

Scientific skills among pre-service Science teachers at Universiti Teknologi Malaysia

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Abstract

Scientific skills such as making hypotheses, making inferences and stating variables are fundamental skills in scientific investigation. These scientific skills are introduced to secondary school students at the beginning of their Science lesson by their teachers. Hence, it is important that science teachers possess such skills to enable them to deliver the skills effectively to the students. This research aims at investigating the level mastery of these skills among pre-service teachers studying at a university in Malaysia. In this study, a set of questionnaire was distributed to 76 undergraduates studying Science education at the Faculty of Education, Universiti Teknologi Malaysia to survey the level of mastery of these skills. From the sample, 12 students we selected to conduct some science experiments and their reports were analyzed to further understand their mastery of these scientific skills. It was found that the level of mastery of making hypotheses, making inferences and stating variables are moderate among these pre-service science teachers.

Keywords: Pre-service science teacher education, scientific skills

1.0 Introduction

It is undeniable that scientific skills, or more specifically science process skills such as observing, hypothesizing, conducting experiments and so on are among the ingredients to produce scientific society (Chiappetta & Koballa, 2006). Scientists do not use a specific, step-by-step method in their research but through several ways to approach a problem (Martin et al., 2009). The compilation of all these skills is what we call “science process skills” which are always associated with scientific inquiry (Chiappetta & Koballa, 2006). Different researchers provide different sets of skills that are to be included in science process skills. Friedl & Koontz (2005) suggested six process skills – observing, inferring, communicating, classifying, measuring and experimenting. However, the more common definition of science process skills contains two levels of skills – the basic skills and the integrated skills (Abruscato, 2004; Chiappetta & Koballa, 2006; Curriculum Development Centre, 2002; Martin et al., 2009).

Again, researchers have different views when it comes to categorizing the skills into these two sub-categories. Table 1 shows some suggested categories of basic and integrated science process skills.

Table 1: Categories of basic and integrated science process skills

	Abruscato (2004)	Chiappetta & Koballa (2006)	Curriculum Development Centre (2002)	Martin et al. (2009)
Basic skills	Observing	Observing	Observing	Observing
	Classifying	Classifying	Classifying	Classifying
	Predicting	Predicting	Predicting	Predicting
	Using number	Using number	Using number	Using number
	Measuring	Measuring	Measuring	Measuring
	Inferring	Inferring	Inferring	
	Using space/time relationships	Using space/time relationships		
	Communicating			Communicating
			Questioning	
Integrated skills	Interpreting data	Interpreting data	Interpreting data	Interpreting data
	Controlling variables	Controlling variables	Controlling variables	Controlling variables
	Hypothesizing	Hypothesizing	Hypothesizing	Hypothesizing
	Defining operationally	Defining operationally	Defining operationally	Defining operationally
	Experimenting	Experimenting		Experimenting
		Formulating models		Formulating models
				Inferring
			Communicating	
			Using space/time relationships	
		Concluding		

Despite the differences in categorization, the following is a set of science process skills agrees by all the authors in Table 1 (as shaded):

- a. Observing
- b. Classifying

- c. Predicting
- d. Using numbers
- e. Measuring
- f. Inferring
- g. Interpreting data
- h. Controlling variables
- i. Hypothesizing
- j. Defining operationally

The learning of science among students is greatly influenced by the mastery of science process skills (Awelani, 2002; Mohd Najib & Mohd Yusuf, 1995; National Curriculum Council, 1989; Needham & Hills, 1987; Padilla et al., 1980). However, the learning of science can be hindered if teachers themselves do not master the science process skills. The quality of science teachers will affect the quality of science students, and further impacts the quality of science undergraduates as well as the future science workforce of a nation (Phang, 2010). Hence, it is crucial for the present pre-service science teachers to be able to master science process skills in order for them to inculcate the skills to students.

Previous studies in Malaysia show that the level of mastery among pre-service teachers studying in higher education institution is below satisfactory. Tan & Chin (2001) found that some 44 pre-service teachers in Kuching did not master the skill of inferring while Mohd Isa (2001) discovered that 113 pre-service teachers in Perlis did not perform in identifying variables and hypothesizing. Hanizah & Shaharom (2008) also reported that 41 pre-service teachers at Universiti Teknologi Malaysia (UTM) did not understand the skills of communicating and experimenting through a survey using a set of questionnaires.

