills to formulate responses to questions, to justify points of view, to explain events or procedures, and to interpret or describe data.

The modern science curriculum includes what scientists have found out (content) and what they do to find out (process). Concepts, explanations, understanding, and theories constitute the content of science. Through science process skills, scientists collect knowledge, put experiments together, analyse data, and formulate results (Bilgin, 2006). Some science educators have argued that the scientific approach to enquiry can be thought of as a set of science process skills. The process skill approach (Chiappetta & Koballa, 2002) is argued as one teaching method that could be employed by teachers in the effort to teach science as inquiry. This is because science process skills are very important for meaningful learning; to find, interpret, and judge evidence under different conditions. Therefore, it is essential for students to be provided with science process skills (Harlen, 1999).

The process skill approach focuses on teaching broadly transferable abilities that are appropriate to many science disciplines and are reflective of the behavior of scientists (Padilla, 1990). Chiappetta (1997) states that "the acquisition and frequent use of theses skills can better equip students to solve problems, learn on their own, and appreciate science". Science process skills have been portray as a set of discrete 'thinking skills', which can be practiced and developed separately before being combined to tackle more demanding problems.

Related Research

Several studies have investigated on the learning of integrated science process skills. Studies have been conducted which dealt with student acquisition of integrated science process skills (Renner & Weber, 1972; Boyer & Linn, 1978; Allen, 1973; Linn & Their, 1975) in relation to other variables. Tobin and Capie (1982a) found a significant inter-correlation (r =0.60) between formal reasoning ability and process skill achievement. Padilla, Okey and Dillashaw (1983) showed that they are closely related to the formal thinking abilities described by Piaget. In fact one of the ways that Piaget decided whether someone was formal or concrete was to ask that person to design an experiment to solve a problem. Tobin & Capie (1982a) found that formal reasoning was the strongest predictor of process skills outcomes. Their finding underscores the importance of formal reasoning to achievement in science. A study on the relationship between the logical thinking skills and the integrated science process skill of high school students in North Carolina and Japan was carried out by Mattheis et al. (1992). A moderately strong and almost identical correlation was found to exist between the reasoning skills as measured by the GALT test and integrated process skills as measured by the TIP II test for each sample.

Research studies showed that there were positive relationships between the students' science process skills and their achievement in science (Bybee, 2000; Padilla, 2004). Further study of process skills by Doran & Sellers (1978) investigated relationships between students' mental ability, gender, biology achievement and science process achievement. The achievement measures contained items on experimenting, predicting, and concluding. The authors reported that mental ability was related to the process achievement. The relationship was not strong, however, as biology achievement and mental ability together accounted for only nine percent of the variance in process skill achievement.

Problem Statements

The science process skills, along with the knowledge those skills produce, and the scientific values and habits of mind define the nature of science. Science includes both the process of inquiry about natural phenomena and the content derived there from. Unfortunately, the teaching and learning of science does not always reflect the true nature of science. Most science lessons emphasized either science content or science processes. Before the emphasis of science processes in the curriculum, most teachers view of science education as being concerned only with the development of scientific concepts and knowledge (Tobin et al., 1990). Students memorise scientific laws and knowledge to pass examination. At the end of the science programs, students merely possess chunks of discrete science knowledge.

Some science educators, however, have argued that explicit teaching about the methods of science is necessary and have the opinion that an understanding of science processes (or science method) is more important than the knowledge content (Millar,1990). With the emphasis on the science process skill, some teachers now practice science education where the process of doing science becomes almost the sole focus. Science learning was primarily in terms of the development of pupils' process skill. They did not realize that the process is the tool through which knowledge is acquired, but it alone is not science (Hinman, 1998). Though the major thrust of the science program is to develop the pupil's skills in using science processes, science content should not be neglected. While it is true that without processes, the content of science would become static or even decay. The content of science is the accumulated and ever-expanding body of knowledge in any discipline to which scientific inquiry can be applied. By overemphasizing process, teachers may not be preparing students properly for continuing science learning to the higher level. According to Livermore (1964), both the processes as well as content are important. Students use science process to learn science content. The integrated process skills are involved when conducting investigation or experiments; formulating a hypothesis, identify and control variables in designing an experiment, and making generalizations after collecting data. (Padilla & Okey, 1983).

The National Science Educational Standards (National Research Council, 1996) also emphasize the importance of scientific content when it states, "An essential aspect of scientific literacy is greater knowledge and understanding of science subject matter" (p21). In fact not all science knowledge can be learned through the process approach. A good part of the content of science, especially in the higher grade, must be learned through more traditional methods such as lectures, textbooks, and systematic memorization. The factual and conceptual content is so rich that just to understand it, not to mention master it, requires rigorous, intensive study.

Students' ability to use process skills depend on the extent of their knowledge of the contexts they are asked to work on (Millar, 1990). This is explained by the finding (Song and Black, 1991; Lock, 1993) that performance of tasks requiring these process skills is strongly content-dependent. There is a problem of how to integrate content and process of science. Science process skills always exercised in relation to some science content, and have a crucial role in the development of learning with understanding (Harlen, 1999). Teachers need to capitalize on opportunities in the activities normally done in the science classroom to emphasize science process skills. Students conducting these activities are expected to develop such skills as stating hypotheses, operationally defining variables, designing investigations, and interpreting data in addition to mastering the content of the courses.

There has been claimed that exposure to a systematic science program which emphasis integrated science process promotes cognitive development. With the implementation of the new science curricula which emphasize the teaching of science process skills systematically in both the primary as well as the secondary schools, integrated science processes became the instructional objectives in the Malaysian secondary schools science program. Science educators should be aware of the important aspects of students' competency levels in integrated process skills and their abilities in using these integrate process skills to obtain science knowledge. As such, data is needed to provide information regarding students' development of the process skills in relation to science academic achievement.

Objectives of The Study

This study aims to compare acquisition of science process skill, focusing on integrated science process skill and science achievement using item response theory. The relationship between students acquisition of integrated process skills and their ability to acquire science knowledge, that is, achievement in science was also examined.

Methodology

Instruments

Two instruments were used to collected data for the study. The Test of Integrated Science Process (TISP) is used to determine students' ability in the processes of science. Science process skills are not subject specific. However, these skills operate in conjunction with specific knowledge. There has to be a task, some information to be absorbed or a problem to solve so that these skills can be applied. The performance in any task involving the skills will be influenced by the nature of the subject content as well as the ability to use the skill. Clearly, it is not valid to assess process skills in tasks which require conceptual understanding not available to the student. It is important to assess process skills only in relation to content where the conceptual understanding will not be an obstacle to using process skills (Harlen, 1999). With this in mind, TISP was constructed specific to the science content defined in the Malaysian school science curriculum (Ong, Zurida & Fong, 2006). The items in TISP contain conceptual materials on science as well as requiring the application of component integrated process skills. The objective of the test is the evaluation of process skills that are related to the science content.

TISP is a multiple-choice written test. The use of written tasks for assessing science process skills enable more questions, covering a range of subject-matter, can be asked more quickly and reduce the problem of bias (Harlen, 1999). The integrated science processes selected for testing are those associated with planning investigations. They include formulating hypotheses, operationally defining variable, identifying and controlling variables as well as interpreting data. There were altogether 36 multiple-choice items for TISP. Seven of the items were on formulating hypotheses, 16 items were about controlling variables, seven items were defining variables operationally, three items were about interpreting data and three more items were on designing experiment.

Therefore, a decision was made to utilize a paper-and-pencil group testing format. The purpose of the TISP was skill evaluation. The items were based on concept and principles of science knowledge which are assumed to be familiar to Form IV students. This will not confound skill performance with the students' background.

The second instrument, Science Achievement Test (SAT) consisted of 30 items. There were 10 items each for biology, physics and chemistry. These items required recalled and understanding of the science concepts and principles as well as application of the science knowledge which required higher cognitive levels. Science content knowledge in the SAT items are those required in the TISP.

Sample

Ten secondary schools of different locations, both rural and urban were selected randomly from Penang and Perak. There were Five schools from Perak and five schools from Penang involved in this study. For each school chosen, 2 intact classes were randomly administered the tests. The average number of students from each school is about 60. This method of sampling was done to help in controlling the factor of teaching method and teachers' characteristics. Some science teachers did not emphasized on the acquisition of integrated science process in their classroom activities. The subjects involved were all Form IV students who had undergone the revised science syllabus. Altogether 609 students sat for the TISP and 611 students took the SAT test. Due to some students did not complete both tests, their responses were not used in the final analysis. Finally, a total of 575 students' responses for each test were analysed. It is important to select a sample that has undergone the program and was familiar with the terminology used. All subjects of this study had been given focused instruction on integrated process skills under the review science curriculum which required the systematic teaching of integrated science processes.

Administration of Tests

The tests were administered at the end of the school year to ensure that all subjects have undergone approximately one year of learning integrated process skill in the secondary science program. To minimize disruption of teaching in the classes involved and to avoid fatigue as a result of taking two tests successively, the two tests were administered on two different days. As a result, this causes data loss when students were not present to take both tests.

The two tests were administered at two different teaching periods but during the same week. This is to minimize the effect of learning that will occur in between the administration of the two tests. Each test required 40 minutes administration time. The order of administration of TISP and SAT was randomly given to cancel out the effect of familiarity with the content of science in the test items.

Analysis of Data

The parameter of test items obtained using 2-parameter Item Response Theory as analysed by BILOG-MG. The difficulty estimate for TISP range from -2.73 to 6.36 while for SAT it ranges from -1.17 to 7.50. The mean value and standard deviation is as shown in Table 1.

Table 1
Mean item parameter for TISP and SAT

Parameter	Mean	S.D.
TISP		
Discrimination	0.531	0.32
Difficulty	-0.039	2.108
SAT		
Discrimination	0.539	0.297
Difficulty	0.489	2.19

The ability estimates for all subjects was computed with BILOG-MG for both TISP and SAT. A summary of the ability distribution for the two tests is given in Table 2. The mean value for TISP is found to be slightly higher than that of SAT. The distribution for TISP was negatively skew while SAT has a more symmetrical distribution. This indicated the majority of the ability for TISP is at the upper end of the distribution. Both the ability distributions for TISP and SAT have negative kurtosis values, suggesting that the distributions are platykurtic. The ability calibrated spread out across most of the scale with TISP spread over a bigger range as evidence from the minimum and maximum values obtained.

Table 2
Descriptive statistics for ability in TISP and SAT

Statistics	TISP ability	SAT ability
Mean	.0065	.0044
S.D.	.8992	.9239
Skewness	-.322	.090
Kurtosis	-.136	-.579
Minimum	-2.50	-2.28
Maximum	2.21	2.24

To classify the subjects to the different ability levels with average of ability as logit of zero, the number of subjects as well as percentage in each category is as shown in Table 3. For both TISP and SAT, the majority of the ability range clustered around the mean ability of zero; 72.6% for TISP and 70.5% for SAT. Most of the subjects are not proficient in the Integrated process skills, only 12.4% are above the logits of 2. As for the science knowledge, it is slightly better, with 13.9% considered as proficient in science. 15% were considered as weak in the integrated science process skills, and 15.7% as not mastering the science content.

Table 3
Ability Levels for TISP and SAT

Ability Levels θ in logits	TISP	SAT
θ>2.0	3 (0.5%)	7 (1.2%)
2.0 > θ >1.0	69 (11.9%)	73 (12.7%)
1.0 > θ >0.0	237 (41.2%)	206 (35.8%)
0.0 > θ >-1.0	180 (31.4%)	199 (34.6%)
-1.0 > θ >-2.0	72 (12.6%)	86 (15%)
-2.0 > θ	14 (2.4%)	4 (0.7%)
N	575	575

To determine the relationship between students' science process ability and science achievement, Pearson correlation coefficient is computed and was found to be 0.51. This showed that there is a moderate relationship between science process skills and science achievement as demonstrated by the scatter plot.

Science Achievement against Integrated Science Process Skills

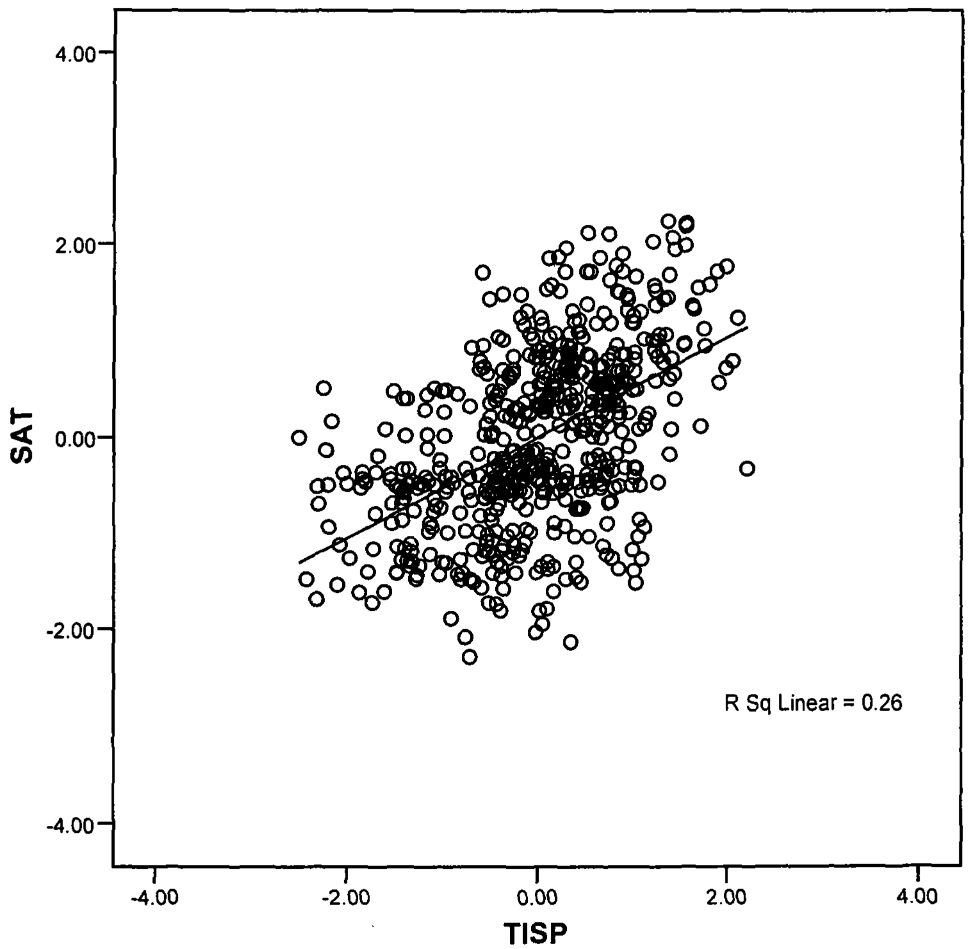


Figure 1 Scatter plot of science achievement and integrated science process skill

To assess whether there is a statistically significant difference between means ability in TISP and SAT, the paired t-test is used. The value of t (574) =-0.056 is not significant at the 0.05 level. This indicated that competency in Integrated science process skill is not higher than the science achievement even though students have been learning these skills in all the three disciplines of science; that is, physics. chemistry and biology.

Regression analysis was run to determine whether integrated science process skill can be a good predictor of the science achievement. It was found that R^2=0.26, this mean it accounts for 26% of performance in science achievement. However, the value of t = 14.2 was found to be significant at p= 0.01. The regression equation can be represented as: SAT = 0.52 TISP + 0.001

Discussion and Conclusion

Integrated science process skills are important for students ~~to~~ use the inquiry-centered process to learn the content of science knowledge through a social process, as scientist often do. These help development of mental habits that are essential for ~~the~~ inquiry process and built on to prepare students for a realistic view of science. Educators promoting content and the inquiry process as the essence of learning science believe firmly that this combined approach in the early years will make a significant contribution to improving scientific awareness in later life.

The results of this study showed that there is no significant difference between students' competency in Integrated science process skill compared to science achievement. Though students learned these abilities repeatedly in the three disciplines of science; biology, physics and chemistry but in the context of the respective content area. This may be due to science process skill are broad transferable abilities which may not help in ensuring acquisition of content knowledge. A statement of caution here is that competency of integrated science process skills in this study is not measured directly, that is where students are required to demonstrate in hands-on experiment or investigation. Instead the learners are asked to select from a list of choices in stating the hypothesis, define operationally and identify variables. In this case, indirect assessment has the obvious advantages of efficiency. However, the written test may not tell if learners would be able to display the process skill when required. Study has been carried out to teach all of these skills involve in conducting experiment (Padilla, Okey and Garrard, 1984). Their results indicated that these complex process skills cannot be learned via a two weeks unit in which science content is typically taught. Rather, experimenting abilities need to be practiced over a period of time.

In line with the emphasis of the teaching of integrated process skills for the secondary school science curriculum, the Malaysian Examination Board has revamped the standardized tests. Beginning with the year 2003, the assessment of integrated process skill in a written format is introduced in the public examination besides the school based laboratory assessment (Lembaga Peperiksaan Malaysia, 2002). Items in the written test required students to plan and design an investigation that involves the use of all the integrated process skills. To answer items correctly, students must possess all components of integrated process skill as well as knowledge in science. Students who are weak in the content area may not be able to apply these skills. The result of this study showed that mastery of the Integrated Science Process Skill, however, does not ensure acquisition of scientific knowledge. This implied that the teaching of content must take precedent over the training of students on the acquisition of science process skills.

