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ABSTRACT

The study reported in the paper attempted to compare the science laboratory teaching practices and the learning environments of secondary schools in some developing and developed South Pacific countries. This study combined qualitative (observation, interview, and case study techniques) with quantitative methods. Analysis of data found similar science laboratory learning environments across high schools with one of the environmental scales, Open Endedness as the least favorable scale. Overall male students' attitudes toward science were more favorable than female students' attitudes. A study of teaching practices showed some similarities and differences between developed and developing South Pacific countries. Female science teachers were under-represented amongst South Pacific science teachers. Teachers preferred demonstrations to students doing experiments. If students did experiments the teacher explained step-by-step how to do the experiment. The study also suggested that teachers generally show a strongly didactic approach to science teaching irrespective of whether they are from a developing or developed South Pacific country. (PR)

TEACHING PRACTICES, SCIENCE LABORATORY LEARNING ENVIRONMENT AND ATTITUDES IN SOUTH PACIFIC SECONDARY SCHOOLS

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Abstract

The study reported in this paper attempted to compare the science laboratory teaching practices and the learning environments of secondary schools in some developing and developed South Pacific countries. This study combined qualitative (observation, interview and case study techniques) and quantitative (questionnaire and survey instruments) methods. The study used an version of the Science Laboratory Environment Inventory that had been previously validated for a developing country context. This instrument was demonstrated to be both valid ana reliable, had adequate discriminant validity and was able to distinguish between different schools. Analysis of data generated found similar science laboratory learning environments across high schools with one of the environments scales, Open Endedness, as the least favourable scale. Overall male students' attitudes towards science were more favourable than female students. A study of teaching practices showed some similarities and differences between developed and developing South Pacific countries. Female science teachers were under-represented amongst South Pacific science teachers. This typical South Pacific science teachers largely used factual questions in their classrooms and rarely asked thought provoking questions. There was a strong belief amongst both students and science teachers that copious notes were an important ingredient for the success in the final external science academic examination.

The science teacher preferred teacher demonstrations to students doing experiments in small groups. If students did experiments, then they were divided into small groups to do the experiment. In this case, science teacher had already decided the problem to be examine, the experiment, the method and the equipment necessary to solve this problem. The science teachers first demonstrated the experiment and explained step-by-step how to do the experiment, then the students conducted the experiment. The science teachers were very didactic in their approach to teaching and there appeared very little variation in approaches to teaching and student experimentation. Students stated that confusion often existed during experiments. The study suggests that science teachers generally show a strongly didactic approach to science teaching irrespective whether they are from a developed or developing South Pacific country.

BACKGROUND AND RATIONALE

Society is increasingly becoming more concerned about the "standards" of the education system. As a result of this concern about educational "standards", governments are seeking greater accountability about teachers' use of the educational resources provided by the government. As a consequence of this greater accountability, governments have been examining ways to reduce unnecessary spending. Since one component of science teaching in secondary schools that has significant expenditure is the science laboratory, the possibility of future expenditure restrictions is implied. As developing countries spend 22 times less on instructional material per pupil than do developed countries (Caillods & Postlethwaite, 1989), it could be important to examine the science laboratory classroom within developing countries, namely South Pacific countries, to identify the current state of science laboratory classroom teaching practices.

Research has shown that there has been some disagreement over the value of the science laboratory classroom (Lynch, 1986; Tamir, 1989; Lehman, 1989). Other factors besides physical facilities affect the nature and quality of learning. One of the major factors that appear to affect student learning is the classroom psychosocial environment (Fraser & Fisher, 1982; Fraser, 1989). There is substantial evidence which indicates that teachers do make a more substantial difference to student achievement, attitude and motivation in developing countries than what would be expected to find in developed countries (Brophy & Good, 1986; Twoli & Power, 1989). However, there has been comparatively little research into teaching practices in science (Roadrangka & Yeany, 1982; Harpole, 1987). Even less research has been conducted into the state of science laboratory teaching activities in developing countries. There is virtually no published research into the current teaching practices in South Pacific science laboratory classrooms.

PURPOSE OF STUDY

The study reported here attempted to fill some of this dearth of research by identifying and describing the nature of current secondary school science laboratory practices within the countries of the South Pacific. Specifically, the research sought to (a) determine which teaching practices form the basis of science laboratory teaching in the countries of the South Pacific, (b) examine in particular the relationship of these teaching practices to a number of variables that could affect students' learning in their science laboratory classrooms, (c) determine whether there is a gender effect with respect to the relationship between these teaching practices and the variables examined.