2.0 Purpose and Methods

Therefore, the purpose of this research is to investigate the level of mastery of science pre-service teachers studying in a university (UTM) in the skills of inferring, identifying variables and hypothesizing. This is an extension to the work of Hanizah & Shaharom (2008) for their discovery of the poor understanding of communicating and experimenting skills among the pre-service science teachers at UTM.

In this research, a set of questionnaires consisting of 30 multiple-choice items (adapted from Noor Hayati (2003)) was used to measure the level of mastery of inferring, indentifying variables and hypothesizing skills. This was conducted to 76 second year undergraduates at the Faculty of Education, UTM studying Bachelor of Science and

Education majoring Physics, Chemistry and Mathematics (minor Science). The pilot test showed that the reliability of the questionnaires calculated using Alpha Cronbach coefficient was 0.82 (see the details in Nor Athirah (2010)).

Later, the laboratory reports of 12 undergraduates over seven experiments were collected and analyzed to further understand the pattern of the mastery of science process skills. A focus group was formed to probe and interview the undergraduates of their understanding and mastery of science process skills as well as their suggestion to improve the acquisition of the skills. The process was video recorded for duration of 41 minutes after they all have filled in the consent forms.

3.0 Data analysis

The percentages of correct responses of the questionnaires were calculated and the results are as presented in Table 2.

Table 2: Results of the correct responses for the skills of inferring, identifying variables and hypothesizing

Skills	Percentage (%)
Inferring	68.5
Identifying variables	86.0
Hypothesizing	81.6

It is clear that the undergraduates did not perform well in making inferences. This is in line with the analysis of the focus group where the undergraduates were asked the meaning of inference. They showed confusion between inference and hypothesis as to which one means “early conclusion”. The question was rephrased to “what is the difference between inference and hypothesis?” The following is an excerpt of the transcript of the focus group (translated from the original in Malay language).

Undergraduate A: Hypothesis is early conclusion and inference is... [confused and looked at her friends]

Undergraduate Z: Which one is the one that uses “the more... the more...”, is that the inference?

Undergraduate S: Hypothesis is the one that uses “the more... the more...”

Researcher: So, inference is the one that uses “the more... the more...”?

Undergraduate F: No, that’s the hypothesis!

Undergraduate S: Inference is the early conclusion

A few undergraduates: No, that’s the hypothesis!

Undergraduate S: Ok, hypothesis is the early conclusion

Undergraduate F: It has to do with the correct (Physics) concepts
 Undergraduate A: Hypothesis is our initial prediction
 Undergraduate C: But isn't initial prediction the same with early conclusion? They are just different way of saying it.
 Undergraduate R: Hypothesis has to do with relationships, relationships between manipulated and responding variables, now that's the hypothesis.
 Researcher: So, that sorted out hypothesis, what about inference?
 Undergraduate R: It's like what F said [everyone laughed]
 Undergraduate F: What did I say?

After more than two minute of discussion, the undergraduates failed to arrive at a solid understanding of the meaning of "inference" and "hypothesis". However, in the laboratory reports, most of the undergraduates were able to write correct hypotheses and inferences for most of the experiments where the percentage of writing the correct inference is 91.3% and for hypothesis is 96.4% (refer Table 3). It may be argued that the undergraduates tend to copy most parts of the laboratory reports from text books, reference books or from the previous undergraduates' reports because when asked during the focus group what should be written in a laboratory report, they admitted that the format is fixed, so there is always a template to be found elsewhere. The reports will only be different in the results or data collected, graphs and maybe some parts of the conclusion. The rest should be roughly similar. There is even one undergraduate admitted that he never tried to write his own laboratory report from zero. There is always copy from somewhere else and develop into his own report with a few little changes.

Table 3: The results of the laboratory report analysis

	Part of the report evaluated	Percentage of correct response (%)
1	Inferring	91.3
2	Hypothesizing	96.4
3	Identifying variables	88.4
4	Definition of operation	30.4
5	List of apparatus	88.3
6	Procedures	89.8
7	Diagrams	80.9
8	Table of results	64.1
9	Writing of observation	79.0
10	Plotting of graphs	89.6
11	Writing the discussion	66.9
12	Conclusion	89.5
	Average	79.6

From the analysis of laboratory reports, it was found that defining operationally has the lowest correct percentage – 30.4%. Many students either failed to write the definition of operation or did not explain well enough to make the testing of hypotheses to be operated. To clarify this, the undergraduates were asked the meaning of “definition of operation”. There was a long pause and the undergraduates were pointing at each other to give an answer. Then the following conversation occurred:

Undergraduate W: It's about the procedure

Undergraduate S: No, it's not a procedure, it's like something more random

Undergraduate C: No, it's like, for example the time is measured by using a stopwatch

Undergraduate R: Oh... it's like the behaviour and the apparatus

A few undergraduates: Yeah, right...