For students to demonstrate the integrated process skills, assessment using hands-on procedures to determine skill acquisition by groups of students is also carried out in the Malaysian science curriculum. This has being implemented by the practical work, which is known as PEKA. The problem of using such procedure can be a burdensome task to teachers as it is common to have 40 or so students per class in the science classrooms. Some students in this study do not acquired both integrated science process skills and science content knowledge. Further studies may be needed to investigate what actually happens in the science classrooms to shed some light on the effectiveness of the teaching of science program at the secondary school level.

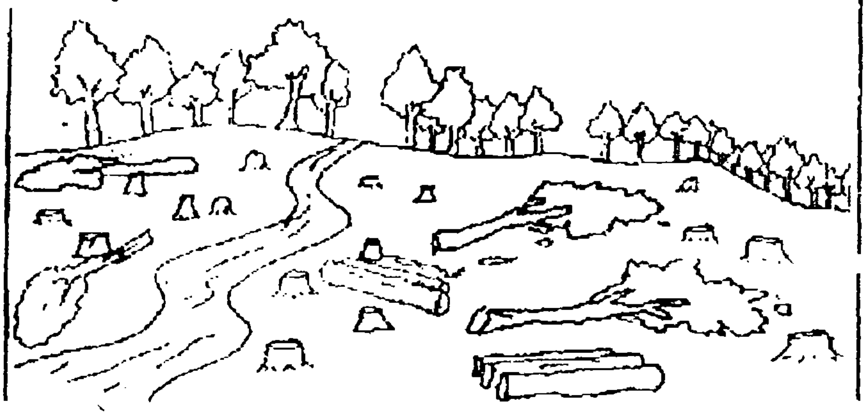
3. *TEST of INTEGRATED SCIENCE PROCESS*

Kemaihran Proses Sains

1. Ali ingin tahu apakah faktor-faktor yang mempengaruhi pertumbuhan anak benih kacang. Dia membalut sebiji kacang hijau dengan kertas tisu lembap dan menyimpannya di dalam tabung uji. Dia menyediakan dua tabung uji seperti itu. Satu tabung uji itu diletakkan di tepi tingkap supaya kena cahaya matahari. Satu tabung uji yang lain diletakkan dalam peti sejuk yang gelap. Selepas satu minggu, panjang anak benih itu diukur. Manakah antara pemboleh ubah berikut mempengaruhi pertumbuhan anak benih itu?

   A. Suhu dan kelembapan
   B. Kelembapan dan panjang tabung uji
   C. Keamatan cahaya dan suhu
   D. Keamatan cahaya dan tempoh masa anak benih itu tumbuh

Soalan 2-5 merujuk kepada Rajah 1



Rajah 1

Satu aktiviti penebangan hutan secara haram telah memusnahkan pokok-pokok di satu kawasan yang ditunjukkan dalam Rajah 1. Beberapa Pegawai Pertanian bercadang menggunakan kawasan itu untuk mengkaji kesan rumput yang berlainan jenis ke atas hakisan tanah. Pegawai-pegawai Pertanian itu telah memilih sepuluh plot tanah di kawasan itu yang sama saiz dan menerima kuantiti cahaya matahari yang sama. Mereka menanam rumput yang berlainan jenis ke dalam sepuluh plot tanah itu. Setiap plot juga mempunyai jenis tanah yang sama dan kecerunan yang sama. Ukuran hakisan tanah dilakukan setiap minggu selama empat bulan.

2. Apakah faktor yang dimanipulasikan dalam kajian ini?
   A Saiz plot tanah
   B. Jenis rumput
   C. Banyaknya hakisan tanah
   D. Jenis tanah pada plot-plot

3. Yang manakah di bawah merupakan pembolehubah bergerak balas dalam kajian ini?

   A. Saiz plot tanah
   B. Jenis rumput
   C. Banyaknya hakisan tanah
   D. Jenis tanah di plot-plot

4. Apakah hipotesis yang diuji dalam kajian ini ?

   A. Beberapa jenis rumput lebih berkesan mengurangkan hakisan tanah daripada yang lain.
   B. Hakisan tanah dipengaruhi oleh kecerunan tanah tersebut.
   C. Kawasan yang terbakar akan mengalami lebih hakisan daripada kawasan yang masih berpokok.
   D. Penanaman rumput yang berlainan akan mengurangkan hakisan tanah.

5. Yang manakah antara faktor berikut TIDAK dikawal dalam kajian ini ?

   A. Saiz plot tanah
   B. Jenis tanah di plot
   C. Banyaknya hakisan tanah
   D. Banyaknya cahaya matahari yang diterima oleh plot

6. Seorang pengurus tanaman rumah hijau ingin mencepatkan penghasilan buah tomato untuk memenuhi permintaan pelanggannya. Dia menanam benih-benih tomato di dalam beberapa talam. Dia membuat jangkaan bahawa lebih tinggi kelembapan, benih-benih tomato lebih cepat bercambah. Bagaimanakah beliau boleh menjalankan kajian untuk menguji hipotesis ini ?

   A. Kira bilangan hari yang diperlukan untuk percambahan benih yang menerima jumlah air yang berlainan.
   B. Ukur tinggi pokok-pokok tomato selepas satu hari pokok-pokok itu disiram air.
   C. Ukur jumlah air yang digunakan oleh pokok-pokok tomato di dalam talam yang berlainan.
   D. Kira bilangan benih tomato yang diletakkan dalam setiap talam.

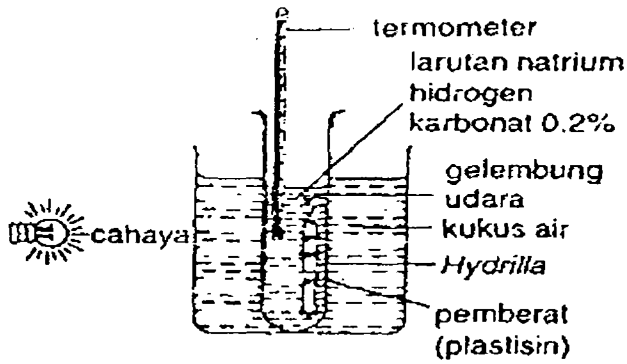
7. Satu eksperimen dijalankan untuk menunjukkan kesan ***hormon auksin (IAA)*** ke atas pertumbuhan koleoptil (apeks pucuk) anak benih jagung. Lima koleoptil sepanjang 2 mm direndam dalam larutan IAA dalam satu tabung uji. Empat tabung uji disediakan dengan empat larutan IAA yang berlainan kepekatan. Selepas 24 jam, kesemua panjang koleoptil dari setiap tabung uji diukur dan panjangnya direkodkan dalam jadual seperti berikut.

Tabung Uji	Kepekatan IAA (mg/ l)	Panjang Koleoptil (mm)				
A	0.1	3.4	3.0	3.3	3.3	2.8
B	0.2	5.1	4.9	5.2	5.1	5.0
C	1.0	7.0	6.8	7.0	7.2	7.1
D	10.0	2.1	2.1	2.3	2.3	2.1

Apakah kepekatan auksin (IAA) yang paling sesuai untuk pertumbuhan koleoptil anak benih ?

A. 0.1 mg/ l
B. 0.2 mg/ l
C. 1.0 mg/ l
D. 10.0 mg/ l

Soalan 8 -9 berdasarkan Rajah 2 di bawah :



Rajah 2 menunjukkan eksperimen untuk mengkaji kesan keamatan cahaya ke atas kadar fotosintesis.

8. Bagaimanakah kadar fotosintesis ditentukan dalam eksperimen ini ?

   A. menghitung bilangan gelembung gas dibebaskan dalam masa 5 minit.
   B. mengubah kedudukan jarak sumber cahaya dari bikar.
   C. Menggunakan kepekatan larutan natrium hidrogen karbonat setiap 5 minit.
   D. Mengukur suhu larutan Natrium hidrogen karbonat dalam masa 5 minit.

9. Apakah hipotesis eksperimen ini?

   A. Semakin tinggi suhu, semakin tinggi kadar fotosintesis
   B. Semakin tinggi kepekatan karbon dioksida, semakin tinggi kadar fotosintesis
   C. Semakin tinggi keamatan cahaya, semakin tinggi kadar fotosintesis
   D. Semakin jauh sumber cahaya, semakin rendah keamatan cahaya.

10. Empat orang pelajar A, B, C dan D telah mereka bentuk penyiasatan untuk menentukan kesan pH ke atas aktiviti enzim.

    Reka bentuk penyiasatan mereka adalah seperti dalam jadual-jadual berikut:

Reka bentuk Pelajar A

Tabung uji	Kandungan	pH	Suhu (oC)
1	E	3	20
2	E	7	20
3	E	12	20
4	S	3	20
5	S	7	20
6	S	12	20

Reka bentuk Pelajar B

Tabung uji	Kandungan	pH	Suhu (oC)
1	E+S	3	20
2	E+S	7	20
3	E+S	12	20
4	S	3	20
5	S	7	20
6	S	12	20

Reka bentuk Pelajar C

Tabung uji	Kandungan	pH	Suhu (oC)
1	E+S	3	10
2	E+S	7	20
3	E+S	12	30
4	S	3	10
5	S	7	20
6	S	12	30

Reka bentuk Pelajar D

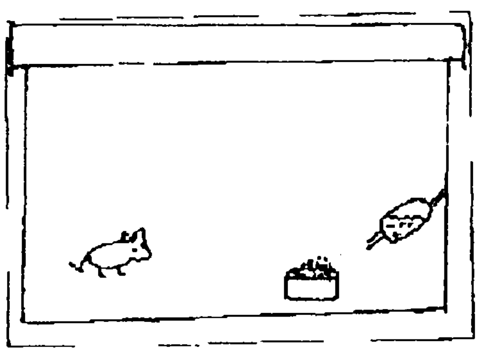
Tabung uji	Kandungan	pH	Suhu (oC)
1	E+S	7	10
2	E+S	7	20
3	E+S	7	30
4	S	7	10
5	S	7	20
6	S	7	30

Petunjuk: E = Enzim S = Substrat

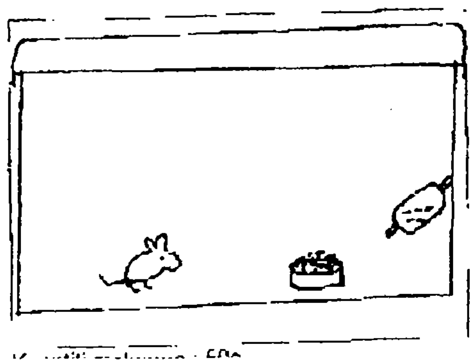
Reka bentuk pelajar yang manakah paling sesuai?

Soalan 11-12 merujuk kepada kajian berikut:

Satu kajian dijalankan di makmal untuk menguji sama ada kuantiti Vitamin A yang diberikan kepada tikus putih mempengaruhi bilangan anak tikus yang dilahirkan. Dalam kajian itu, tikus baka putih dewasa dibela dalam dua sangkar yang berlainan selama dua bulan



Kuantiti makanan : 50g
Nutiren : Lengkap + Vitamin A
Suhu : 2 8 °C Suhu :



Kuantiti makanan : 50g
Nutrien : Tanpa Vitamin A
2 8 °C

11. Yang manakah antara pemboleh ubah berikut **TIDAK** dikawal dalam kajian itu?

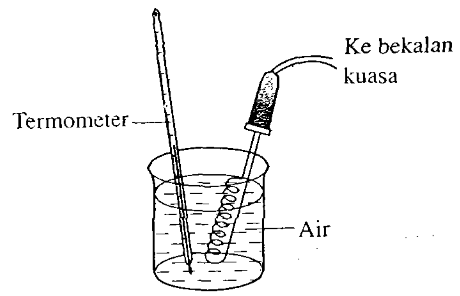
    a. Kuantiti Vitamin A
    b. Kuantiti makanan
    c. Baka tikus
    d. Suhu sangkar

12. Pengukuran yang manakah digunakan untuk memperolehi kesan vitamin A?

    a. kuantiti makanan diberikan kepada setiap tikus putih
    b. kuantiti Vitamin A dalam nutrien dibekalkan
    c. Berat badan tikus putih betina
    d. bilangan anak tikus yang dilahirkan

Kemahiran Proses Sains

13. Salina ingin menyukat kuantiti haba yang dibebaskan oleh pemanas rendam dalam 10 minit. Radas disusun seperti dalam gambar rajah untuk memanaskan 1000 cm^3 air dalam suatu bikar.

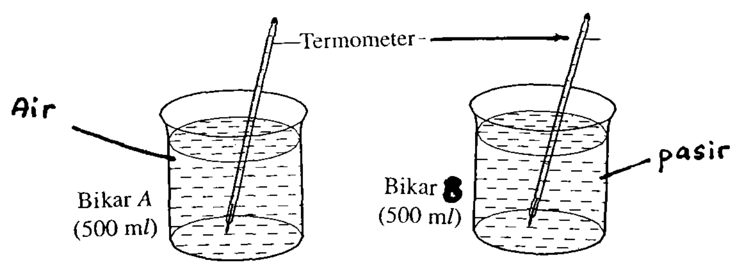


Bagaimanakah tenaga haba yang dibebaskan pemanas rendam boleh diukur?

A Catat perubahan suhu air panas selepas 10 minit
B Sukat isipadu air selepas 10 minit
C Sukat suhu pemanas selepas 10 minit
D Hitung masa yang diambil untuk mendidihkan 1000 cm^3 air

Soalan 14-16, rujuk kepada penerangan di bawah

Mariam ingin menjalankan satu penyiasatan untuk menentukan sama ada bumi dan lautan dipanaskan dengan kadar yang sama oleh matahari. Radas seperti di bawah telah disediakan (satu baldi telah diisi dengan pasir dan satu lagi dengan air) kemudian diletakkan supaya mendapat jumlah cahaya matahari yang sama. Suhu dalam tiap-tiap baldi diukur setiap satu jam dari 8.00 pagi hingga 6.00 petang.



14. Yang manakah pernyataan di bawah diuji oleh Mariam?

A Semakin banyak cahaya matahari, semakin panas air dan tanah
B Semakin lama tanah dan air didedah kepada cahaya matahari, semakin panas air dan tanah
C Bahan-bahan yang berbeza dipanaskan dengan kadar yang berbeza oleh matahari
D Jumlah cahaya matahari berbeza mengikut peredaran masa

15. Yang manakah kuantiti di bawah dimalarkan dalam penyiasatannya?

A Jenis air yang dimasukkan ke dalam baldi
B Suhu air dan tanah
C Jenis bahan yang dimasukkan ke dalam baldi
D Tempoh setiap baldi didedahkan kepada cahaya matahari

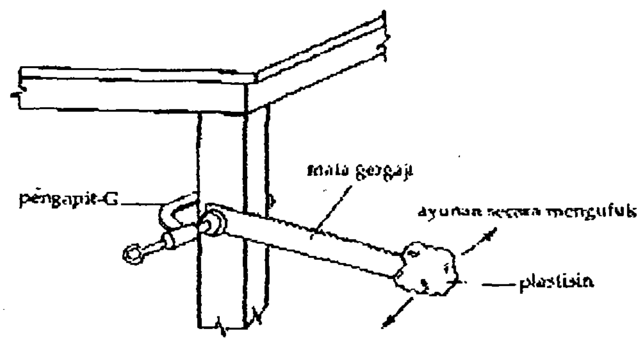
16. Apakah pembolehubah bergerak balas dalam eksperimen ini?

A Jenis air yang dimasukkan ke dalam baldi
B Suhu air dan tanah
C Jenis bahan yang dimasukkan ke dalam baldi
D Tempoh setiap baldi didedahkan kepada cahaya matahari

Soalan 17-19, rujuk kepada penerangan di bawah

Seorang pelanggan menolak troli di sebuah pasar raya . Pelanggan itu mendapati lebih sukar untuk mula menggerakkan atau memberhentikan troli yang telah berisi barangan. Kejadian ini berlaku disebabkan inersia troli.

Untuk menyisat kejadian tersebut, pelajar menyusun radas seperti yang ditunjukkan pada Rajah 1.



