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Enhancing the Standard of Project Work in Primary Science

Boo Hong Kwen and Daniel Tan Kim Chwee

Introduction

This article suggests two main ways of enhancing the standard of project work in primary science. The first way is for teachers to view project work as a significant learning strategy for pupils; a means of discovering the natural world first-hand and not vicariously via the experiences of others. This implies that there is a need to change the way project work is perceived by many pupils. Many pupils view project work in science as a form of assessment of how much scientific knowledge or scientific skills and processes they have acquired or as a form of competition, where prizes are given to top projects. There is a need to help pupils view project work as an adventure, a journey of discovery of the mysteries and marvels of the natural world around them.

The second way is to scrutinize tasks set in school examination papers (as well as homework and class assignments) to ensure that they exemplify good experimental techniques. The argument here is that poor techniques for science investigations and project work may be consciously or subconsciously assimilated by pupils through their exposure to poorly set science tasks, in particular, those aimed as assessing their acquisition of science skills and processes.

The nature of science

Everyone in modern society has some views on the nature of science. The 'man in the street' generally views science as a subject in the school curriculum or as a body of knowledge to be learned. This view of science emphasizes science as a product.

Some science education journal articles and textbooks emphasize the process view of science, as for example, the article entitled "Science is about not knowing but trying to find out" (Manganus, Rottkamp & Koch, 1999). Esler and Esler (1996, p6) declare that "science is not a set of facts". Instead, they define science as a process of "asking questions about the world around us and searching for 'best' answers". Gilbert (1991) defines as science as "a process of constructing predictive conceptual models".

It can be seen therefore that science can be viewed as both a product as well as a process. As a product, science is a vast body of knowledge which is changing and
increasing and is described by physical, mathematical, and conceptual models. As a process, science can be viewed as man’s (man the scientist) systematic investigation of the attributes and behavior of the physical world. Scientists engage in skills and processes of investigation to generate knowledge about the natural world. Pupils in schools need to acquire the knowledge generated by scientists as well as the skills and processes of investigation. Engaging in science project work is a good means of acquiring the skills and processes of scientific investigations.

**View project work as a means of discovering the physical world**

Project work can be defined as an extended piece of assignment carried over a period of a few days or a few weeks (Teng and Lim, 1997). As such, it offers pupils a means of learning the skills and processes of investigations and scientific knowledge as well.

Youngsters of all ages, particularly those in the primary school are naturally curious and love to investigate. If project work is seen less in terms of assessment of their mastery of the skills and processes of investigation but more in terms of discovering the natural world around them, then the pupils’ natural sense of curiosity and wonder are more likely to be stimulated. Hence, they will become intrinsically motivated in carrying out their project work.

Pupils, working in small cooperative groups, should be encouraged to raise their own questions about aspects of their physical world and should be encouraged to do carry out literature and/or media research (including the exploration of internet resources) on their topic of interests. They should be encouraged to formulate their own hypotheses and generate alternative ideas/methods of testing out their hypotheses. Teachers could guide by helping to clarify pupils thinking through listening, probing and questioning.

Pupils should be encouraged to practise the various process skills such as communicating, generating, analyzing, evaluating, problem solving and decision making. More specifically, as pupils are generating ideas about different ways of attacking the problem, they could be guided through the process of weighing the merits and demerits of each way, and selecting the best line of attack (using the integrated process of decision making) and planning the investigation. As the investigation is executed, observations and measurements are taken, and answers to the problem will be suggested. This should lead to evaluation of the investigation and a modification of the method, if necessary. In so doing, students would be practising creative problem solving processes and at the same time, broadening their understanding of scientific ideas underlying different approaches or methods.

**Ensure and exemplify good experimental techniques**

Another important means of enhancing the standard of science projects, and in particular, investigative projects, is to ensure that tasks set in school tests and
examination papers (as well as in homework and class assignments) exemplify good experimental techniques. The argument here is that poor techniques for science investigations and project work may be consciously or subconsciously assimilated by pupils through their exposure to poor science tasks, in particular, those aimed as assessing their acquisition of science skills and processes.

To illustrate this point, two specific test items, both taken from recent primary six preliminary examination papers of two different schools are discussed in the following section.

