Science at the University of the South Pacific : A Learning or a Teaching Problem?

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In November 1990 the USP Department of Education received a memorandum from the Head of the Chemistry Department expressing concern about problems many students were having coping with certain scientific concepts. After consultation it was decided that diagnostic testing should be carried out to assess the extent of these problems and identify major areas of weakness.

Methodology

The test was intended to be diagnostic, thus questions were selected which did not demand a great deal of scientific knowledge. Instead they concentrated on those higher cognitive skills students should have developed by the time they enter tertiary education. Questions were selected from United Kingdom General Certificate of Secondary Education papers. This is a United Kingdom National Form 5 examination. The test was given to both the Foundation and Level-100 science students. A total of 25 marks was available and each raw score was converted into a percentage. Those questions which could not be scored objectively were scored analytically to increase reliability. Means were compared using a t-test.

Discussion

Perhaps the most striking feature of the results of this comparatively simple high school science test is the very wide score distribution (Appendix A). Within any group one would expect to encounter a variation of performance, but by the time students have reached tertiary level, the various selection processes should have narrowed this significantly.

Results

Group	Mean Score (M.S.) %	Number (N)	t	p
Total	55.3	302		
Foundation	55.5	213		
100 Level	54.9	89	0.26	N.S.
100 Level -				
Foundation entry	64.4	32		
Form 7 entry	50.8	32	1.97	<0.05
Indo-Fijian	67.2	107		
Fijian	47.5	136	9.4	<0.01
Other Pacific Islanders	47.9	48	0.29	N.S.
Male	56.7	180		
Female	53.5	113	1.51	N.S.

For some comparisons certain groups of students have been omitted. Thus values for N do not always seem to correspond with the total.

At Foundation level almost 20% of the students failed to score above 40% while at the 100-level 17% failed to reach this mark. This indicates that a significant minority of the students had considerable difficulty with the test. Conversely 24% of the Foundation students and 22% of students in the 100-level achieved a score of 70% or more and apparently encountered little difficulty. This disparity in performance would suggest that the teaching of science at the USP must present particular problems, especially as none of the usual mechanisms which facilitate teaching a wide range of students, namely setting or banding, exist at the university.

The situation is compounded at present because those arriving directly into the 100-level from Form 7 performed significantly less well (M.S. 50.8%) compared with those who had completed the Foundation year in 1990-91 (M.S. 64.4%). This difference may reflect the standard of students coming through Form 7, the type of training they receive, or more likely a combination of both.

The gap between the performance of Indo-Fijian (M.S. 67.2%) and indigenous Fijian students (M.S. 47.5%) was pronounced. However, there was no significant difference between the performance of Fijians (47.5%) and that of other Pacific Islanders (M.S. 47.9%). Nor was the difference between male (M.S. 56.7%) and female students (M.S. 53.5%) significant.

In the test itself two items caused particular problems for students. These were questions 6c and 7 (Appendix B). Both items involved calculation, which is perhaps significant. Fewer than 50% of the students obtained the correct answer to 6c which required reading the percentage content of nitrogen in a fertilizer from a histogram, and using this value in a simple calculation. Many students failed to attempt this question while others commonly selected the wrong histogram from which to obtain the initial percentage value. Question 7 was only attempted by approximately 60% of students and a large number of these failed to score any marks despite partial credit being given for correct working. A common mistake was to balance the chemical equation for one substance, for example hydrogen, but leave the others unbalanced. Many students seemed to know the correct procedure for calculating relative molecular mass but did not follow their calculations through to completion.

The final question involved rearranging and interpreting data to show the relationship between temperature and reaction rate in the catalysed reaction ($2H_2O_2 \longrightarrow 2H_2O + O_2$). Most students organised the data appropriately by either plotting a graph or compiling a table. However, the graphs revealed a number of common errors. These included confusing the dependent and independent variables, fitting straight lines through obvious curves and failing to join the curves to the origin. Most students were able to relate the increase in the rate of the reaction to the increasing temperature, but many individuals simply suggested that increasing temperatures produced more gas. About 3% of students related the results to photosynthesis or evaporation, and a similar percentage related them to Boyle's Law.