Rajah 1

17. Yang manakah kuantiti berikut boleh digunakan oleh pelajar untuk menentukan inersia?

A Laju jisim
B Tempoh ayunan
C Amplitud ayunan
D Panjang neraca

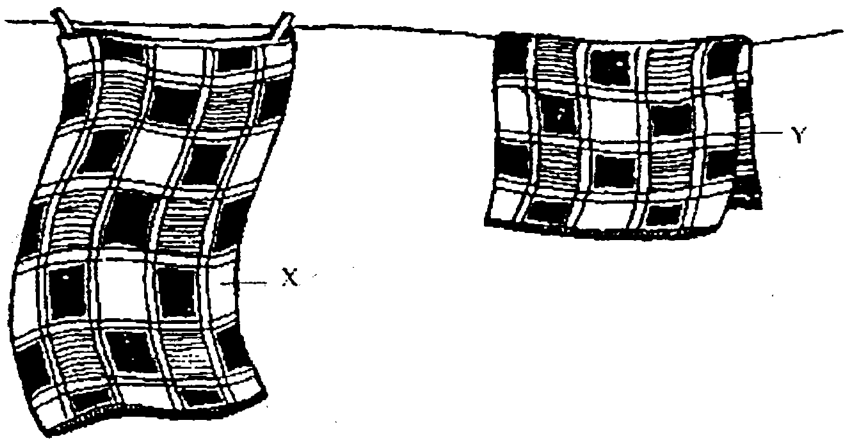
18. Kuantiti yang manakah perlu dikawal supaya tidak berubah?

A Panjang gergaji yang bebas berayun
B Jisim plastisin pada hujung bebas gergaji
C Tempoh ayunan
D Bilangan ayunan

19. Kuantiti yang manakah diubah-ubahkan dalam eksperimen?

A Panjang gergaji yang bebas berayun
B Jisim plastisin pada hujung bebas gergaji
C Tempoh ayunan
D Bilangan ayunan

20. Dua helai kain X dan Y, yang serupa disidai seperti ditunjukkan pada Rajah 2. Didapati kain X lebih cepat kering daripada kain Y.



Rajah 2

Untuk menyiasat pemerhatian di atas, satu hipotesis yang mungkin ialah

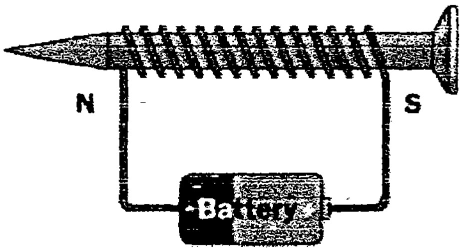
A Semakin besar kain, semakin tinggi kadar sejatan
B Semakin kuat matahari, semakin tinggi kadar sejatan
C Semakin besar luas terdedah, semakin tinggi kadar sejatan
D Semakin kuat angin bertiup, semakin tinggi kadar sejatan

21. Yang manakah susunan radas di bawah boleh disedikan untuk menyiasat hipotesis tersebut?

A Isikan 20 cm^3 eter dalam piring Petri berdiameter 3 cm, 4 cm dan 6 cm
B Isikan 20 cm^3, 30 cm^3 dan 40 cm^3 eter ke dalam piring Petri berdiameter 4 cm
C Isikan 20 cm^3 eter ke dalam piring bertinggi 2 cm, 4 cm dan 6 cm
D Isikan 20 cm^3eter ke dalam piring, bikar dan mangkuk

Soalan 22-24, rujuk penerangan di bawah

James mempunyai sel kering, wayar, dan klip kertas. Dengan radas ini, James menyusun radas seperti di Rajah 3 untuk membina satu electromagnet.



Keputusan dicatat dalam jadual di bawah:

Bilangan lilitan	Bilangan klip kertas ditarik
15	5
20	7
30	10

22. Yang manakh pernyataan berikut adalah benar untuk eksperimen James?

A Apabila bilangan lilitan bertambah, kekuatan magnet bertambah
B Apabila bilangan lilitan bertambah, kekuatan magnet berkurang
C Apabila bilangan lilitan bertambah, kekuatan magnet kekal
D Apabila panjang wayar bertambah, kekuatan magnet bertambah

23. Yang manakah di bawah sesuai untuk mendefinisi kekuatan magnet?

A Bilangan lilitan gegelung
B Diameter gegelung
C Bilangan klip kertas yang ditarik
D Arus yang mengalir melalui gegelung

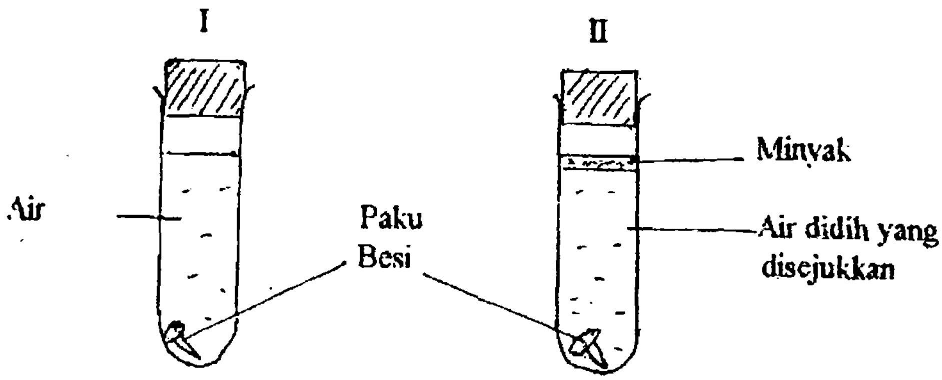
24. Yang manakah kuantiti di bawah perlu dimalarkan sepanjang eksperimen?

A Bilangan sel kering yang digunakan
B Bilangan klip kertas
C Bilangan wayar
D Bilangan lilitan

Soalan 25-26, rujuk kepada Rajah 1

Aminah menyediakan set radas seperti yang ditunjukkan pada Rajah 1 untuk mengkaji suatu faktor yang mempengaruhi pengaratan besi.

Rajah 1



Selepas seminggu, didapati paku besi di dalam tabung uji I berkarat manakala paku besi di dalam tabung uji II tidak.

25. Hipotesis yang manakah diuji oleh Aminah?

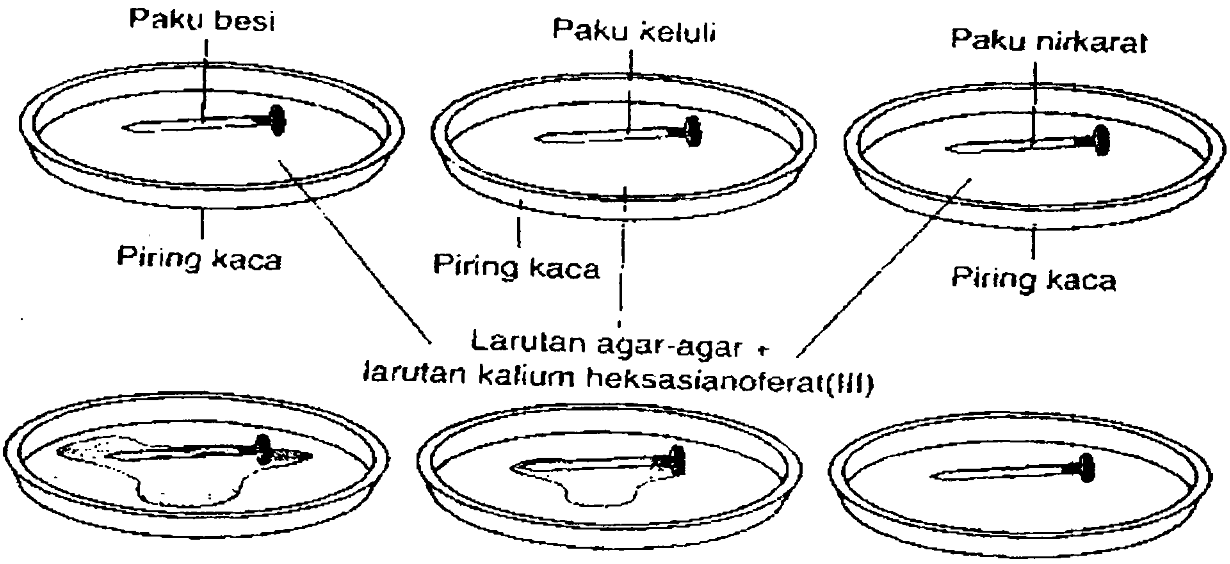
A Air tidak perlu dididih untuk pengaratan besi
B Minyak mencegah pengaratan besi
C Jenis air berlainan mempengaruhi pengaratan besi
D Udara diperlukan untuk pengaratan besi

26. Yang manakah faktor berikut dimalarkan dalam eksperimen ini?

A Bilangan paku besi
B Kehadiran udara
C Kuantiti minyak
D Saiz tabung uji

Soalan 27-29, rujuk Rajah 2

Kok Leong ingin membandingkan kadar kakisan tiga jenis paku. Dia masukkan paku besi, paku keluli dan paku keluli nirkarat ke dalam tiga piring kaca berasingan. Kemudian dia tuangkan larutan agar-agar yang telah ditambahkan dengan tiga titis larutan kalium heksasianoferat(III) ke dalam ketiga-tiga piring kaca itu. Rajah 2 menunjukkan pemerhatian yang diperoleh selepas dua hari.



Rajah 2

27. Bagaimanakah Kok Leong menentukan kadar kakisan paku?

A Memerhatikan perubahan warna yang berlaku
B Memerhatikan amaun warna merah jambu yang terbentuk
C Memerhatikan amaun warna biru tua yang terbentuk
D Memerhatikan pepejal perang yang terbentuk

28. Dalam eksperimen ini, yang manakah adalah pembolehubah yang dimanipulasikan?

A Jenis keluli
B Jenis paku
C Jenis piring kaca
D Larutan agar-agar

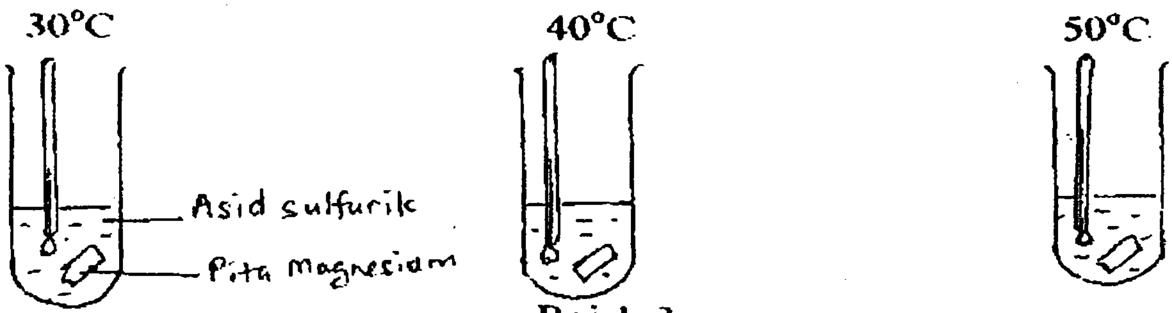
29. Yang manakh keadaan perlu ditetapkan sepanjang eksperimen ini?

I Suhu
II Kepekatan larutan agar-agar
III Kuantiti kalium heksasianoferat(III)

A I dan II sahaja
B I dan III sahaja
C II dan III sahaja
D I, II dan III

Soalan 30-32, rujuk Rajah 3

Krishnan telah menjalankan satu eksperimen untuk mengkaji bagaimana faktor suhu mempengaruhi kadar tindak balas di antara pita magnesium dan asid sulfurik. Dia menyediakan set radas seperti yang ditunjukkan dalam Rajah 3. Bagi setiap tabung uji, pita magnesium dengan panjang 3 cm dimasukkan ke dalam 30 cm^3 asid sulfurik 0.5 mol dm^{-3}.



Rajah 3

30. Antara yang berikut, yang manakah paling sesuai untuk mengukur kadar tindak balas bagi tindak balas magnesium dengan asid sulfurik?

A Pengurangan jisim magnesium mengikut masa
B Pengurangan kepekatan asid sulfurik mengikut masa
C Kehilangan pita magnesium mengikut masa
D Jumlah isipadu gas yang terbebas

31. Faktor yang manakah diubah-ubahkan dalam eksperimen ini?

A Jisim pita magnesium
B Isipadu asid sulfurik yang digunakan
C Jenis termometer
D Suhu asid sulfurik

32. Pernyataan yang manakah dapat dibuktikan dalam eksperimen ini?

A Semakin tinggi suhu asid, semakin cepat magnesium habis bertindak balas
B Semakin tinggi suhu asid, semakin panjang masa yang diambil untuk pita magnesium bertindak balas
C Semakin tinggi suhu asid, semakin banyak magnesium bertindak balas
D Semakin banyak asid yang digunakan, semakin tinggi suhu

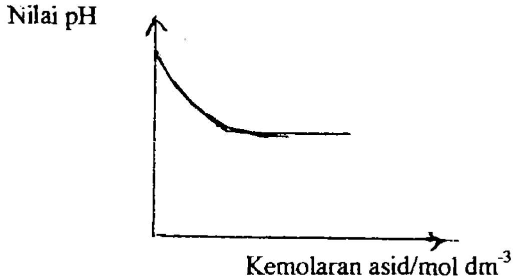
Soalan 33-36, rujuk penerangan di bawah

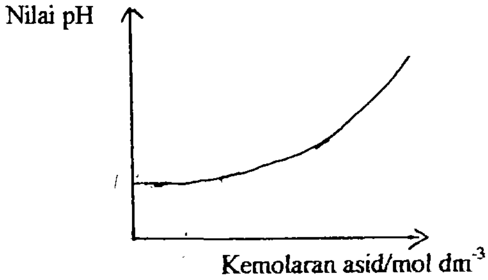
Dalam satu eksperimen, pH bagi empat larutan asid hidroklorik yang masing-masing berkepekatan 0.1 mol dm^{-3}, 0.01 mol dm^{-3}, 0.001 mol dm^{-3} dan 0.0001 mol dm^{-3} diukur dengan menggunakan meter pH. Keputusan adalah seperti direkodkan dalam Jadual 1. Kemudian data yang diperoleh diplotkan dalam satu graf.

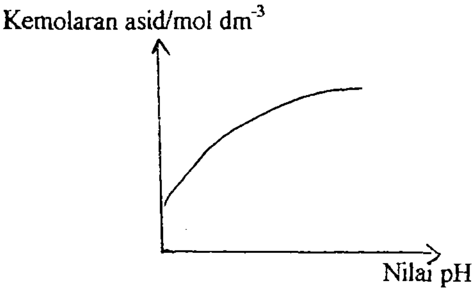
Jadual 1

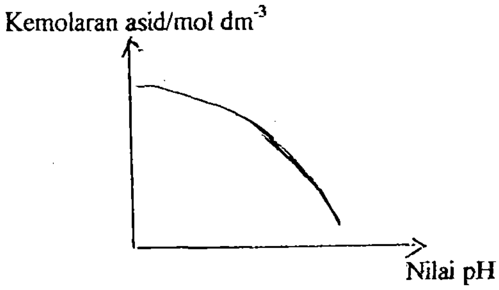
Kemolaran asid/mol dm^{-3}	Nilai pH
0.1	1
0.01	2
0.001	3
0.0001	4

33. Antara graf yang berikut, yang manakah menunjukkan keputusan eksperimen ini?

A 

B 

C 

D 

34. Dalam eksperimen ini, perkara yang manakah adalah pembolehubah yang dimanipulasikan?

A Nilai pH
B Kemolaran asid
C Suhu asid
D Isipadu asid

35. Pernyataan yang manakah paling sesuai disokong oleh keputusan eksperimen ini?

A Semakin tinggi kemolaran asid, semakin tinggi nilai pH
B Semakin tinggi kemolaran asid, semakin rendah nilai pH
C Semakin tinggi nilai pH, semakin tinggi kemolaran asid
D Semakin rendah nilai pH, semakin tinggi kemolaran asid

36. Bagaimanakah pelajar itu boleh menjalankan penyelidikan ini?

A Menjalankan elektrolisis larutan kuprum(II) sulfat dengan menggunakan elektrod logam anu dan logam kuprum
B Mengukur dan membandingkan voltan sel kimia yang dibina dengan menggunakan logam anu dan logam kuprum dicelupkan dalam larutan kuprum(II) sulfat
C Mengukur dan membandingkan nilai arus yang mengalir dalam sel kimia yang dibina daripada dua logam dicelup dalam larutan kuprum(II) sulfat
D Membandingkan kecergasan tindak balas logam anu dengan larutan kuprum(II) sulfat

1. Pertumbuhan awal anak benih dipengaruhi secara bertentangan oleh keadaan bercahaya dan gelap. Antara berikut , yang manakah merupakan satu contoh kesan yang dipengaruhi oleh faktor tersebut?

Keadaan Bercahaya	*Keadaan Gelap*
A. Aktiviti enzim tersekat	Aktiviti enzim meningkat
B. Kadar pemanjagan ruas berkurangan	Kadar pemanjangan ruas bertambah
C.Ketiadaan pigmen klorofil	Pembentukan pigmen klorofil
D. Peligninan tisu vaskular berkurangan	Peligninan tisu vaskular bertambah

2. Pembangunan pertanian yang mapan(lestari) dan pengurusan serta teknik pemeliharaan tanah-tanih adalah perlu untuk mencegah hakisan tanah. Antara berikut yang manakah adalah amalan-amalan pertanian tersebut?

