SCIENCE PROJECT WORK IN SINGAPORE – SOME CASE-STUDIES

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Abstract: In 1988 a scheme was launched by the Ministry of Education which promoted the use of project work as one of the formal means of assessment in the lower secondary science curriculum. Under the scheme, every lower secondary science pupil was expected to undertake a science project, in teams comprising 2 to 4 members, with assessment based on the products (research reports, models, etc.) and the team's oral presentation. Besides the formal school science curriculum, science projects have also been given prominence through the annual Singapore Youth Science Festival which features a a science project competition every year, alternating between secondary/junior college and primary science projects. To further encourage project work, the Ministry of Education has revised the admission criteria for university admission to include interdisciplinary project work with effect from the year 2003. This paper discusses recent examples of actual science projects done by secondary school students and considers the lessons to be learned from them with respect to the conceptualisation and execution of projects.

Introduction

Since the mid-1980s science process skills, including controlling variables, formulation of questions and hypotheses and planning of investigations have been included in the primary science curriculum and been tested in the Primary School Leaving Examination (PSLE). In 1988 a scheme was launched by the Science Curriculum Branch of the Ministry Education which involved the use of project work as one of the formal means of assessment in the lower secondary science curriculum (MOE, 1990 page 14). Under the scheme, every lower secondary science pupil was expected to undertake a collaborative science project. Each project was assessed based on the products (such as research reports, models, artifacts and so forth) and the oral presentation. During the oral presentations students were assessed, among other things, their ability to present salient points of their projects as well as their ability to handle questions from their peers as well as from teachers. A video-tape entitled "Science Through Inquiry and Investigation" was produced to assist teachers in the implementation of the project work assessment scheme.

An important rationale for project work is that, with proper guidance from teachers and enlightened adults, students can develop not only process and inquiry skills, but also information retrieval skills, information organisation skills, study skills, thinking skills, problem solving and social skills – skills which will equip them for life-long learning and growing (Boo, 1987). Project work can also be seen as a useful and effective means of teaching students how to behave like scientists, because through project work they should experience some of the problems of working on a scientific investigation.

From another perspective, project work is seen as providing excellent opportunities not only for pupils to use process and thinking skills, and apply what they have learnt, but also for teachers to assess pupils on inquiry skills. Project work is also seen as a means of providing for the development of other talents and skills as well as providing opportunities for cross subject linking, enabling pupils to see the interconnectedness and inter-dependence among subjects" (MOE, 2000 page 5-6).

Besides the formal school science curriculum, science projects have also been given prominence through the annual Singapore Youth Science Festival which features an exhibition of science projects every year, alternating between secondary/junior college and primary science projects. To further encourage project work, the Ministry of Education has revised the admission criteria for university admission to include interdisciplinary project work with effect from the year 2003. This paper discusses recent examples of actual science projects done by secondary school students and considers the lessons to be learned from them with respect to the conceptualisation and execution of projects.

Recent Examples of Science Projects

Example 1

Title of Project: Investigating the caffeine level in different types of tea

This project was carried out by a group of four Secondary 2 students. The aim of the project was to "know which tea (given five types of tea) contain the most caffeine and so that we can avoid drinking too much of it. Hence we cut down our chance of getting harmful effects caused by caffeine."

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In the introduction section, project students reported that caffeine "causes regular tea drinkers to feel nervous, restless, sleepy, irritable and headaches when they miss or cut down their coffee/tea intake. In extreme cases, nausea and vomiting have also been reported."

The procedure was given in 21 steps, under three headings; firstly, "Extraction of caffeine from tea solution", secondly, "Measurement of absorbance" and, thirdly, "Obtaining calibration graph". The content of the latter two headings was produced verbatim.

Extraction of caffeine from tea solution

The method described in steps 1-16 was not clear, but appear to involve boiling 2g of each type of tea with 50ml of water for 60minutes, followed by filtration to remove the tea leaves. This is then followed by extraction with chloroform (without the removal of tannins; there is no mention of the presence of tannins in tea in the report.). The procedure was not clearly described; and it gave the impression that the students really did not understand what they were doing. Instead the impression given was that instructions were followed mechanically without much understanding.

Measurement of absorbance (content of which is reproduced here verbatim)
"*17. Caffeine extracted from each tea were measured in UV spectrophotometer to record absorbance value at 274nm*".