**Example 1: A test question that does not exemplify good experimental design**

<table>
<thead>
<tr>
<th>VASE</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of stalks of flowers</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Type of chemicals</td>
<td>P</td>
<td>Q</td>
<td>R</td>
<td>S</td>
</tr>
<tr>
<td>Amount of water (ml)</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Number of days flowers stayed fresh</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

(a) What was Janet trying to find out from her experiment? [1]
(b) Besides using similar vases in size and quality, state 2 other variables which she must keep the same for the experiment. [2]

**Comments on weaknesses/flaws in Example 1 (test item)**

It should be noted that in experiments dealing with organisms (whether plant or animal) a sample of one (1) is not acceptable. Unlike physical science experiments where non-living things are involved, and where relationships between variables can often be described unambiguously ("proportional to", "inversely proportional" or defined in terms of an equation) living things such as flower stalks incorporate many uncontrollable variables and their behavior cannot be reliably predicted.

Thus, the exploration of possible relationships between causes and supposed effects is not as straightforward as physical science experiments. Correlational reasoning is the process used to assess the strength of relationships between variables, and a sample size for each condition investigated should be as large as is feasible. A sample size of one (1) for each condition of the experiment is unacceptable. The improved version of this test item suggested below has the sample size increased from one (1) to ten (10) and a very minor modification made to the last row of data where instead of "Number of days flowers stayed fresh" it was changed to "Number of flowers stayed fresh after 10 days".
Janet carried out an experiment in her living room with 40 stalks of the same kind of cut flowers. She recorded the results of her experiment in a table as shown below.

<table>
<thead>
<tr>
<th>VASE</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of stalks of flowers</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Type of chemicals</td>
<td>P</td>
<td>Q</td>
<td>R</td>
<td>S</td>
</tr>
<tr>
<td>Amount of water (ml)</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Number of flowers stayed fresh after 10 days</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

(a) What was Janet trying to find out from her experiment? [1]
(b) Besides using similar vases in size and quality, state 2 other variables which she must keep the same for the experiment. [2]

Example 2: A question that does not exemplify good experimental procedure.

In the experiment shown above, weights were added until the wooden block began to move over the sandpaper. The experiment was repeated by replacing the sandpaper with the following surfaces: carpet, wood and glass.

<table>
<thead>
<tr>
<th>Type of surface</th>
<th>Sandpaper</th>
<th>carpet</th>
<th>wood</th>
<th>glass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force required</td>
<td>190g</td>
<td>180g</td>
<td>160g</td>
<td>135g</td>
</tr>
</tbody>
</table>

What was the purpose of this experiment? [2marks]

It was to find out _______________________________________________________
Comments on weaknesses/flaws in Example 2 (test item)

The most obvious flaw in this test item is that an incorrect unit for force has been used. Instead of using the unit “g” which represents “gramme” and which is a unit for mass, a scalar quantity, the unit for the force required, ought to have been stated as “gwt” which stands for “gramme weight” a unit for force, which is a vector quantity. Repetition of the unit for force required could have been avoided by stating the unit in the first column, row 2 of the data table (see improved version below).

Unlike the previous example, this test item involves non-living things. While non-living things are more predictable, in any physical science experiment, there are various uncertainties or errors associated with each trial of the experiment. These uncertainties can be minimized by carrying out repeated trials for each type of surface used. Thus, the test item as it stands, does not exemplify good experimental procedure. A more acceptable format of the table of data is suggested below.

Improved version of table of data

<table>
<thead>
<tr>
<th>Type of surface</th>
<th>sandpaper</th>
<th>carpet</th>
<th>wood</th>
<th>glass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force required (gwt)</td>
<td>Trial I</td>
<td>189</td>
<td>184</td>
<td>161</td>
</tr>
<tr>
<td></td>
<td>Trial II</td>
<td>185</td>
<td>183</td>
<td>157</td>
</tr>
<tr>
<td></td>
<td>Trial III</td>
<td>187</td>
<td>185</td>
<td>163</td>
</tr>
<tr>
<td>Average force required (gwt)</td>
<td></td>
<td>187</td>
<td>184</td>
<td>160</td>
</tr>
</tbody>
</table>

Conclusion

Project work is a natural and meaningful way for primary school pupils to learn the skills and processes of science as well as the products of science. We need to downplay the assessment and competition aspects of project work and to foster a sense of curiosity and wonder about the natural world among our pupils. We need to check tasks set on our examination papers (as well as homework and class assignments) to ensure that they exemplify good experiment design and procedure. Our pupils will then be acquainted with good experimental techniques which they could emulate in their inquiry about nature and produce better projects.
References


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