I. penanaman berjalur
II. ragutan terkawal
III. pembajakan kontur
IV. penanaman tanaman tutup bumi

A. I, II dan III sahaja
B. I, III sahaja
C. II, IV sahaja
D. I, II, III dan IV

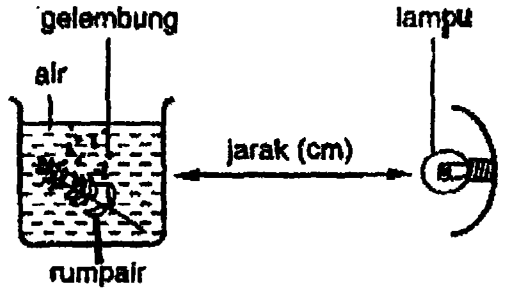
3. Yang manakah di antara berikut adalah gerak balas pertumbuhan bagi tumbuhan hijau?

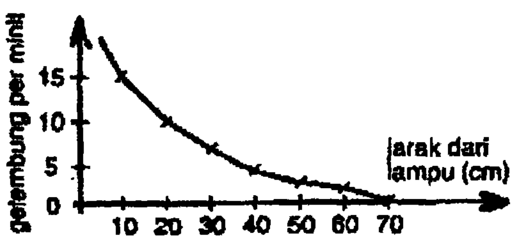
A. Pergerakan nukleus jantan ke arah mikropil ovul tumbuhan
B. Pergerakan *Euglena* ke arah cahaya
C. Pembukaan dan penutupan stoma pada daun
D. Pergerakan koleoptil jagung ke arah cahaya

4. Di antara berikut, yang manakah adalah hormon tumbuhan yang menggalakkan pertumbuhan koleoptil pada anak pokok jagung?

A giberelin
B auksin
C sitokinin
D etilena

5. Rajah 2 menunjukkan satu eksperimen yang disediakan untuk mengkaji kesan keamatan cahaya ke atas kadar fotosintesis. Keputusan eksperimen ditunjukkan pada graf. Apakah kesimpulan yang dapat dibuat daripada eksperimen?





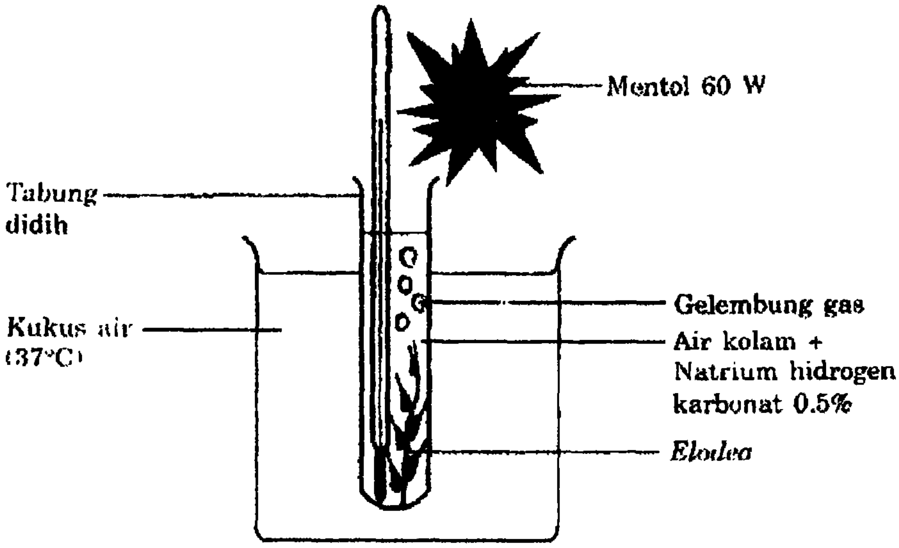
A. Keamatan cahaya tidak mempunyai kesan ke atas kadar fotosintesis
B. Rumpair menjalankan fotosintesis dengan kehadiran cahaya
C. Kadar fotosintesis semakin berkurang dengan peningkatan keamatan cahaya
D. Kadar fotosintesis semakin bertambah apabila keamatan cahaya bertambah

6. Apakah faktor yang mempengaruhi kadar fotosintesis rumpair dalam kolam air?

I. Suhu air
II. Keamatan cahaya
III. pH air
IV. kepekatan karbon dioksida

A. I dan II
B. I,II dan IV
C. II dan IV
D. I, II, III dan IV

7. Gambar rajah menunjukkan satu eksperimen fotosintesis.

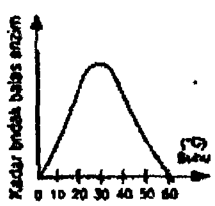


Antara berikut, yang manakah akan meningkatkan kadar pembebasan gelembung gas di dalam eksperimen ini ?

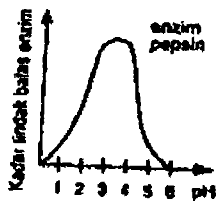
A. menggunakan mentol 40 W
B. menggunakan suhu rendaman 45 °C
C. menggantikan *Elodea* dengan *Hydrilla*
D. menggunakan larutan natrium hidrogen karbonat 1.0%

8. Antara graf berikut, yang manakah bukan graf untuk kadar tindak balas enzim terhadap faktor tertentu?

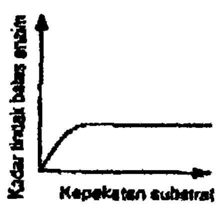
A.



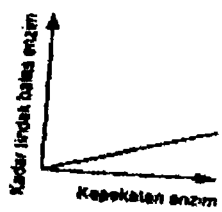
C.



B.



D.



9. Vitamin A diperlukan dalam gizi untuk

I. memelihara dan menyegarkan kulit
II. membantu proses pertumbuhan fetus
III. mengawal metabolisme karbohidrat
IV. pembinaan fotokimia di mata

A. I dan III sahaja
B. I dan IV sahaja
C. I, II dan III sahaja
D. I, II dan IV ahaja

10. Dalam kajian persaingan interspesies yang melibatkan pokok jagung dan pokok padi, pokok jagung telah berjaya dalam persaingan untuk mendapatkan

I ruang hidup
II garam mineral
III air
IV makanan

A. I dan II
B. II dan III
C. I, II dan III
D. II, III dan IV

11.

Logam	Muatan haba tentu /J $kg^{-1}\,°C^{-1}$
A	460
B	370
C	890
D	510

Jadual di atas menunjukkan muatan haba tentu logam A, B,C dan D. Logam yang manakah paling sesuai digunakan sebagai bahan untuk membuat periuk yang cepat panas?

12. Muatan haba tentu sesuatu bahan ditakrifkan sebagai kuantiti haba yang diperlukan untuk

A mengubah suhu 1 kg bahan
B mengubah suhu 1 kg bahan sebanyak 1 °C
C mengubah 1 kg pepejal kepada cecair pada takat lebur
D mengubah 1 kg cecair kepada gas pada takat didih

13. Dua bikar yang sama, satu diisi dengan 100 g parafin dan satu lagi 100 g air. Suhu awal parafin dan air adalah sama. Haba dibekalkan dengan kadar seragam yang sama.kepada kedua-dua bikar. Didapati parafin lebih cepat panas daripada air. Ini kerana parafin

A mempunyai takat lebur yang lebih rendah
B adalah lebih tumpat daripada air
C mudah menyejat jika dibandingkan dengan air
D mempunyai muatan haba tentu yang lebih kecil daripada air

14. Antara pernyataan berikut, yang manakah benar tentang inersia?

A Semakin besar jisim jasad semakin besar inersia
B Suatu jasad yang pegun tidak mempunyai inersia
C Suatu jasad yang jatuh bebas tidak mempunayi inersia
D Inersia suatu jasad di Bulan adalah lebih kecil daripada di Bumi

15. Antara berikut, yang manakah menunjukkan sifat inersia?
A Duit suiling di atas sekeping kadbod disesarkan secara mengufuk apabila kadbod ditarik dengan perlahan
B Satu jasad dilepaskan dari tebing tinggi akan jatuh
C Seorang penumpang di dalam sebuah bas terhumban ke hadapan apabila bas berhenti dengan tiba-tiba
D Satu gelembung gas dari dasar tasik naik ke atas

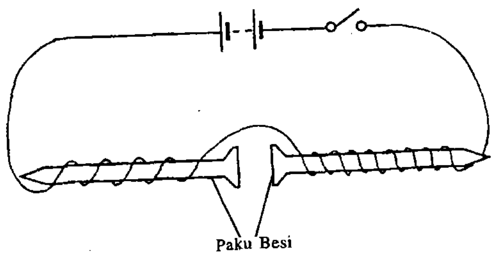
16. Neraca inersia boleh digunakan untuk membandingkan jisim dua jasad yang berlainan dengan menentukan

A amplitud ayunannya
B tempoh ayunanya
C panjang bilahnya
D paksi ayunannya

17. Kadar sejatan air di dalam sebuah kolam tidak dipengaruhi oleh
A suhu udara di sekitar kolam
B peratus klembapan udara di sekitar kolam
C luas permukaan kolam
D isipadu air dalam kolam

18. Antara pernyataan berikut, yang manakah **tidak benar** tentang sejatan?
A Cecair berubah menjadi wap
B Berlaku pada sebarang suhu
C Berlaku di permukaan cecair
D Kadar sejatan bertambah apabila tekanan atmosfera bertambah

19. Rajah menunjukkan dua batang paku besi dililit dengan dawai kuprum bertebat dan disambung kepada sebuah bateri. Antara pernyataan berikut yang manakah benar tentang kedua-dua paku itu apabila suis dihidupkan?



A Kekuatan medan magnetnya sama
B Kutub di hujung tajam sama
C Berlaku tarik menarik
D Menjadi panas

20. Di antara pasangan bahan teras dan bilangan lilitan wayar bertebat, yang manakah boleh digunakan untuk membina sebuah electromagnet yang paling kuat?

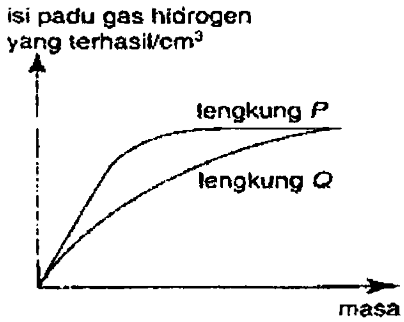
	Bahan teras	Bilangan lilitan wayar bertebat
A	Kuprum	500
B	Kuprum	100
C	Besi	500
D	Besi	100

21. Faktor-faktor yang mempengaruhi sesuatu logam terkakis adalah
I udara
II mangkin
III air

A I sahaja
B I dan II sahaja
C I dan III sahaja
D I, II dan III

22. Di antara yang berikut, yang manakah **bukan** kaedah untuk mencegah pengaratan besi?

A Pengaloian
B Penyaduran logam
C Penggalvanian
D Pemasangan dengan logam yang kurang elektropositif



23. Lengkung Q dalam rajah di atas menunjukkan isipadu gas hidrogen yang terbebas melawan masa dalam satu eksperimen yang menggunakan butiran zink dan asid sulfurik cair yang berlebihan. Antara keadaan yang berikut, yang manakah bukan cara yang dapat menghasilkan lengkung P?

A Memanaskan asid sulfurik
B Menggunakan serbuk zink untuk menggantikan butiran zink
C Menggunakan isipadu asid sulfurik yang lebih besar
D Menambahkan sedikit hablur kuprum(II) sulfat pada asid sulfurik

24. Dalam tindak balas di antara marmar dengan asid hidroklorik cair, kadar tindak balas bertambah apabila suhu asid bertambah. Antara pernyataan berikut, yang manakah menjelaskan pemerhatian ini?

A Apabila suhu bertambah, tenaga kinetik zarah asid bertambah dan lebih banyak zarah mencapai tenaga pengaktifan
B Apabila suhu bertambah, tenaga pengaktifan direndahkan
C Apabila suhu bertambah, lebih banyak zarah wujud dalam se unit isipadu asid
D Apabila suhu bertambah, lebih banyak zarah bergerak bebas

25. Keberkesanan cuka dagangan sebagai bahan pengawet berkadar dengan kepekatan ion H^+ yang hadir dalam cuka itu. Diberi beberapa jenis cuka dengan jenama P, Q, R dan S dan nilai pHnya, yang manakah lebih berkesan sebagai pengawet?

	Jenama Cuka	Nilai pH
A	P	3.0
B	Q	4.0
C	R	4.5
D	S	3.8

26. Antara pernyataan berikut, yang manakah benar tentang nilai pH suatu asid?

A Asid kuat mempunyai pH yang lebih tinggi daripada asid lemah
B Asid pekat mempunyai pH yang lebih tinggi daripada asid cair
C Nilai pH asid mineral lebih tinggi daripada asid organik
D Nilai pH mewakili kepekatan ion hidrogen dalam suatu asid

27. Untuk menguji sesuatu bahan anu adalah bahan asid, seorang pelajar menambahkan larutan akueus bahan anu itu ke dalam serbuk zink dalam sebuah tabung uji. Antara pemerhatian berikut, yang manakah menunjukkan bahan anu itu ialah bahan asid?

A Memerhatikan perubahan warna larutan
B Memastikan gas yang terbebas menghasilkan bunyi'pop' dengan kayu uji bernyala
C Memastikan gas yang terbebas mengeruhkan air kapur
D Memerhatikan tabung uji berasa panas

28. Antara bahan berikut, W, X, Y dan Z, bahan yang manakah adalah sebatian ion?

Bahan	*Takat lebur/°C*	*Kekonduksian elektrik*
W	-65	Mengkonduksikan dalam keadaan akueus
X	150	Tidak mengkonduksikan
Y	800	Mengkonduksikan dalam keadaan leburan atau akueus
Z	3020	Tidak mengkonduksikan

A W
B X
C Y
D Z

29. Antara unsur yang berikut, yang manakah membentuk sebatian ion dengan natrium dan sebatian kovalen dengan oksigen?

A Magnesium
B Argon
C Plumbum
D Sulfur

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30.

Pasangan logam	*Nilai voltan/Volt*	*Terminal positif*
P-Cu	1.1	Cu
Q-Cu	2.7	Cu
R-Cu	0.8	Cu

Jadual di atas menunjukkan bacaan nilai voltan bagi sel kimia yang dibina dengan menggunakan pasangan logam berlainan, P, Q dan R dengan kuprum direndam dalam suatu elektrolit. Susunan keelektropositifan bagi unsur P, Q, R dan kuprum mengikut tertib menurun ialah

A P, Q, R Cu
B P, Q, Cu, R
C Q, P, R, Cu
D Cu, R, P, Q

5. Assessing Competency in Integrated Science Process Skill and its relation with Science Achievement

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Background

In Malaysia, science has received a high priority in both primary and secondary schools. Anderson (1987) defined good science teaching as that geared toward developing an attainable form of high scientific literacy. A scientifically literate person should develop an understanding of the concepts, principles, theories, and processes of science, and an awareness of the complex relationship between science, technology and society. To be scientifically literate, a person needs to have knowledge of concepts and theories of science, and, in addition, to have some understanding of how this knowledge has been obtained in the past and is still being learned today.

The goal for science education (Rezba et. al, 1995) in the nineties and beyond, stress science as ways of thinking and investigating as well as a body of knowledge. Padilla (1990) called these ways of thinking in science as the process skills. Other terms such as the scientific method, scientific thinking and critical thinking are terms used at various times to describe these skills. Today the term "science process skills" is most commonly used.

The main aim of the science curriculum is to help students understand, and become able to use, scientific knowledge. Throughout the last four decades science educators have advocated that science processes be taught in primary and secondary schools. Science educators (Gagne, 1965) have argued that acquisition of the science process skills should be a major goal of science instruction as most curricula also aim to develop students' ability of the scientific approach to enquiry

Process skill learning has become an important component of science curricula at all levels. Acceptance of this view is reflected in curricula developed in recent years with an emphasis on the science process skills. Some science educators, however, have argued that explicit teaching about the methods of science is necessary and have the opinion that an understanding of science processes (or science method) is more important than the knowledge content (Millar,1990).

Science – A Process Approach (SAPA) grouped process skills into two types - basic and integrated (Livermore, 1964). The basic science process skills provide a foundation for learning the more complex integrated science process skills (Padilla, 1990). Processes such as observing, classifying and recording data, which are typically taught in elementary grades (primary schools), act as prerequisites for integrated processes. Examples of integrated science include skills such as formulating hypotheses, operationally defining, controlling, and manipulating variables, planning investigations, and interpreting data (Livermore, 1964).

Although science process skill has been introduced in the United States since 1960s, it was not given much emphasis in Malaysia until very recently. During the nationwide science curriculum review in the year 2002 for both primary and secondary schools (Kementerian Pendidikan Malaysia, 2001), explicit teaching of the science process skill is necessary with an introduction of a paper-and-pencil test being introduced to assess students acquisition of this skill.

Scientific approach as integration of process skills

Many science curriculum guides and textbooks have cited important outcomes on the acquisition of integrated science process skills. These processes are rooted in the simple processes and seem necessary to the aim of acquiring a scientific approach to knowledge at the intermediate levels (Livermore, 1964). This is because process skills represent the rational and logical thinking skills used in science. These process skills are intellectual skills used in collecting and analyzing data so as to solve problems. Students can use process skills to formulate responses to questions, to justify points of view, to explain events or procedures, and to interpret or describe data.