On the basis of the results it would appear that the majority of students performed adequately. However, there is a significant minority whose performance was so poor on a comparatively simple test that one must question their presence on a university degree course. The vast majority of students at the university are from Fiji and to some extent this poor performance must be a reflection of the teaching students have received at high school. For although the test was rather simple, the questions were designed to assess skills rather than the recall of scientific facts. Research into science education in Fiji has revealed that these skills are often not being developed. Instruction in science is in the main very teacher-centred with a strong emphasis on the transfer of knowledge. Whitehead (1986) reported that the teaching of science in many schools in Fiji was very bookish rather than based on experiments and discovery techniques. Muralidhar (1989) confirms this, and cites a number of incidents in which he observed teachers explaining experiments on the blackboard. During the observation of 189 science lessons in Fiji he seldom saw students getting actual "hands on" experience of science.

One reason for this may be a mis-match between the objectives of the science curriculum in Fiji which encourages the development of skills, and the evaluation procedures which test for scientific knowledge (Taylor 1991). Certainly Fiji's education system has long been characterised by a succession of selective external examinations. National and external examinations are set for students in Class 6, Class 8, Form 4, Form 6 and Form 7. It is therefore not surprising that preparation for examination becomes a major concern of teachers. According to Whitehead (1986) teachers are firmly wedded to examination pass rates as a measure of their success. As a result, they employ the strategy best suited to achieving high pass rates, namely a teacher-centred approach to the point of rote learning. This may gain the desired results but is unlikely to encourage the development of higher cognitive skills.

As Dallas (1984) stated "it is reasonable for teachers of older pupils to aim for the best possible public examination results, but it is short-sighted and damaging to the pupils' best interests if the teacher insists on making life easy for them by employing teaching methods which require little of the victim but sponge-like absorption power. Should the pupil finally reach the desired nirvana of higher education, the lack of skills essential to make full use of what is offered there leads certainly to anxiety, if not to frustration and failure". This is what is happening in certain cases at the USP.

However, poor high school teaching does not explain the gap in performance between indigenous Fijians and Indo-Fijians. This is perhaps not surprising in view of the findings of Stewart (1983) who discovered that Fijian students did not perform as well as Indo-Fijians in science and mathematical subjects at any level. To support this he cited science pass rates in the Fiji Junior Certificate Examination for 1980 which were 36% for Fijian students and 44% for Indo-Fijian, while those for the New Zealand Secondary Certificate for the same year were 15% for Fijian and 30% for Indo-Fijian.

A number of studies have shown that the difference in science performance is not related to general intelligence or language competence, where Fijian and Indo-Fijian students' scores are not sigificantly different (Chandra 1975A and Elley and Thomson 1978, 1979). However, work by Basow (1982B) and Kishor (1982) have shown lower levels of self-esteem in Fijian students as compared to Indo-Fijians. The more sure individuals feel about themselves and their abilities, the more willing they are to place themselves in potential learning situations which may involve taking risks. Both authors have found that there is a tendency amongst Fijians to attribute success and failure (say on a class test) to external factors such as luck or favouritism. Indo-Fijians on the other hand attribute success or failure to internal factors such as hard work.

However, it is also possible that the Western model of science education may not be entirely appropriate for Fijian students. At present Ethnoscience - the use of a cultural view to explain the observed world - is gaining ground in many parts of the world. In the United States for example such an approach is being used to teach Hispanic children science from the viewpoint of the ancient Mayan mathematical system and Aztec ethnobotany. In New Zealand a new draft science syllabus, which acknowledges the beliefs, values and heritage of Maori students, is under consideration by the Ministry of Education. By applying a Maori perspective it is hoped to encourage more Maori students to take up science and to feel less alienated from science (Hyde 1991). A similar model might help those Fijian students who presently struggle with the conventional approach to science.

These arguments may go some way towards explaining the poor performance of a number of the students in the test but they can only be addressed at the school level. Whatever the reasons for the wide range in performance, the fact is that it must cause problems in both the teaching of science and the setting of examinations at the USP. University education by its very nature is not designed to cope with a wide range of performance.

One obvious way to ease the problem would be to raise the entry requirement for a science degree or introduce an entrance test. Certainly the present selection procedures do not seem to be adequate and there is little logic in admitting students who are always going to struggle and may achieve nothing. Apart from other issues, this causes a considerable waste of resources. Alternatively, a more refined diagnostic test could be introduced and used to place students in tutorial groups on the basis of their performance. If the more experienced lecturers were then allocated to those groups with the weakest students, these students could be given intensive instruction in both the problem-solving and study skills necessary to help them complete a science degree.