Obtaining calibration graph (content of which is reproduced here verbatim)
"*18. 0.0050, 0.010, 0.0125mg/ml of caffeine solution were prepared*
l9. Absorbance value of these solutions were obtained.
20. A calibration graph was obtained from a Absorbance Vs Concentration graph.
21 Concentrations of caffeine (in terms of mg/ml) in different teas were obtained by reading off the graph. "

There were no explanation as to why UV spectroscopy was used, and why absorbance value was recorded at the specific wavelength of 274nm. The conclusion of the experiment was "*we found that type A tea has the most caffeine contained in them. Followed by type B, type C, type D and lastly, type E, which has the least caffeine contained in them. So we advice you not to drink type A tea that often and change to type E instead!*"

Strengths of the project
One strong point of the project is that the problem appeared to be identified by students themselves and is related to the everyday life.

Areas for improvement
The written report explicitly states the commercial names of the five types of tea investigated. This is not advisable at all and in this paper, where verbatim statements are taken from the students' report, the commercial names of the five types of tea have been replaced with letters A to E.

In the problem definition, the students appeared to have adopted a rather narrow view and make the assumption that the kind of tea which has the highest level of caffeine is worst for regular drinkers. The result is that they had over-generalised and concluded that since type A tea has the highest level of caffeine, it is to be avoided by all regular tea drinkers! They should have delimited their case to people who are extra-sensitive to caffeine perhaps. Perhaps also they should consider the possibility that different kinds of tea might contain different amounts of other substances which might have been found to be beneficial to regular drinkers; and recommend further research to investigate these other substances.

When asked to say a bit more about what they understand by the key term "absorbance" which occur many times in their report, none of the students were able to offer even the slightest suggestion. Here it should be reasonable to expect that though not having encountered this concept in their school science curriculum, in the course of their project they should have thought about the meaning of this key term on which the project appears to be based. One would think that it should be reasonable to expect them to be able perhaps to suggest that the term "absorbance" relates to absorption of light by the caffeine; and since the UV spectrophotometer has been used, it would be reasonable to expect them to mention the absorption of ultra violet light by the caffeine.

Students were also asked what they thought was the meaning of the term "nm" in the context of the statement "Caffeine extracted from each tea was measured in UV spectrophotometer to record absorbance value at 274nm". After a lapse of several minutes, one of them ventured the answer, "newton metre". This further revealed that the students lacked of understanding of the basic science ideas involved.

When probed further as to whether their investigation could be conducted in the absence of sophisticated scientific equipment such as the UV spectrophotometer, the students replied that there would be no way then of carrying out their investigation! Such a response from the students is disconcerting. Did these students really think that there is no way of comparing the amounts of caffeine present in different types of tea without the use of the UV spectrophotometer? Should not they have explored the use of more simple methods (such as 'wet chemistry') which invoke scientific principles more within their reach, and which involve apparatus available within a normal secondary school laboratory, before even thinking about more advanced methods? For example, by increasing the masses of each of the five types of tea leaves used, and by using saturated zinc acetate solution to precipitate the tannins, the students could have isolated, weighed and thus compared mass of caffeine crystals on a sensitive weighing balance.

It is important in the process of finding answers to problems raised that students learn to generate different possibilities of answering their questions and to weigh the merits and demerits of different solutions. In this case, some pertinent questions that the students should ask themselves are, "Why are we using the UV spectrophotometer?" "Are there other alternative means of comparing the amounts of caffeine contained in the different teas?"

The use of spectroscopic techniques (involving the use of sophisticated scientific equipment) in secondary school projects is commendable, provided students know the reasons for selecting the techniques; and especially if they have some notions of the science concepts underlying that particular technique. At the secondary level, assuming that students have chosen to use spectroscopic techniques, it might still be good to encourage students to check or verify their results by using school science ie "wet chemistry" techniques. Alternately, they could use school science to determine the results and sophisticated apparatus to check or verify.

Other pertinent questions that one would raise concern the role of the mentoring teacher. Are the teachers giving students proper guidance? Is there adequate provision of time for the mentoring process? Do teachers themselves think that the more sophisticated the equipment used, the better the project?

Example 2

Title of project: Analysis of table salt content in preserved

This project was carried out by a group of four Secondary 3 students. The aim of the project was to determine the amounts of sodium chloride (table salt) present in five different brands of salted prunes. The procedure involved was given as follows, "We cut out the flesh, chopped and mashed them into smaller pieces and placed 5g into a beaker. Next 200ml of distilled water was added, the mixture was then boiled for 20minutes and then left to settle for a short while. The mixture was filtered slowly. 5ml of this clear solution was added each to 20ml, 30ml, 40ml and 50ml of silver nitrate. We then filtered the white precipitate using 3 pieces of filter papers. We left the filter papers to dry overnight. The dried filter papers were then weighed and the amount of white precipitate was computed. We repeated the experiments with the other 4 brands of preserved prunes.