The modern science curriculum includes what scientists have found out (content) and what they do to find out (process). Concepts, explanations, understanding, and theories constitute the content of science; the ways scientists make observations, try to explain the observations, and invent concepts and theories constitute the process of science. The report by the American Association for the advancement of Science (AAAS) titled Science for All Americans (1990) emphasized that the teaching of scientific concepts should be consistent with the nature of scientific inquiry. The process skill approach (Chiappetta & Koballa, 2002) is argued as one teaching method that could be employed by teachers in the effort to teach science as inquiry.

Some science educators have argued that the scientific approach to enquiry can be thought of as a set of science process skills. As a result of this, Science, A Process approach (SAPA), which was based on Gagne's analysis of the processes of science and of learning was recommended (Liver, 1967). Several science courses in the UK in the 1980's also follow this line, some using the processes (rather than science content) to structure the program, and science learning was primarily in terms of the development of pupils' process skills, that is their ability to carry out these processes in a range of context (Millar, 1990).

The process skill approach focuses on teaching broadly transferable abilities that are appropriate to many science disciplines and are reflective of the behavior of scientists (Padilla, 1990). Chiappetta (1997) states that "the acquisition and frequent use of theses skills can better equip students to solve problems, learn on their own, and appreciate science". Science process skills have been portray as a set of discrete 'thinking skills', which can be practiced and developed separately before being combined to tackle more demanding problems.

Problem Statements

The science process skills, along with the knowledge those skills produce, and the scientific values and habits of mind define the nature of science. Science includes both the process of inquiry about natural phenomena and the content derived there from.

Unfortunately, the teaching and learning of science does not always reflect the true nature of science. Most science lessons emphasized either science content or science processes. Before the emphasis of science processes in the curriculum, science instruction merely cover vast amounts of abstract science contents. Students merely memorise scientific laws and knowledge to pass examination. At the end of the science programs, students merely possess chunks of discrete science knowledge.

With the emphasis on the science process skill, some teachers now practice science education where the process of doing science becomes almost the sole focus. Science learning was primarily in terms of the development of pupils' process skill. The process is the tool through which knowledge is acquired, but it alone is not science (Hinman, 1998). Though the major thrust of the science program is to develop the pupil's skills in using science processes, science content should not be neglected. While it is true that without processes, the content of science would become static or even decay. The content of science is the accumulated and ever-expanding body of knowledge in any discipline to which scientific inquiry can be applied. By overemphasizing process, teachers may not be preparing students properly for continuing science learning to the higher level. The science content is the accumulated knowledge of past scientific endeavors. According to Livermore (1964), both the processes as well as content are important. Students use science process to learn science content. The integrated process skills are involved when conducting investigation or experiments; formulating a hypothesis, identify and control variables in designing an experiment, and making generalizations after collecting data. (Padilla & Okey, 1983).

The National Science Educational Standards (National Research Council, 1996) also emphasize the importance of scientific content when it states, "An essential aspect of scientific literacy is greater knowledge and understanding of science subject matter" (p21). In fact not all science knowledge can be learned through the process approach. A good part of the content of science, especially in the higher grade, must be learned through more traditional methods such as lectures, textbooks, and systematic memorization. The factual and conceptual content is so rich that just to understand it, not to mention master it, requires rigorous, intensive study.

Science process skills, cannot be acquired by observation, it cannot be learned from being told; it has to be constructed by the learner. In addition, students' ability to use process skills depend on the extent of their knowledge of the contexts they are asked to work on (Millar, 19). This is explained by the finding (Song and Black, 1991; Lock, 1993) that performance of tasks requiring these process skills is strongly content-dependent. There is a problem of how to integrate content and process of science. In higher grades, inquiry and content are fused together. In fact, as has been frequently stated, there is no necessary connection between how to learn science and how to do science (Nola, 1997; Ogborn, 1997). Teachers need to capitalize on opportunities in the activities normally done in the science classroom to emphasize integrated science process skills. Students conducting these activities are expected to develop such skills as stating hypotheses, operationally defining variables, designing investigations, and interpreting data in addition to mastering the content of the courses.

Although process-oriented curriculum materials such as Science- A Process Approach have been used for more than four decades, few studies have investigated variables associated with integrated process skill competency in the United States. There has been claimed that exposure to a systematic science program which emphasis integrated science process promotes cognitive development. With the implementation of the new science curricula which emphasize the teaching of science process skills systematically in both the primary as well as the secondary schools, integrated science processes became the instructional objectives in the Malaysian secondary schools science program. Science educators should be aware of the important aspects of students' competency levels in integrated process skills and their abilities in using these integrate process skills to obtain science knowledge. As such, data is needed to provide information regarding students' development of the process skills in relation to science academic achievement.

Objectives of The Study

This study aims at comparing competency in integrated science process skill and science achievement as well as examining the relationship between student acquisition of integrated process skills and their ability to acquire science knowledge, that is, achievement in science.

Related Research /Background literature

TIPS II by Burns, Okey and Wise (1985) was translated to Bahasa Malaysia by Zurida (1998). The translated version of TIPS II was then administered to 268 Form 4 secondary school students. Zurida reported (1998) that acquisition of Integrated Process Skills was not satisfactory. In a similar study, Nordin (1997) found that less tan 40% of the primary school students showed mastery in the Integrated Process Skills. This may be a result of the content of the item being unsuitable to the Malaysian students. Further, at the time the skill being measured, the Malaysian schools did not emphasized on the teaching of the science process skill explicitly in the science curriculum. This lead to many of the teachers do not teach the process skill in the science classroom. Many teachers did not acquired science process skills as reported by Mohamed (2001) in his study on pre-service as well as in-service teachers.

Several studies have investigated on the learning of integrated science process skills. Both Quinn and George (1975) and Wright (1981) found that students can be taught to formulate hypotheses and that this ability is retained over time. Others have tried to teach all of the skills involve in conducting experiment (Padilla, Okey and Garrard, 1984). Their results indicated that these complex process skills can not be learned via a two weeks unit in which science content is typically taught. Rather, experimenting abilities need to be practiced over a period of time.

Studies have been conducted which dealt with student acquisition of integrated science process skills (Renner & Weber, 1972; Boyer & Linn, 1978; Allen, 1973; Linn & Their, 1975) in relation to other variables. Tobin and Capie (1981) found a significant inter-correlation (r =0.60) between formal reasoning ability and process skill achievement. Padilla, Okey and Dillashaw (1983) showed that they are closely related to the formal thinking abilities described by Piaget. In fact one of the ways that Piaget decided whether someone was formal or concrete was to ask that person to design an experiment to solve a problem.

Tobin & Capie (1982) found that formal reasoning was the strongest predictor of process skills outcomes. Their finding underscores the importance of formal reasoning to achievement in science. A study on the relationship between the logical thinking skills and the integrated science process skill of high school students in North Carolina and Japan was carried out by Mattheis et al. (1992). A moderately strong and almost identical correlation was found to exist between the reasoning skills as measured by the GALT test and integrated process skills as measured by the TIP II test for each sample.

German (1989) investigated the effect of the directed-inquiry approach on science process skills and scientific problem solving. The researcher reported that the use of a directed-inquiry approach had no significant effect on the learning of science process skills or on cognitive development.

Further study of process skills by Doran & Sellers (1978) investigated relationships between students' mental ability, gender, biology achievement and science process achievement. The achievement measures contained items on experimenting, predicting, and concluding. The authors reported that mental ability was related to the process achievement. The relationship was not strong, however, as biology achievement and mental ability together accounted for only nine percent of the variance in process skill achievement.

Methodology

Instruments

Two instruments were used to collected data for the study. The Test of Integrated Science Process (TISP) is used to measure how competent students are in the processes of science. Science process skills are not subject specific. However, these skills operate in conjunction with specific knowledge. There has to be a task, some information to be absorbed or a problem to solve so that these skills can be applied. TISP purports to be specific to the science content defined in the Malaysian school science curriculum. The items in TISP contain conceptual materials on science as well as requiring the application of component integrated process skills. The objective of the test is the evaluation of process skills that are related to the science content. The Test of Integrated Process Skill II by Burns, Okey & Wise (1985) was non-curriculum specific and is not suitable to be adopted for this study.

The integrated science processes selected for testing are those associated with planning investigations. They include formulating hypotheses, operationally defining variable, identifying and controlling variables as well as interpreting data. There were altogether 36 multiple-choice items for TISP. Seven of the items were on formulating hypotheses, 16 items were about controlling variables, seven items were defining variables operationally, three items were about interpreting data and three more items were on designing experiment.

For students to demonstrate the integrated process skills, assessment using hands-on procedures to determine skill acquisition by groups of students deem most appropriate. This is being implemented by the practical work, which is known as PEKA in the Malaysian science curriculum. The problem of using such procedure can be a burdensome task to teachers as it is common to have 40 or so students per class in the Malaysian school. Thus science teachers need a means of measuring process skill competency that can be administered efficiently and objectively. Therefore, a decision was made to utilize a paper-and-pencil group testing format. The purpose of the TISP was skill evaluation. The items were based on concept and principles of science knowledge which are assumed to be familiar to Form IV students. This will not confound skill performance with the students' background.

The second instrument, Science Achievement Test (SAT) consists of 30 items. There were 10 items each for biology, physics and chemistry. These items required recalled and understanding of the science concepts and principles as well as application of the science knowledge which required higher cognitive levels. Science content knowledge in the SAT items are those required in the TISP.

Sample

Ten secondary schools of different locations, both rural and urban was selected randomly from Penang and Perak. Five schools from Perak and five schools from Penang were involved in this study. For each school chosen for the study, approximately 60 students (2 intact classes) were randomly administered the tests. This may help to control the factor of teaching method and teachers' characteristics. As some teachers may not emphasized on the acquisition of integrated process science in their classroom activities. The subjects involved were Form IV students who had undergone the revised science syllabus. Altogether 609 students sat for the TISP and 611 students took the SAT test. Due to some students did not complete both tests, their responses were not used in the final analysis. Finally, a total of 575 students' responses for each test were analysed. It is important to select a sample that has undergone the program and was familiar with the terminology used. All subjects of this study had been given focused instruction on integrated process skills under the review science curriculum which required the systematic teaching of integrated science processes.

Administration of Tests

The tests were administered at the end of the school year to ensure that all subjects have undergone approximately one year of learning integrated process skill in the secondary science program.

The tests were administered at two different teaching periods but during the same week. This is to minimize the effect of learning that will occur in between the administration of the two tests. Each test required 40 minutes administration time. To minimize disruption of teaching in the classes involved and to avoid fatigue as a result of taking two tests successively, the two tests were administered on two different days. As a result, this causes data loss when students were not present to take both tests.

Analysis of Data

The characteristic of the TISP is anlaysed as in Table 1. All the mean value were above the mid-point score with the exception of designing experiment. For component skills in

Constructing Hypotheses, Defining Operationally, Interpreting Data and Designing Experiment, there were respondents who did not answer any of the item correctly.

All the distributions were negatively skew with only Integrated Process distribution with no skew. The distribution for Constructing hypotheses is the most leptokurtic, it is the most highly peaked, with most of the score clustered around a small central portion of the scale. Designing experiment and Defining operationally are of the slightly platykurtic distribution with the scores spread out across most of the scale.

Table 1
Descriptive statistics for Test of Integrated Science Process

Statistics	Controlling Variable	Constructing Hypotheses	Operational Definition	Interpreting Data	Designing Experiment	Integrated Process
Mean	10.51	4.53	3.34	1.93	1.31	21.62
S.D.	2.59	1.25	1.43	0.71	0.82	4.86
Skewness	-0.64	-0.98	-0.13	-0.47	0.00	-0.70
Kurtosis	0.14	1.16	-0.67	0.39	-0.68	0.27
Minimum	2	0	0	0	0	5
Maximum	16	7	6	3	3	32

The relationship between component skills and the overall Integrated Process were computed. The component skill that correlated highly with the process skill is Controlling Variable. The next one is Constructing Hypotheses. Designing experiment has a moderate relationship of 0.43 with Integrated Process. Among the component variable, the relationship is moderate with the weakest at 0.15.

Table 2
The relationship between component integrated science process skill

	Controlling Variable	Constructing Hypotheses	Operational Definition	Interpreting Data	Designing Experiment	Integrated Process
Controlling Variable		0.51	0.38	0.41	0.23	0.88
Constructing Hypotheses			0.33	0.36	0.16	0.71
Operational Definition				0.31	0.23	0.66
Interpreting Data					0.15	0.57
Designing Experiment						0.43

Students' performance on the Integrated Science Process Skill were analysed as shown in Table 3. Interpreting Data is the highest, 79.1% were above mean value. Students performed badly in Defining Operationally with only 47.7% scored above the average. Overall, the performance in Integrated Science Process skill is good with 58.8% scoring above the mean.

Table 3
Performance on the Component skills and Integrated Science Process Skill

	Controling Variable	Constructing Hypotheses	Operational Definition	Interpreting Data	Designing Experiment	Integrated Process
<mean value	42.6% (245)	39.5% (227)	52.3% (301)	21.9% (126)	57.4% (330)	41.2% (237)
>mean value	57.4% (330)	60.5 (348)	47.7 (274)	79.1% (449)	42.6% (245)	58.8% (338)

In the analysis of the Science achievement, the mean value for Physics and Chemistry is almost the same, 5.59 for Physics and 5.60 for Chemistry. The mean value of Biology is the lowest, 4.10 only. The mean value of the overall, sum up as science is at the 50% mid-point value, that is, 15.29. All distributions were negatively skewed with the exception of Biology, that is skewness = 0. All the distribution have negative kurtosis, that is slight platykurtic or flattened distribution where scores are spread over the scale.

Table 4
Descriptive Statistics of Science Achievement Test

Statistics	Biology	Physics	Chemistry	Science
Mean	4.10	5.59	5.60	15.29
S.D.	1.62	2.03	2.32	4.77
Skewness	0.00	-0.46	-0.15	-0.16
Kurtosis	-0.33	-0.44	-0.85	-0.62
Minimum	0	0	0	3
Maximum	8	9	10	26

The correlation between the three disciplines of science were computed. From Table 5, Chemistry performance has the highest correlation with the overall science performance, that is 0.85. Biology has the lowest correlation, however, the difference is not big, which is 0.70

Table 5
Correlation between Biology, physics, chemistry and science achievement

	Biology	Physics	Chemistry	Science
Biology		0.38	0.41	0.70
Physics			0.53	0.81
Chemistry				0.85

Student performance in Science Achievement is as shown in Table 6. The highest percentage of students scoring above the mean value, that is, 59.1% is in physics. Students perform poorly in Biology, only 40.3% score above the mean. For the overall science achievement, slightly more than half of the sample, 50.7% scored above the mean.

Table 6
Performance of the Science Achievement Test

	Biology	Physics	Chemistry	Science

<mean	59.7% (338)	41.9% (241)	46.9% (269)	49.3% (302)
>mean	40.3% (237)	59.1% (334)	53.1% (306)	50.7% (273)

To assess whether there is a statistically significant difference between means of TISP and SAT, the paired t-test is used. The value of t=76.59 is significant at the 0.05 confidence interval. This result indicated that performance in Integrated science process skill is significantly higher than the science achievement.

Regression analysis was run to determine which of the component process skill can be good predictor of the science achievement. It was found that Interpreting Data being the best component skill that can predict science achievement. However, R^2=22.3, this mean it accounts for only 21.2% of performance in science achievement. In the case of the overall Integrated process skill, 21.2% of the variation in science achievement can be explained by process skill.

Discussion and Conclusion

Integrated science process skills are important for students to use the inquiry-centered process to learn the content of science knowledge through a social process, as scientist often do. These help development of mental habits that are essential for the inquiry process and built on to prepare students for a realistic view of science. Educators promoting content and the inquiry process as the essence of learning science believe firmly that this combined approach in the early years will make a significant contribution to improving scientific awareness in later life.

The results of this study showed that students are more competent in Integrated science process skill compared to science achievement. This may be due to science process skill are broad transferable abilities. Students learn these abilities repeated in the three disciplines of science; biology, physics and chemistry but in the context of the respective content area. However, competency of integrated science process in this study is not measured directly, that is where students are required to demonstrate in hands-on experiment or investigation. Instead the learners are asked to select from a list of choices in stating the hypothesis, define operationally and identify variables. In this case, indirect assessment has the obvious advantages of efficiency. However, the written test may not tell if learners would be able to display the process skill when required

In line with the emphasis of the teaching of integrated process skills for the secondary school science curriculum, the Malaysian Examination Board has revamped the standardized tests. Beginning with the year 2003, the assessment of integrated process skill in a written format is introduced in the public examination besides the school based laboratory assessment. Items in the written test required students to plan and design an investigation that involves the use of all the integrated process skills. To answer items correctly, students must possess all components of integrated process skill as well as knowledge in science. Students who are weak in the content area may not be able to apply these skills. The result of this study showed that mastery of the Integrated Science Process Skill, however, does not ensure acquisition of scientific knowledge. This implied that the teaching of content must take precedent over the training of students on the acquisition of science process skills. Further studies may be needed to investigate what actually happens in the science classrooms to shed some light on the effectiveness of the teaching of the review science program at the secondary school level.