According to Buckingham (1989) the university may be coping with these problems by taking the course of least resistance. He felt that examinations were too closely tied to previous class tests or tutorial sessions, with students being "coached" to the correct answer rather than meeting a question for the first time. The Chemistry Department agrees that this is the case at Foundation level where, because the students have such an ingrained attitude to passing examinations, any other approach would be difficult. However, it is claimed that the extent of the "coaching" declines as the students progress through the Chemistry programme. In the circumstances this may be a pragmatic approach, but it is still a perpetuation of the school system which helped to create the problems in the first place. Although a more radical approach would be uncomfortable for the students and could lead to a higher attrition rate in science, it might also produce graduates capable of thinking more scientifically. Since most of the USP science graduates ultimately become teachers this might help improve the nature of science teaching in the schools.

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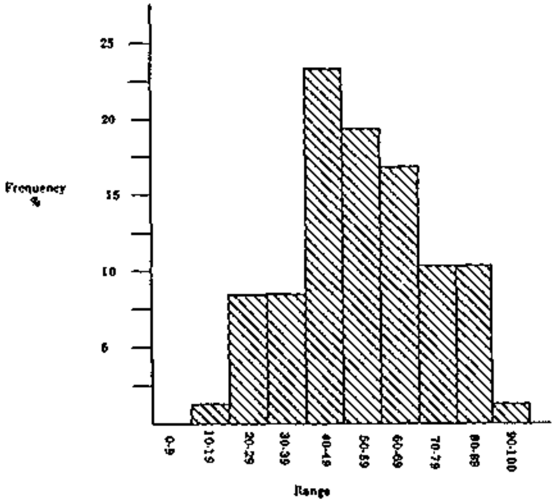
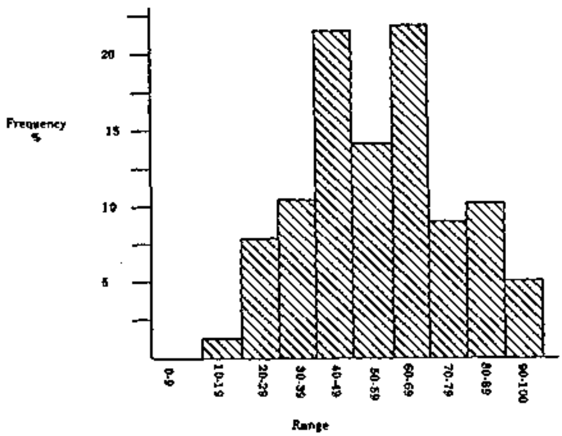
APPENDIX A

The Score Distribution for Foundation Students

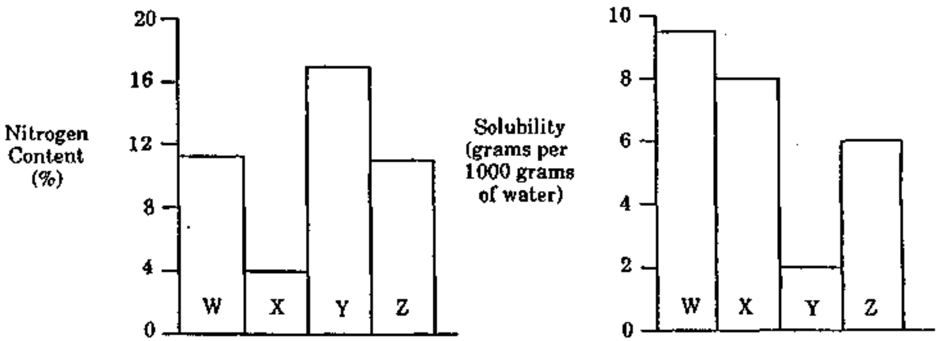


The Score Distribution for 100-Level Students



APPENDIX B

Information is given below about the **nitrogen content** and the **solubility** of four fertilizers W, X, Y, Z.



(a) Which fertilizer contains the highest percentage of nitrogen?

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(b) Calculate the number of grams of X that will dissolve in 1000 grams of water.

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(c) How many grams of nitrogen are supplied if 500 grams of fertilizer Z are spread over the ground?

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(d) Which fertilizer would you use for a crop that needs high content of nitrogen but is sown in part of a country which has a heavy rainfall?

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Using the relative atomic masses provided calculate:

(i) How much ammonia and sulphuric acid are needed to produce 396 kg of ammonium sulphate ($N = 14$; $H = 1$; $O = 16$; $S = 32$).

(ii) How much ammonia and nitric acid are needed to produce 480 kg of ammonium nitrate?