Researcher: So, behaviour and apparatus? [all the undergraduates laughed]

Undergraduate F: The behaviour of using an apparatus

Undergraduate R: It's more like to say like taking the time using a stopwatch

Undergraduate C: It's like the relationship between an apparatus and a variable

Undergraduate R & F: Yeah

Another significant finding from the laboratory report analysis is that many of the undergraduates did not practice the rule of taking more than one attempt for each measurement to ensure the precision of the measurement. In their laboratory reports, some of them committed the following errors which causes the percentage of making the 'table of results' is 64.1%:

- a. Not using the same decimal points
- b. Not using the correct decimal points
- c. Not writing the symbol of a variable measured in the table of results

According to ASE-Nuffield (2010), school students also face the same problem because there is a misconception of the language or terminology used in scientific measurement.

4.0 Discussion

From the data analysis, the second year science undergraduates of the Faculty of Education, UTM are facing the problem of defining the scientific skills, especially the understanding of 'inference', 'hypothesis' and 'definition of operation'. While in term of practicing the skills, they show weaknesses in writing the definition of operation and the table of results, as well as making measurements. According to Chiappetta & Koballa (2006), "a hypothesis is a generalization that relates to a class of objects or events

whereas an inference is related to a specific object or event” (p.204). A hypothesis is an “educated guess” (Abruscato, 2004). To formulate a hypothesis, it should be based on observations and inferences. Inferring is to use logic to draw conclusions from what is observed. From the excerpt presented earlier regarding hypotheses and inferences, none of the undergraduates tried to relate observations with inferences and to related inferences with hypotheses.

As for defining operationally, Martin et al. (2009) stated that it is to describe what works; explain how to measure variables in an experiment, relationships between observed actions to explain phenomena and to explain relationships by generalizing to other events not observed. According to Curriculum Development Centre (2002), it is to give interpretations of a concept by stating it in terms of what to be done and observed. For this, the understanding among the undergraduates is not too far from the correct definition, however, in practice, not many of the undergraduates correctly stated the definitions of operation in their laboratory reports. Moreover, six out of 12 undergraduates did not write the definitions of operation in any of the laboratory reports analyzed in this research. It could be that the undergraduates perceived that this is not an important part of a scientific investigation because when they were asked during the focus group interview about the purpose to state the definition of operation in an experiment, they said, they did not think that it is necessary to report it.

5.0 Implications & Conclusion

From this research, it is apparent that science undergraduates at UTM do not have the correct understanding of inferences, hypotheses and definitions of operation. However, in writing laboratory reports, it seems that they do not face too much of a problem to write the correct inferences and hypotheses. It could be argued that they do not need deeper understanding to be able to state the inference and hypothesis of an experiment. On the other hand, it could also be argued that they might copy a part of the report from text books, reference books or from the past year reports obtained from senior undergraduates – as suggested by some undergraduates involved in the focus group interview. If the later is the stronger possibility, it will not help the undergraduates in improving their scientific skills. Sharifah & Lewin (1993) argued that the less students involved in planning a scientific investigation, the poorer their mastery of scientific skills. If these pre-service teachers fail to master the scientific skills to a level that they can inculcate these skills to their students in the future, the students will only learn science as any other subjects in schools.

It is also the duty of the lecturers to provide opportunities for undergraduates to acquire such skills. One of the ways to achieve this is to let the undergraduates perform real

scientific investigations from planning until reporting. During the focus group interview, the undergraduates stated that they actually learn deeper about scientific skills when they were put into a new situation of scientific investigation. They need to read the related materials about a new experiment that they are going to carry out. On the day of conducting the experiment, good questioning from the lecturers also highly facilitate the learning of scientific skills because questions that probe the undergraduates to want to find out more will lead them to plan and perform more investigations. It is through this kind of planning that they can acquire scientific skills. Finally, undergraduates should be given the freedom and time to explore as much as they like about a topic using the facilities in the laboratory.

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