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6. BRIDGING INTEGRATED SCIENCE PROCESS SKILL AND SCIENCE ACHIEVEMENT

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Abstract: The main aim of the science curriculum is to help students understand, and become able to use, scientific knowledge. In addition, the science curricula also aim to develop students' ability of the scientific approach to inquiry. Good teachers create genuine intellectual activity that requires substantial proficiency with subject matter knowledge and science process skills. The science process skills, along with the knowledge those skills produce are the instructional objectives of Malaysian science education. With the emphasis on acquisition of science process, some teachers concentrated on the teaching of these skills ignoring the content of science. This study investigate pre-service teachers' development in the process skills with relation to science achievement. The Test of Integrated Science Process, a paper-and-pencil objective test that has been developed specific to the science content defined in the Malaysian school science curriculum is used to measure how competent pre-service teachers are in the processes of science. Science process skills are not subject specific. However, these skills operate in conjunction with specific knowledge. Items in the Test of Integrated Science Process contain conceptual materials on science as well as requiring the application of component integrated process skills. An objective test that required application of the science concepts in the Test of Integrated Science Process is used to determine science academic achievement. The relationship between competency in process skills and science content knowledge is determined using correlation coefficient and regression analysis. [In H.S. Dhindsa, et al. (Eds) (2006). *Shaping the future of science mathematics and technical education (pp. xx-yy).* Gadong, Brunei: ETC - Universiti Brunei Darussalam].

Introduction

In Malaysia, science has received a high priority in both primary and secondary schools. The main aim of the science curriculum is to help students understand, and become able to use, scientific knowledge. In addition, the science curricula also aim to develop students' ability of the scientific approach to enquiry. The modern science curriculum includes what scientists have found out (content) and what they do to find out (process). Some science educators have argued that explicit teaching about the methods of science is necessary. For some years, science educators (Gagne, 1965) have argued that acquisition of the science process skills should be a major goal of science instruction. Process skill learning has become an important component of science curricula at all levels. Acceptance of this view is reflected in curricula developed in recent years with an emphasis on the integrated process skills such as stating hypothesis, identifying and controlling variables and operationally defining variables. In some cases an understanding of science processes (or science method) is regarded as more important than content knowledge.

It is obvious that teachers need to know the subject matter knowledge that students are to learn. Moreover, subject matter must be understood in such a way to be usable in teaching. This means teachers must have the capacity to deconstruct their knowledge into a less polished and final form, so that critical components are accessible and visible to students.

Science Process Skills and Science Education

Science includes both the process of inquiry about natural phenomena and the content derived there from. The content of science is the accumulated and ever-expanding body of knowledge in any discipline to which scientific inquiry can be applied. The process is the tool through which knowledge is acquired, but it alone is not science (Hinman, 1998). The distinction between science content and process of acquiring it has important implications for science education. Some teachers now practice science education where the process of doing science becomes almost the sole focus. By overemphasizing process, teachers run the risk of not preparing students properly and turning them off science. To emphasize the importance of scientific content, the National Science Educational Standards (National Research Council, 1996) states, "An essential aspect of scientific literacy is greater knowledge and understanding of science subject matter" (p21). Not all science knowledge can be learned through the process approach. A good part of the content of science, especially in the higher grade, must be learned through more traditional methods such as lectures, textbooks, and systematic memorization. The factual and conceptual content is so rich that just to understand it, not to mention master it, requires rigorous, intensive study.

Though the major thrust of the elementary science program is to develop the pupil's skills in using science processes, science content should not be neglected. According to Livermore (1964), both the processes as well as content are important. Students use science process to learn science content. The integrated process skills are involved when conducting investigation or experiments; formulating a hypothesis, identify and control variables in designing an experiment, and making generalizations after collecting data. (Padilla, Okey & Dillashaw, 1983).

Science – A Process Approach (SAPA) grouped process skills into two types - basic and integrated (Livermore, 1964). The basic process skills such as observing, classifying and recording data are typically taught in primary schools. These skills provide a foundation for learning the integrated process skills such as formulating hypotheses, defining operationally, controlling and manipulating variables, planning investigations and interpreting data (Padilla, 1990), which are taught in secondary schools.

Many science curriculum guides and textbooks have cited important outcomes on the acquisition of integrated science process skills. This is because process skills represent the rational and logical thinking skills used in science. These process skills are intellectual skills used in collecting and analyzing data so as to solve problems. Chiappetta & Koballa (2002) has the opinion that the process skill approach is one teaching method that could be employed by teachers in the effort to teach science as inquiry.

It is important that inquiry-based instruction be conceptualized as teaching both the content (what) and the process (how) of science (Chiappetta & Adam, 2004). To help students in selecting productive questions to investigate, design suitable experiments to collect data, making a planned series of observations or measurements, analyzing and interpreting these data to reach a conclusion which is supported by the data, and being able to evaluate the quality of the support which their evidence gives to their conclusion.

Children's ability to use process skills depend on the extent of their knowledge of the contexts they are asked to work on. This would explain the finding that performance of tasks requiring these 'process skills' is strongly content-dependent (Song and Black, 1991; Lock, 1993)

The process is the tool through which knowledge is acquired and are reflective of the behavior of scientist. Chiappetta (1997) states that "the acquisition and frequent use of these skills can better equip students to solve problems, learn on their own, and appreciate science".

Studies have been conducted which dealt with student acquisition of integrated science process skills (Allen, 1973; Boyer & Linn, 1978; Linn & Their, 1975) in relation to other variables. Tobin and Capie (1981) found a significant inter-correlation (r =0.60) between formal reasoning ability and process skill achievement. Padilla, Okey and Dillashaw (1983) showed that they are closely related to the formal thinking abilities described by Piaget. In fact one of the ways that Piaget decided whether someone was formal or concrete was to ask that person to design an experiment to solve a problem. Tobin & Capie (1982) found that formal reasoning was the strongest predictor of process skills outcomes. Their finding underscores the importance of formal reasoning to achievement in science. A study on the relationship between the logical thinking skills and the integrated science process skill of high school students in North Carolina and Japan was carried out by Mattheis et al. (1992). A moderately strong and almost identical correlation was found to exist between the reasoning skills as measured by the GALT test and integrated process skills as measured by the TIP II test for each sample.

German (1989) investigated the effect of the directed-inquiry approach on science process skills and scientific problem solving. The researcher reported that the use of a directed-inquiry approach had no significant effect on the learning of science process skills or on cognitive development.

Problem Statements

There is a debate whether teachers should major in education or a discipline. In most teacher education program, little attention has been paid to the development of science subject matter knowledge in pre-service teachers. The implicit assumption is that an undergraduate doing a degree in a subject area provides an adequate basis for teaching. However, as concerns increase regarding children misconception in science, corresponding concerns are being raised about teachers' subject matter knowledge (Cochran & Jones, 1998). Dewey (1938) believed that good teachers were those who could recognized and create genuine intellectual activity in students, and he argued that methods of such activity were tied into disciplines.

Ball (2000) is of the opinion that subject matter and being able to use it is at the heart of teaching. Knowing content is crucial to being able to create worthwhile opportunities for learning that take learners' experiences, interest, and needs into account. Substantial proficiency with subject matter is needed in designing instruction that take into consideration of individual differences.

Although some teachers may understand the content, they often do not know it in ways that help them to select good tasks, or help all their students learn. Not being able to do this means that teachers cannot reach all students, teach flexibly in multicultural settings, represent ideas in multiple ways, connect content to contexts effectively, and think about things in ways other than their own (Ball, 2000)

Teacher education curriculum usually prevailed with separate domain of knowledge such as educational psychology, sociology of education, methods of teaching, and the academic disciplines corresponding to school subjects. These are complemented by experience which may include supervised practice and student teaching (Ball, 2000). To what extent the acquisition of knowledge in such discrete separation can bridge content closer to practice and to prepare teachers to know and to use subject matter knowledge effectively in their work as teachers. Teachers need to use content understanding in the context of practice to carry out the core activities of their work.

Wenner (1993) found that pre-service primary teachers have low levels of science knowledge overall and less confidence in their ability to teach science. Lee (1995) provides similar evidence from a case study approach, and shows that the limitation in subject matter knowledge of one middle school teacher resulted in a heavy reliance on the textbook and on seatwork, and on avoidance of whole class methods such as discussion.

In general, teachers are found to hold the same types of misconceptions as do students, but they are fewer in numbers (Wandersee et al. 1994). The teachers' misconceptions were similar in nature and pattern to those found for students, but were couched in more sophisticated scientific language.

Hashweh (1987) found teachers have less accurate conception in areas with which they are less familiar embedded misconceptions into their lesson plans for teaching and would have directly pass on these ideas to students.

The science process skills, along with the knowledge those skills produce, and the scientific values and habits of mind define the nature of science. Unfortunately, the teaching and learning of science does not always reflect the true nature of science. Too often, science instruction inside the science classrooms merely cover vast amounts of abstract science contents. As a result, students merely possess chunks of science knowledge at the end of the science program.

Most science lessons emphasized either science content or science processes. There is a problem of how to integrate content and process of science. Teachers need to capitalize on opportunities in the activities normally done in the science classroom to emphasize integrated science process skills. Students conducting these activities are expected to develop such skills as stating hypotheses, operationally defining variables, designing investigations, and interpreting data in addition to mastering the content of the courses. Science teachers may not possess pedagogical knowledge to teach students scientific facts in relation to the procedures of science process skills (Sears, Paul & Kessen, 1964). Most of them did not learn science process skill systematically while they were in schools or in the training institutions.

There has been claimed that exposure to a systematic science program which emphasis integrated science process promotes cognitive development. With the implementation of the new science curricula which emphasize the teaching of science process skills systematically in both the primary as well as the secondary schools, integrated science processes became the instructional objectives in the Malaysian secondary schools science program. Science educators should be aware of the important aspects of students' competency levels in integrated process skills and their abilities in using these integrate process skills to obtain science knowledge. As such, data regarding pre-service teachers' development of the process skills in relation to science academic achievement is needed. This will provides insights on implementation of the new science curriculum.

Teachers Knowledge

Garnett & Tobin (1988) identify a factor that contributed to the effective teacher was the impressive content knowledge and pedagogical content knowledge. These teachers were able to use their content knowledge to stimulate learner engagement on higher-cognitive-level objectives. The teacher used questions directed to individual student to promote thinking about content. They attributed this was possible because the teacher had a firm grasp of the content he wanted to teach and knew how to sustain student engagement. Content knowledge was necessary to answer student questions, diagnose problems or misunderstandings, and ask questions to stimulate productive thought.

Garnett & Tobin (1988) went on further to suggest that the teacher extensive knowledge of content enable him to introduce the content in an appropriate manner and assists students to link concepts within lessons and from one lesson to the next. Teachers also able to use illustrative examples from real life so as to provide students with a model of how science ought to be presented and learned.

Many teachers did not acquired science process skills as reported by Mohamed (2001) in his study on pre-service as well as in-service teachers.

Objectives of This Study

The development of curricula which emphasize the process of science has created a need for evaluating the mastery of the process of science. Assessing competence in the process skills can be difficult and time consuming if done through observation of laboratory situations. However, quality paper and pencil test can be used to achieve accurate measures of performance in these skills.

The purpose of this study is to compare the competency of pre-service teachers on the integrated science process skill and achievement in science content knowledge. This study also looks at the relationship between acquisition of integrated process skills and achievement in science knowledge. It is hope that acquisition of science process skill may be able to predict achievement in science.

Research Questions

This study will seek to answer the following questions:

1. What is the level of pre-service teachers' competency in integrated science process skill?
2. What is the level of pre-service teachers' achievement in science content knowledge?
3. Is there any significant relationship between acquisition in the science process skill and science knowledge achievement?
4. Is science process skill ability a good predictor of science achievement?

Methodology

Test of Integrated Science Process, TISP (Ong, Zurida and Fong, 2006) is used to assess pre-service teachers' competency in integrated science process skill. This is a paper-and-pencil group test that provides a means of measuring process skill competency efficiently and objectively.

TISP measures how competent pre-service teachers are in the processes of science. TISP items are curriculum specific, which were developed based on the Malaysian secondary school science curriculum. The integrated science processes selected for testing are those associated with planning investigations. They include formulating hypotheses, operationally defining variable, identifying and controlling variables as well as interpreting data.

The academic achievement in science is determined using the science achievement test. Test of science achievement consists of 30 items required application of the science knowledge in the TISP.

These two tests were administered to the second and third year B. Sc. Science students. The subjects of this study included 21 students taking Physics Teaching Method II course and 85 Chemistry Teaching Method II course students. Tests were administered after lecture on science process skills. There were a total of 106 students who has taken both tests. Test of Integrated Science Process Skills was administered during the 3rd week of the course, while the science achievement test was administered during the subsequent week. Each test required 30 minutes administration time.

Analysis of Data

Subjects' performance on both TISP and science achievement were compare using descriptive statistic as well as t-test. To determine pre-service teachers ability in integrated science process skill and science achievement, Rasch's model using computer program WINDSTEPS was used. Competency in the integrated science process and science content knowledge is then compared.

Table 1
Descriptive Statistic for Science Achievement and Integrated Science Process Skill

	Science Achievement	Process Skill
Mean	19.59	23.74
S.D.	3.29	3.35
Variance	10.82	11.19
Skewness	-.21	.253
Kurtosis	-.02	-.93
Minimum	11	16
Maximum	27	32
N	106	106

Findings

Statistic descriptive to summarized data for science achievement and integrated science process skill is given in Table 1. The mean score in science achievement is 19.59 with s.d of 3.29. The mean score of integrated science process skill is 23.74 with s.d of 3.35. For both test, no subject obtained a full score, maximum score for science achievement is 27 (Total=30) and maximum score for integrated science process skill is 32 (Total =36).

Using the score obtained by the subjects, the correlation between science achievement and process skill acquisition was found to be moderate, that is $r=0.394$.

When a simple regression analysis is run to see whether science process skill is a good predictor of success in science, the value of $R^2 = 0.099$. This means that only 9.9% of performance in science achievement can be attributed to acquisition of science process skill. However, the model was found to fit the regression equation of

$$\text{Science achievement} = 12.27 + 0.31\text{x Science process skill}$$

The low coefficient of determination showed that competency in science process skill may not guarantee success in acquiring science knowledge.

The analysis from WINSTEPS show that the mean of integrated process skill ability is 0.83, that is, higher than the mean ability in science achievement as shown in Table 2.

Table 2
Mean and Standard Deviation of Person Ability

	Mean	N	S.D.	S.E.M
Integrated Process Skill	.83	106	.62	.06
Science Achievement	.66	106	.73	.07

The ability of the subjects is classified into three levels; lower than zero logits, below the mean value and above 2. Those who are classified as below zero are considered as weak, while those who are above 2 are the proficient one. For ability above mean value but less than 2 would have mastered the necessary knowledge to be a science teacher. The bulk of the subjects are classified in this category. However, 14 of them who do not master enough science content knowledge will be of much concern.

Comparison between integrated process skill and science achievement showed that ability in integrated science process skill is higher than achievement in science. There were 13.2 % (N=14) of them having ability below zero for the science achievement as compared to 4.73% (N=5) for integrated science process skill. As for comparison with the mean value, 52.8% (N=56) have ability above the mean ability of integrated science process skill and slightly smaller, 43.4% (N=46) of them are above the mean ability in science knowledge. The results is classified as in Table 3.

Table 3
Classification of Subjects' Ability for Integrated Science Process Skill and Science Achievement

	$\theta > 2$	$\theta >$ mean value	$\theta < 0$
Integrated Process Skill	5	56	5
Science Achievement	4	46	14

When comparing integrated science process skill ability and science knowledge ability by computing paired-sample t-test, $t=2.207$, and was found to be significant at $p=0.05$ with $df=105$. This suggests that ability of pre-service teachers in science process skill seem to be better than that of science achievement. Pre-service teachers knew science process skill but not as well in science content knowledge. The correlation between ability in integrated science process and science content knowledge, $r=.37$ was significant at $p=0.05$.

Discussion and Implication of the Study

Teachers should teach science in such a way which further its value in pupil's education. They will not be able to structure curriculum to make complex information more accessible to students if they are not proficient in the science concepts and skills they are teaching. The results of this study showed that pre-service teachers are not proficient in the science process skill and especially science content knowledge. Garnett & Tobin (1988) stressed the importance of science content knowledge to teachers in order to link and sequence lessons carefully as well as using concrete model to facilitate understanding. The in-service and pre-service programs designed to improve science teaching should first establish that teachers have the necessary science content knowledge that they are to teach.

Studies have suggested that the characteristics and levels of teachers' subject matter knowledge are specifically related to teaching practices (Tobin et al. 1994). This study raises concern about teachers' science content knowledge. More research need to be carried out to tell us about what teachers really know, what influences teacher knowledge has on teaching and on the subsequent learning of their students.

It is a pedagogical triumph to teach scientific fact in relation to the integrated process skill. To become an effective science teacher, a science teacher must understand how to guide pupils to use these processes in the context of learning science concepts. In the teaching of science process skills, science teachers main job is to provide the situation for the hands-on learning rather than to tell about or explain theses skills. Competency in the integrated science process skills and science content knowledge among pre-service science teachers was found to be unsatisfactory. Steps need to be taken to develop teachers' ability in this area. Information obtain from this study will be useful to plan appropriate teacher training program so as to prepare science teachers in the implementation of the science education in school.