Strengths of the project

One strong point of the project is that it involves application of knowledge and techniques that are learned in normal secondary school curriculum. Another strong point is that the problem investigated is real to the students, i.e., it is related to the everyday life, and appears to be motivating and interesting for the students.

Areas for improvement

As reflected in the write-up, there are a number of weaknesses in the design and in the experimental techniques. There were no explanation for important steps in the procedure, such as why "5ml of this clear solution was added each to 20ml, 30ml, 40ml and 50ml of silver nitrate". There was no explanation for the use of only 5ml of the extract; also no explanations on why 20ml, 30ml, 40ml and 50ml of silver nitrate were being used.

There were no tests conducted to ensure that all (or the maximum possible amount) of salt has been extracted from the 5g of prunes; at the same time, there were also no tests conducted to ensure that all the chloride in the 5ml of extract has been precipitated by silver nitrate.

Example 3

Title of project: Investigation of rusting of iron nails in different environments.

This project was carried out by a group of four secondary 3 students. The aim of this project was to determine how much iron nails rust in different parts of Singapore and to provide explanations for the findings. The students hypothesized that iron nails rust faster in the following kinds of environment:

1. Areas with heavy rainfall
2. Areas close to the industrial zones
3. Areas near the sea
4. Areas close to busy roads

The procedure involved project students distributing iron nails in petri dishes to their schoolmates living in the various parts of Singapore and these nails were weighed at regular intervals. The greater the % increase in mass, the greater the rusting.

Strengths of the project

The strengths of this project include that fact that problem definition, hypotheses formulation and procedures to test the hypotheses were identified by the students themselves. Also, the procedure identified is such that it could be carried out by students themselves with minimal help; otherwise there could not be a possibility that the it might not be a students' project, but instead, their teachers' or parents' project.

Another merit of this project is that it is related to what students study in class; this gives more meaning to the project as well as what they learn in class.

Area for improvement

One area for improvement in this project is to address the uncertainties caused by the fact that weight gained by the iron nails as measured might not be solely due to formation of rust, but instead due to moisture or dust collected.

Conclusion

Based on the above discussion of the three project cases, one can infer that the following features which characterise good projects:

1. Projects should start with a problem or a question which is real to the student.

2. The question is likely to arise from the science topics studied, or it may arise from the students' own interests. In the latter case this usually concerns questions or problems that relevant to the experiences and everyday life of students.

3. The process of project work should involve students in analysing the factors relevant to the question or problem and using their information retrieval skills to assemble relevant information, so as to avoid making questionable assumptions and as a consequence, over-generalisation of the conclusions.

4. The project work process should also involve students in generating ideas about different ways of attacking the problem, weighing the merits and demerits of each way, selecting the best line of attack and planning the investigation. As the investigation is executed, observations and measurements are taken, answers to the problem will be suggested. This should lead to evaluation of the investigation and a modification of the technique, if necessary. In so doing, students would be using higher order thinking skills and processes and at the same time, broaden their understanding of scientific ideas underlying different approaches or techniques.

5. The actual procedural work involved in the project is such that it could be carried out by students themselves with minimal adult help.

6. There should be greater supervision by teachers to ensure that students understand what they are doing in the process of carrying out and completing the project.

Greater supervision by teachers should also avoid the pitfalls of neglecting the process in favour of the product of project work.

In conclusion, it cannot be over-emphasised that the process of carrying out the project work is just as important, if not more important, than the final product itself. Also, project work at the secondary level (especially at the lower secondary level) should involve students in using knowledge that they have learned at their level in innovative and creative ways, rather than involving them in using sophisticated expensive scientific equipment based on principles which are clearly beyond their ability to comprehend. In the latter case, there is the risk that some students may develop the misconception that usage of sophisticated scientific equipment alone (and without any understanding of the science ideas involved) is equivalent to good science investigations.

However, this does not exclude the case for the use of sophisticated equipment and higher level scientific knowledge in project work where exceptionally gifted students are concerned (i.e., those particularly gifted in a particular science topic); especially if the students are able to demonstrate some understanding of the techniques or methods and the scientific ideas involved. In such a case perhaps students should be encouraged to verify their results by using alternative methods.

References

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