The relationship between science process skills and science achievement was moderate. This may indicate acquisition of science process skill does not in any way help in improvement in science achievement. As competency in process skills does not improve achievement in science, a further look as to whether decision on emphasizing the teaching of these skills over the content of science should be continued. Information regarding relationship between competency in process skill and achievement in science may help to shed some light on the direction of the teaching of science program in the secondary school level.

Limitations of the study

A note of caution about the science process skill being measured. Competency of integrated science process in this study is not measured directly, that is where students are required to demonstrate in hands-on experiment or investigation. It would be very time-consuming to directly measure all these skills in science classroom activities. Instead the pre-service teachers were asked to select from a list of choices in stating the hypothesis, define operationally and identify variables. In this case, indirect assessment has the obvious advantages of efficiency. However, the written test may not tell if learners would be able to display the process skill when required.

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7. Assessing Preservice Science Teachers Competency in Integrated Science Process Skill

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Abstract: *The aim of science education is to help students to understand scientific knowledge and to develop students' ability of the scientific approach to enquiry. The process skill approach is one teaching method that could be employed by teachers in the effort to teach science as inquiry. The process skill approach focuses on teaching broadly transferable abilities that are appropriate to many science disciplines and are reflective of the behavior of scientists. The acquisition and frequent use of theses skills can better equip students to solve problems, learn on their own, and appreciate science. In Malaysia, science process skills has been given great emphasis in the review science curriculum which was implemented simultaneously for both primary and secondary schools nationwide in 2002. Process skill learning has become an important component of science curricula at all levels. Students, however need to acquire both science process skills and the knowledge of science. Too often, science instruction inside the science classrooms merely cover vast amounts of abstract science contents. When this happens, students merely possess chunks of science knowledge at the end of the science program. On the other extreme, some teachers now practice science education where the process of doing science becomes almost the sole focus. Both the processes as well as content are important. However, most science teachers emphasized either science content or science processes. They encounter problem of how to integrate content and process of science. Science teachers may not possess pedagogical knowledge to teach students scientific facts in relation to the procedures of science process skills. Most of them did not learn science process skill systematically while they were in schools or in the training institutions. The aim of this study is to determine pre-service science teacher competency level in integrated science process skills. This competency level may help to provide insight on how well the new emphasis in the science curriculum will be implemented. The Test of Integrated Science Process Skills (TIPS II) is being used to assess pre-service teachers competency in integrated science process skill. The test was administered to science with education undergraduates who registered for the physics teaching methods course.*

Introduction

Reform has been a major part of science education for the last few decades. Science will never be a finished body of knowledge because new ideas and theories are always being proposed, new discoveries being made. The main aim of the science curriculum is to help students understand, and become able to use, scientific knowledge. In addition, most curricula also aim to develop students' ability of the scientific approach to enquiry. The report by the American Association for the

Advancement of Science (1990) emphasized that the teaching of scientific concepts should be consistent with the nature of scientific inquiry.

To be scientifically literate, a person needs to have knowledge of concepts and theories of science, and, in addition, to have some understanding of how this knowledge has been obtained in the past and is still being learned today. Some science educators, however, have argued that explicit teaching about the methods of science is necessary. The process skill approach (Chiappetta & Koballa, 2002) is one teaching method that could be employed by teachers in the effort to teach science as inquiry. In some cases an understanding of science processes or science method is regarded as more important than knowledge content (Millar,n.d.).

To study science is to learn about what other people have found out and to learn about the methods that allowed them to arrive at this knowledge. (Howe & Jones, 1998). Throughout the last three decades science educators have advocated that science processes be taught in primary and secondary schools. For some years, science educators (Gagne, 1965) have argued that acquisition of the science process skills should be a major goal of science instruction. Process skill learning has become an important component of science curricula at all levels. Acceptance of this view is reflected in curricula developed in recent years with an emphasis on the integrated process skills such as stating hypothesis, identifying and controlling variables and operationally defining variables.

The goal for science education (Rezba et. al, 1995) in the nineties and beyond, stress science as ways of thinking and investigating as well as a body of knowledge. Padilla (1990) called these ways of thinking in science as the process skills. Other terms such as the scientific method, scientific thinking and critical thinking are terms used at various times to describe these skills. Today the term "science process skills" is most commonly used.

Types of Process Skills

Science – A Process Approach (SAPA) grouped process skills into two types - basic and integrated (Livermore, 1964). The basic science process skills provide a foundation for learning the more complex integrated science process skills (Padilla, 1990). Processes such as observing, classifying and recording data, which are typically taught in primary schools, act as prerequisites for integrated processes such as hypothesizing, controlling and manipulating variables, defining operationally, planning investigations, and interpreting data, which are taught in secondary schools. (Livermore, 1964).

Importance of Science Process Skills

Many science curriculum guides and textbooks have cited important outcomes on the acquisition of integrated science process skills. These processes are rooted in the simple processes and seem necessary to the aim of acquiring a scientific approach to knowledge at the intermediate levels (Livermore, 1964). This is because process skills represent the rational and logical thinking skills used in science. These process skills are intellectual skills used in collecting and analyzing data so as to solve problems. Students can use process skills to formulate responses to questions, to justify points of view, to explain events or procedures, and to interpret or describe data.

The modern science curriculum includes what scientists have found out (content) and what they do to find out (process). Concepts, explanations, understanding, and theories constitute the content of science; the ways scientists make observations, try to explain the observations, and invent concepts and theories constitute the process of science. Although science process skill has been introduced in United States in the 1960s, it was not popularized in Malaysia until very recently. In Malaysia, this emphasis is seen in the recently review science curriculum which was implemented for both primary and secondary schools nationwide in 2002 (Kementerian Pendidikan, 2001). With the implementation of the new science curricula which emphasize the teaching of science process skills systematically in both the primary as well as the secondary schools, integrated science processes became the instructional objectives in the Malaysian secondary schools science program.

There has been claimed that exposure to a systematic science program which emphasis integrated science process promotes cognitive development. Chiappetta (1997) states that "the acquisition and frequent use of theses skills can better equip students to solve problems, learn on their own, and appreciate science". The process skill approach focuses on teaching broadly transferable abilities that are appropriate to many science disciplines and are reflective of the behavior of scientists (Padilla, 1990). The integrated process skills are involved when conducting investigation or experiments; formulating a hypothesis, identify and control variables in designing an experiment, and making generalizations after collecting data. (Padilla & Okey, 1983).

Scientific approach as integration of process skills

Some science educators have argued that the scientific approach to enquiry can be thought of as a set of process skills such as observing, classifying, inferring, predicting, hypothesizing and so on. As a result of this, Science, A Process Approach (SAPA), which was based on Gagne's analysis of the processes of science and of learning was recommended (Liver, 1967). Several science courses in the UK in the 1980's also follow this line, some using the processes (rather than science content) to structure the program, and seeing learning primarily in terms of the development of pupils' process skills, that is their ability to carry out these processes in a range of context (Millar, n.d.).

Instruments to assess process skills were also developed. The characteristic of all these approaches is that science method is portray as a set of discrete 'thinking skills', which can be practiced and developed separately before being combined to tackle more demanding problems.

Problem Statements

The science process skills, along with the knowledge those skills produce, and the scientific values and habits of mind define the nature of science. Unfortunately, the teaching and learning of science does not always reflect the true nature of science. If it is, students would acquired both science process skills and the knowledge of science. Too often, science instruction inside the science classrooms merely cover vast amounts of abstract science contents. As a result, students merely possess chunks of science knowledge at the end of the science program.

Though the major thrust of the elementary science program is to develop the pupil's skills in using science processes, science content should not be neglected. According to Livermore (1964), both the processes as well as content are important. To emphasize the importance of scientific content, the National Science Educational Standards (National Research Council, 1996) states, "An essential aspect of scientific literacy is greater knowledge and understanding of science subject matter" (p21).

Students use science process to learn science content. Science includes both the process of inquiry about natural phenomena and the content derived from these processes. By overemphasizing process, teachers run the risk of not preparing students properly and turning them off to science in the long run. The content of science is the accumulated and ever-expanding body of knowledge in any discipline to which scientific inquiry can be applied. The process is the tool through which knowledge is acquired, but it alone is not science (Hinman, 1998). The distinction between science content and process of acquiring it has important implications for science education. Some teachers now practice science education where the process of doing science becomes almost the sole focus. While it is true that without process the content of science would become static or even decay, it is also true that without content the accumulated knowledge of past scientific endeavors would be lost.

Most science teachers emphasized either science content or science processes. This is because they encounter problem of how to integrate content and process of science. Teachers need to capitalize on opportunities in the activities normally done in the science classroom to emphasize integrated science process skills. Students conducting these activities are expected to develop such skills as stating hypotheses, operationally defining variables, designing investigations, and interpreting data in addition to mastering the content of the courses. Science teachers may not possess pedagogical knowledge to teach students scientific facts in relation to the procedures of science process skills (Sears, Paul & Kessen, 1964).

It is expected that competency in the integrated science process skills among pre-service teachers may not be satisfactory. Most of them did not learn science process skill systematically while they were in schools. It is a pedagogical triumph to teach scientific fact in relation to the integrated process skill. To become an effective science teacher, a science teacher must understand how to guide children to use these processes in the context of learning science concepts. In the teaching of science process skills, science teacher main job is to provide the situation for the hands-on learning rather than to tell about or explain theses skills. Workbooks for science activities have been found to provide inaccurate answers on experiment and investigation that students carried out in the science laboratory. Skills such as stating hypotheses, operationally defining variable, and identifying variables of investigation for the specific science content was not appropriately given. If result from this study indeed show that competency in integrated process skill is low among teachers, steps need to be taken to develop teachers' ability in this area.

It is important that inquiry-based instruction be conceptualized as teaching both the content (what) and the process (how) of science (Chiappetta & Adam, 2004). Science educators should be aware of the important aspects of students' competency levels in integrated process skills and their abilities in using these integrate process skills to obtain science knowledge. To be able to help students in selecting productive questions to investigate, design suitable experiments to collect data, analyzing and interpreting these data, this clearly depend to a very large extent, on the teachers ability to use process skills to acquire science content knowledge in the domain concerned.

Objectives of The Study

The development of curricula which emphasize the process of science has created a need for measures capable of evaluating the understanding of the process of science. This assessment base on students' ability to display behaviors that are components of the process skills.

Assessing ability in the process skills can be difficult and time consuming if done through observation of laboratory situations. However, quality tests can help in providing accurate measures of performance in these skills.

The purpose of this study is to evaluate the competency of preservice secondary school teachers on the integrated science process skill using an established instruments.

Related Research

A number of paper and pencil tests have been developed to assess integrated process skill (e.g. Tannenbaum, 1968; Fyffe, 1971; Riley, 1972; Robinson, 1973; Ludeman, 1975; Dillashaw & Okey, 1980). McLeod et al. (1975) developed the Group Test of Four Processes to measure the skills of controlling variables, interpreting data, formulating hypotheses, and operationally defining. The test was designed to measure these skills as defined by the SAPA elementary school science curriculum

Ridley (1972) developed the Test of Science Inquiry Skills (TSIS) for fifth-grade students. The TSIS measured the skills of identifying and controlling variables, interpreting data, predicting and inferring as defined by the Science

Curriculum Improvement Study elementary science program. In addition to tests for students, tests of the process skills have been developed for teachers. Burns (1972) developed a test to measure the acquisition of the integrated science process skills by undergraduate elementary education majors.

Several studies have also investigated on the learning of integrated science process skills. Both Quinn and George (1975) and Wright (1981) found that students can be taught to formulate hypotheses and that this ability is retained over time. Others have tried to teach all of the skills involve in conducting experiment (Padilla, Okey and Garrard, 1984). Their results indicated that these complex process skills cannot be learned via a two weeks unit in which science content is typically taught. Rather, experimenting abilities need to be practiced over a period of time.

In Malaysia, Ismail and Zurida (1996) translated TIPS II to Bahasa Malaysia. The translated version of TIPS II was administered to 268 Form 4 secondary school students. Zurida reported (1998) that acquisition of Integrated Process Skills was not satisfactory. This may be a result of the content of the item being unsuitable to the Malaysian students. Further, at the time the skill being measured, the Malaysian schools did not emphasised on the teaching of the science process skill explicitly in the science curriculum. As a result many of the teachers do not teach the process skill in the science classroom. Mohamed (2001) reported in his study that many pre-service as well as in-service teachers did not acquired science process skills.

Studies have been conducted which dealt with student acquisition of integrated science process skills (Renner & Weber, 1972; Boyer & Linn, 1978; Allen, 1973; Linn & Their, 1975) in relation to other variables. Tobin and Capie (1981) found a significant inter-correlation (r =0.60) between formal reasoning ability and process skill achievement. Padilla, Okey and Dillashaw (1983) showed that they are closely related to the formal thinking abilities described by Piaget. In fact one of the ways that Piaget decided whether someone was formal or concrete was to ask that person to design an experiment to solve a problem. Tobin & Capie (1982) found that formal reasoning was the strongest predictor of process skills outcomes. Their finding underscores the importance of formal reasoning to achievement in science.

Further study of process skills by Doran & Sellers (1978) investigated relationships between students' mental ability, gender, biology achievement and science process achievement. The achievement measures contained items on experimenting, predicting, and concluding. The authors reported that mental ability was related to the process achievement. The relationship was not strong, however, as biology achievement and mental ability together accounted for only nine percent of the variance in process skill achievement.

Methodology

Instrument

The Test of Integrated Science Process Skills (TIPS II) which was translated to Bahasa Malaysia by Ismail and Zurida (1996) was used to assess preservice teachers competency in integrated science process skill.

The Test of Integrated Process Skills (TIPS) developed by Dillashaw and Okey (1980) for a non-curriculum specific process skills test was developed for middle and secondary students. The TIPS was designed to assess the proficiency in the integrated science process skills that include skills such as formulating hypotheses, operationally defining, controlling, and manipulating variables, planning investigation and interpreting data. Dillashaw and Okey stated that this instrument is a valid and reliable measure of science process skill achievement for students in the 7^{th} to 12th grade. Reliability of the test using Cronbach's alpha was found to be .89. The mean item discrimination of the instrument was reported as .40. In addition, a readability index of .92 was reported for this instrument.

Burns, Okey & Wise (1985) revised TIPS and developed TIPS II to measure five component of integrated process skills: identifying variables (12 items), identifying and stating hypotheses(10 items), operationally defining variables (7 items), designing investigation(2 items) and graphing and interpreting data (6 items).

Sample

TIPS II was administered to second and third year B.Sc. Ed students following the physics methodology course. All students taking the test have at least learned twice on the topics of science process skills in the methodology course. This is because the science methodology course for biology, chemistry and physics all cover this topic. Students were given 20 minutes to complete the test at the end of the lecture on science process skills.

Results

The score obtained by the sample were divided into three categories. The raw score and percentage score obtained by the sample is as shown in Table 1. The spread of the score approximate normal distribution.

Table 1: The number of students for each category of raw score and percentage score

Raw score	Percentage score	N
16 - 21	44.4 – 58.3	20
22 - 28	61.1 – 77.8	88
29 - 32	80.6 – 88.9	16

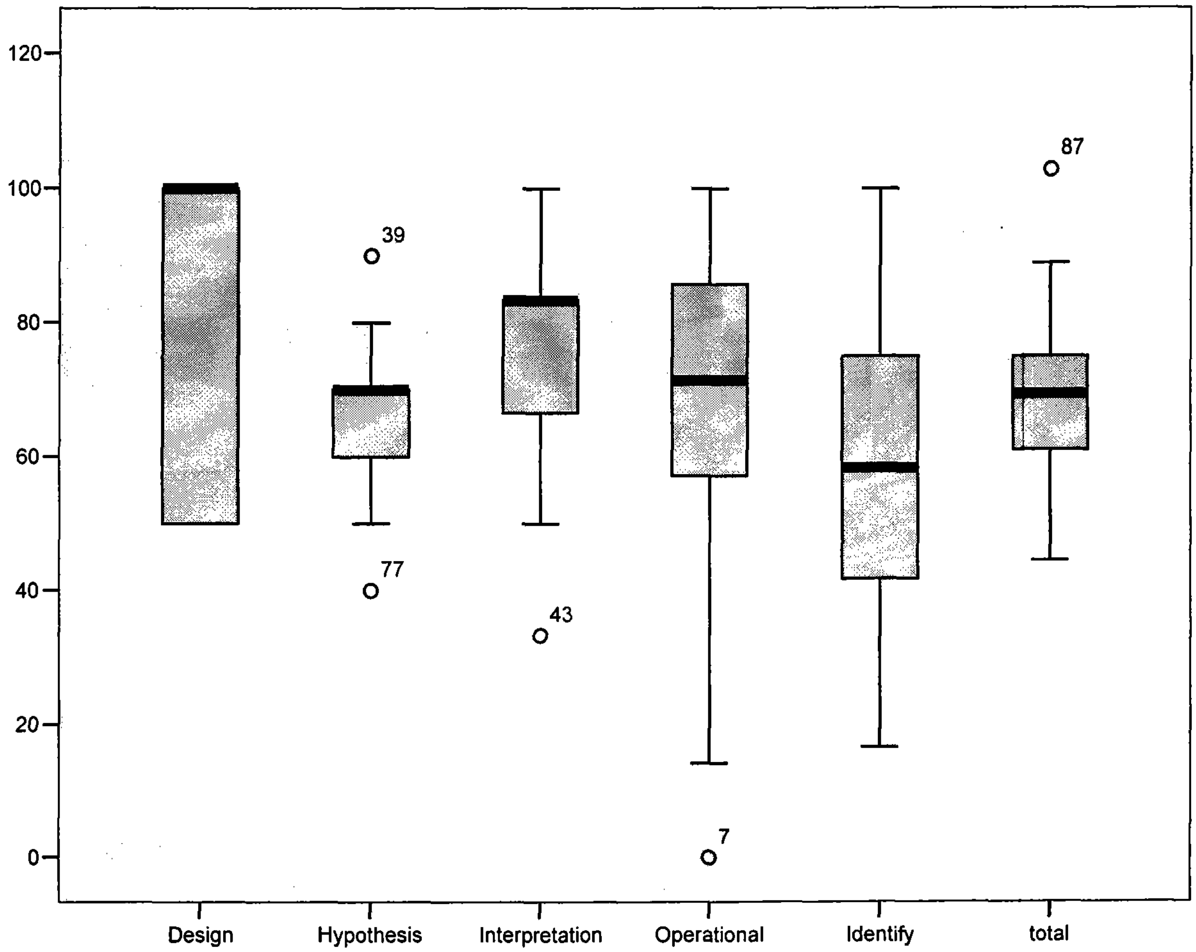
16.1% (20) of the students percentage score were found to be less than 60. The majority of the students, 71% (88) obtained score between 61.1% to 77.8%. Only 12.9% of them have score above 80%.

Analysis was also carried out according to the component skills. The average score for each of the component integrated process skills and the average total score is given in table 2.

Table 2: Average percentage score of the component integrated process skills

Skills	Average Percentage Score
Identify variables	59
Operationally Defining Variables	68
Formulating Hypothesis	68
Interpreting Data	77
Designing experiment	79
Overall	69

The results indicated the highest achievement obtained for designing experiment while the lowest was in identifying variables.



Graph 1: Boxplot in percentage score for component abilities and overall instrument

Analysis of performance on component skills is also computed in terms of percentage and number of pre-service teacher who select the correct answers. Table 3 provide the analysis for ability in formulating hypothesis.

Table 3: Percentage correct for 9 items in formulating hypotheses

Item	4	6	8	12	16	17	27	29	35
Percentage correct	91.1	42.7	90.3	83.1	21.8	99.2	94.4	96	61.3
N	113	53	112	103	27	123	117	119	76

The highest percentage correct, 99.2% for item 17 while the lowest obtained is for item 16, only 21.8% answer correctly.

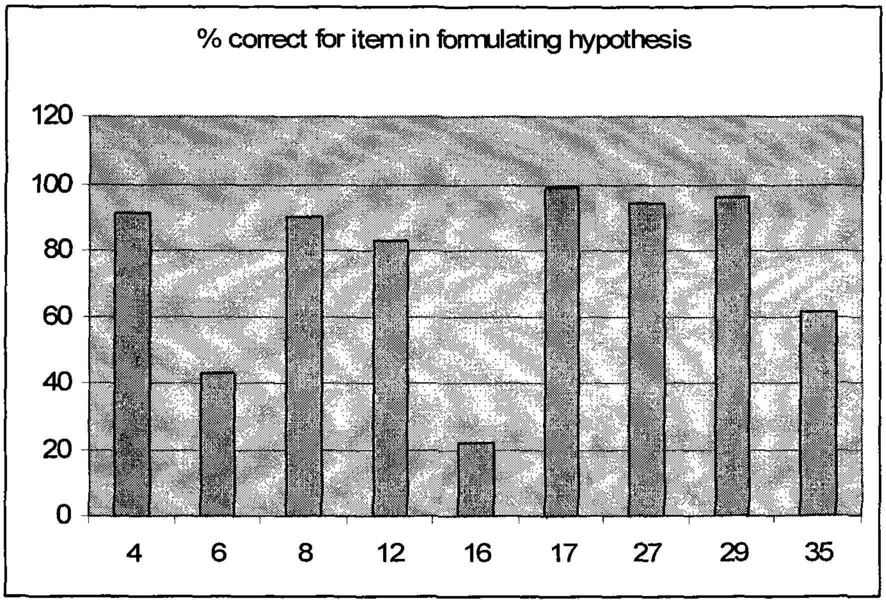


Table 4 provided the analysis for identifying variables.

Table 4: Percentage correct for 10 items in identifying variables

Item	1	3	13	14	15	18	19	20	30	31	32	36
Percentage Correct	61.3	64.5	66.9	82.3	54.8	47.6	87.1	42.7	42.7	82.3	30.6	45.2
N	76	80	83	102	68	69	108	53	53	102	38	56

For identifying variables, the highest percentage correct, 87.1% for item 19 while the lowest percentage correct is 42.7%, which occurs in item 20 and 30.

Analysis for operationally defining variables is computed for seven items as is given in table 5. The highest percentage correct, 91.9% for item 26 while the lowest percentage correct is only 36.3%.

Table 5: Percentage correct for operationally defining variables.

Item	2	7	21	22	23	26	33
Percentage Correct	83.9	61.3	36.3	63.7	76.6	91.9	59.7
N	104	76	45	79	95	114	74

Analysis for interpreting data is computed for six items as is shown in table 6. The highest percentage correct, 98.4% for item 9 while the lowest percentage correct, 83.1% correct for item 34. The range for this ability is small.

Table 6: Percentage correct for interpreting data

Item	5	9	11	25	28	34
Percentage Correct	86.3	98.4	96.8	84.7	89.5	83.1
N	107	122	120	105	111	103

For designing experiment, there were only two items. The analysis is as shown in table 7.

Table 7: Percentage correct for designing experiment

Item	10	24
Percentage correct	99.2	58.1
N	123	72

Discussion

Competency in integrating science process skills of pre-service teachers is classified into three levels. Most of them (71%) are considered in the knowledge level while only 16.1% are considered as in the proficiency level. 20% of them are at the basic level.

The data also showed that pre-service teachers seem to perform better in designing experiment and not good in identifying variables. However, the number of items for assessing designing experiment consisted of only two items. This may limit its function in accurately measuring the component skill.

There appear a big range of performance for answering item correctly in all the component skills except interpretation of data. Pre-service teachers are proficient in interpreting data with percentage correct for all items exceeded 80%. Performance in Formulating hypotheses was satisfactory as five out of the nine items with more than 80% answering correctly. For operationally defining variable, only two out of seven items with percentage correct more than 80%. The poor performance in identifying variable may indicate concern, as only two out of then ten items with percentage correct exceeded 80%.

Limitations

In this study competency of integrated science process skill is not measured directly, that is where students are required to demonstrate in hands-on experiment or investigation. It would be very time-consuming to directly measure all these skills in science classroom activities. Instead a written test is used as the obvious advantage is efficiency. However, learners may not be able to display the process skill when required.

Implication of the study

In line with the emphasis of the teaching of integrated process skills for the secondary school science curriculum, the Malaysian Examination Board has revamped the standardized tests. Beginning with the year 2003, the assessment of integrated process skill in written format is introduced in the public examination besides the school based laboratory assessment which is known as 'PEKA' . Items in this test will ask students to plan and design an investigation that involves the use of all the integrated process skills in physics, chemistry and biology. To answer items correctly, students must possess all components of integrated process skill as well as knowledge in science. Students who are weak in the content area may not be able to apply these skills.

Information obtain from this study will be useful for planning teacher program in preparing pre-service teachers in teaching science process skills. The unsatisfactory performance shown by pre-service teacher indicates that science process skills cannot be acquired by from being told; it has to be constructed by the learner. This may suggest that the approach of lecturing may not be suitable in teaching science process skills.

Science teachers who do not master science process skills may not emphasized teaching of these skills in the school. The teaching of content takes precedent over the training of students on the acquisition of these skills as it is time consuming to do so. This is also driven by the examination structure. For the written format public examination in Malaysia, 80% of the items are testing students' content knowledge and only 20% will be on the integrated process skill. In the secondary schools science program which takes two years to complete, students will be assess on the science process skill in the laboratory by conducting four experiments. This is a school base assessment that is being done by the respective subject teachers, and students normally perform well. Pre-service science teachers who are not proficient in process skill may not be effective in implementing the teaching of the new science program which emphasized on the acquisition of these skills.

Integrated science process skills are important for students to use the inquiry-centered process to learn the content of science knowledge. These help development of mental habits that are essential for the inquiry process and built on to prepare students for a realistic view of science. Educators promoting content and the inquiry process as the essence of learning science believe firmly that this combined approach in the early years will make a significant contribution to improving scientific awareness in later life.

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Tuan/Puan,

Kebenaran Untuk Menjalankan Kajian Di Sekolah, Maktab Perguruan, Jabatan Pelajaran Negeri Dan Bahagian-Bahagian Di Bawah Kementerian Pelajaran Malaysia

Adalah saya dengan hormatnya diarah memaklumkan bahawa permohonan tuan/puan untuk menjalankan kajian bertajuk :

" Assessing Competency In Integrated Science Process Skills And Relation With Science Achievement " diluluskan.

2. Kelulusan ini adalah berdasarkan kepada cadangan penyelidikan dan instrumen kajian yang tuan/puan kemukakan ke Bahagian ini. **Kebenaran bagi menggunakan sampel kajian perlu diperolehi dari Ketua Bahagian/Pengarah Pelajaran Negeri yang berkenaan.**

3. Sila tuan/puan kemukakan ke Bahagian ini senaskah laporan akhir kajian setelah selesai kelak. Sayugia dimaklumkan tuan/puan hendaklah **mendapat kebenaran terlebih dahulu** daripada Bahagian ini sekiranya sebahagian atau sepenuhnya dapatan kajian tersebut hendak dibentangkan di mana-mana forum atau seminar atau untuk diumumkan kepada media massa.

Sekian untuk makluman dan tindakan tuan/puan selanjutnya. Terima Kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menurut perintah,

(DR. AMIR BIN SALLEH @ MOHD SALEH)
Timbalan Pengarah, Sektor Penyelidikan Dasar
Bahagian Perancangan dan Penyelidikan Dasar Pendidikan
Kementerian Pelajaran Malaysia

s.k.

Pengarah
Jabatan Pelajaran Negeri Pulau Pinang

Prof. Dr. Aminah Ayob
Dekan
Pusat Pengajian Ilmu Pendidikan
Universiti Sains Malaysia
11800 Minden
Pulau Pinang

JABATAN PELAJARAN PERAK,
JALAN TUN ABDUL RAZAK,
30640 IPOH,
PERAK DARUL RIDZUAN.

Telefon : 05-527 4355
Faks : 05-527 7273

' KOMUNITI BERILMU PERAK TERBILANG '

J.Pen.Pk.Pend.S4757/Jld.23(66)
Tarikh : 27 Januari 2006

Dr. Ong Saw Lan
Pensyarah
Pusat Pengajian Ilmu Pendidikan
Universiti Sains Malaysia
11800 Minden
Pulau Pinang

Tuan,

KEBENARAN UNTUK MENJALANKAN KAJIAN
<u>DI SEKOLAH-SEKOLAH MENENGAH / RENDAH NEGERI PERAK</u>

Saya diarahkan merujuk surat tuan bertarikh 16 Januari 2006 yang ada kaitannya dengan surat Kementerian Pendidikan Malaysia bilangan KP(BPPDP)603/5 Jld. 010(672) bertarikh 27 Oktober 2005 tentang perkara di atas.

2. Sukacita dimaklumkan bahawa pihak Jabatan Pendidikan Perak tiada halangan memberi kebenaran kepada tuan untuk menjalankan kajian dan soal selidik bertajuk **' Assessing Competency In Integrated Science Process Skills And Relation With Science Achievement'** di sekolah-sekolah negeri Perak.

3. Kehadiran tuan/puan membuat kajian di sekolah berkenaan tidak seharusnya menjejaskan proses pengajaran dan pembelajaran di sekolah berkenaan.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA'

Saya yang menurut perintah,

(ADAM BIN DARUS)
Penolong Pendaftar Sekolah
Jabatan Pelajaran Perak
b.p. Ketua Pendaftar Sekolah dan Guru
Kementerian Pelajaran Malaysia

s.k. 1. Pendaftar Sekolah dan Guru
Jabatan Pelajaran Perak
2. Penolong Pendaftar Sekolah dan Guru
Pejabat Pelajaran Daerah Negeri Perak.

JABATAN PELAJARAN PULAU PINANG
JALAN BUKIT GAMBIR
11700 PULAU PINANG

No. Telefon : 04-657 5500
No. Faks : 04-658 2500
http://www2.moe.gov.my/~jpnpp

Ruj. Tuan :
Ruj. Kami : Bil. (72) dlm. Pen. P. P. 0051-2Jld. 23

Tarikh : 5 Januari 2006

Dr. Ong Saw Lan
Pusat Pengajian Ilmu Pendidikan
Universiti Sains Malaysia
11800 Minden, Pulau Pinang

Tuan/Puan,

KEBENARAN MENGGUNAKAN SAMPEL KAJIAN DI SEKOLAH-SEKOLAH DI BAWAH JABATAN PELAJARAN PULAU PINANG

Dengan hormatnya saya diarah merujuk perkara tersebut di atas.

2. Surat kelulusan menjalankan kajian dari Bahagian Perancangan Dan Penyelidikan Dasar Pendidikan, Kementerian Pelajaran Malaysia Bil.KP(BPPDP) 603/5 Jld.10 .(672) bertarikh 27 Oktober 2005 adalah dirujuk.

3. Adalah dimaklumkan bahawa pihak Jabatan Pelajaran Pulau Pinang, tiada halangan untuk Tuan/Puan menggunakan sampel kajian di sekolah-sekolah negeri Pulau Pinang yang bertajuk:

> **"Assessing Competency In Intergrated Science Process Skills And Relation With Science Achievement"**

4. Walau bagaimanapun Tuan/Puan adalah tertakluk kepada syarat-syarat seperti berikut:
   - 4.1 Mendapat kebenaran dari Pengetua/Guru Besar sekolah berkenaan.
   - 4.2 Tidak mengganggu perjalanan, peraturan dan disiplin sekolah.
   - 4.3 Kajian tidak melibatkan kelas peperiksaan.
   - 4.4 Segala maklumat yang dikumpul adalah untuk tujuan akademik sahaja.
   - **4.5 Menghantar satu salinan laporan kajian ke Jabatan ini setelah selesai kajian.**
   - 4.6 Sila kemukakan surat ini apabila berurusan dengan pihak sekolah.
   - 4.7 Surat ini berkuatkuasa sehingga **30 Jun 2006.**

Sekian, terima kasih.

'BERKHIDMAT UNTUK NEGARA'

Saya yang menurut perintah,

(AZALI BIN AB. RAZAK)
Unit Perhubungan, Pendaftaran dan Pendidikan Swasta
b.p. Pengarah Pelajaran Negeri Pulau Pinang
Jabatan Pelajaran Pulau Pinang

جابتن ڤلاجرن نݢري قدح دار الامان
JABATAN PELAJARAN NEGERI KEDAH DARUL AMAN
KOMPLEKS PENDIDIKAN, JALAN STADIUM
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TELEFON - A.S. 04-7331311
NO. FAX - 04-7317242

"KEDAH MAJU 2010"

Ruj.Kami : JPK(PPPS) 03-12 / 9 Jld.20 (43)
Tarikh : 2 Februari 2006

Dr Ong Saw Lan,
Pusat Pengajian Ilmu Pendidikan,
Universiti Sains Malaysia,
11800 Minden,
Pulau Pinang.

Tuan,

Kebenaran Untuk Menjalankan Kajian di Sekolah

Adalah saya dengan hormatnya diarah memaklumkan bahawa permohonan tuan untuk menjalankan kajian di sekolah-sekolah Negeri Kedah bertajuk ***"Assessing Competency in Integrated Science Process Skills and Relation with Science Achievement "* telah diluluskan.**

2. Kelulusan ini adalah berdasarkan kepada apa yang terkandung di dalam cadangan penyelidikan yang tuan kemukakan ke Kementerian Pelajaran Malaysia.

3. Kebenaran ini adalah tertakluk kepada persetujuan Pengetua sekolah berkenaan dan adalah **sah sehingga 31 Mei 2005**

Sekian, terima kasih.

'BERKHIDMAT UNTUK NEGARA'
'PENDIDIKAN CEMERLANG KEDAH TERBILANG'

Saya yang menurut perintah,

(HAJI CHE OMAR BIN ZAINAL)
Ketua Penolong Pengarah,
Unit Perhubungan, Pendaftaran dan Pendidikan Swasta,
b.p. Pengarah Pelajaran Negeri Kedah Darul Aman.

/tppps.06