METHODOLOGY

The on-going study combined qualitative (observation, interview & case study techniques) and quantitative (questionnaire & survey instruments) methods. The South Pacific (SP) countries studied included Cook Islands (CI), Fiji (F), Papua New Guinea (PNG), Solomon Islands (SI), Tuvalu (T) and Vanuatu (V). A variable number of Grade 10/11 students were sampled from any one country. A questionnaire administered to each sample attempted to examine:

i) students' and their science teachers' perceptions of the science laboratory classroom learning environment;
ii) students' attitudes towards science; and
iii) students' and science teachers' perceptions of the typical science laboratory teaching practices.

Data about the science laboratory learning environment was collected using a modified form of the SLEI, the Science Learning environment Inventory (Giddings & Fraser, 1990) which was adapted for use in South Pacific countries where English was a second language for most students. Data about students' attitudes towards science was obtained using a modified form of the Test of Science-Related Attitudes (Fraser, 1981) and was adapted for use in South Pacific countries where English was a second language for most students. Data about science teachers' and students' views on the nature of science laboratory activities was obtained by the adaptation of the Science Laboratory Activity Questionnaire (Ost & Swanson, 1968).

FINDINGS

The following section describes the typical Papua New Guinea and South Pacific science teacher and his/her teaching practices, perception of science laboratory facilities, science laboratory learning environment and the outcomes of science achievement and students' attitudes towards science. These teaching practices will be described under two groups: teachers' use of demonstrations and class experiments, and teachers' questioning and students' input during the learning process. The data in this study forms part of an ongoing data collection within South Pacific countries. The student sample consisted of Year 11 students in all countries except for

Papua New Guinea which involved Year 10 students. As most of these countries are small nations, some samples were whole country samples, for example, Tuvalu and Vanuatu. The data which forms the basis of these results, were obtained chiefly from the biographical questions of the teacher questionnaire, from the teacher and student versions of the classroom teaching activities questionnaires, from lesson observations and other anecdotal evidence. This "other anecdotal evidence" was based on the researchers' secondary and tertiary teaching experience in the region, and involvement in previous teacher observation and trainee teacher observations within South Pacific secondary schools.

CURRENT SCIENCE LABORATORY TEACHING ACTIVITIES

Classroom observation research has often examined both teachers' and students' activities during any study of teaching and learning. As teachers use questions as a major activity to encourage learning, it seemed important that this study examined teachers' use of questions and the students' contribution to the lesson. In the following section, the teachers' use of demonstrations and class experiments and how the science teacher conducts the class will be discussed.

Teachers' Use of Demonstrations and Class Experiments

This study examined science laboratory classes in particular. Since past research has been somewhat critical about the role of laboratory practical work, it is important to note the way science teachers use demonstrations or class experiments in the science laboratory classroom. Often the science teachers will demonstrate an experiment rather than let the students do the experiment. Lesson observations showed that teacher demonstrations was the fifth most common teaching activity (7.1%). The reason usually given for doing things this way is that there is not sufficient time (PNG - 23%, SP - 28%) for the students to do the experiment or that there is insufficient amount (PNG - 31%, S P - 39%) of equipment. It appears that it was the teacher who mainly demonstrated.

Table 1: Degree to Which Science Teachers Choose Who Works in Each Experimental Groups

Response	Cook Islands		Fiji		Papua New Guinea		Solomon Islands		Tuvalu		Vanuatu	
	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.
The teacher chooses who works in each group when the class does the experiment	3.57	1.27	2.11	1.35	2.65	1.56	2.79	1.63	3.31	1.64	2.22	1.48
Sample Size	7		44		3012		121		87		109	

When students do experiments or the teacher demonstrates, the average teacher will usually have most of the equipment ready. But lesson observations showed that the teacher will finish preparing the rest of the equipment for student use (5.1% of observed teacher activities) while students are copying the notes from the chalkboard. The proportion of teachers (80.4%) who claim that they demonstrate is high and is also similar to Wilson's (1987) findings about PNG science teachers. However, the time students spend in small groups doing experiments has declined. If the teacher has decided that his typical class of 39 students will do the experiment, he will divide them into groups that contain between four and six students. How are the members of each group decided? Table 1 shows that South Pacific students believe that they control who is really in each group.

Table 2: Method of Designing Experimental Problem and Experimental Procedure

		Cook Islands	Fiji	Papua New Guinea	Solomon Islands	Tuvalu	Vanuatu
Follows Expt'l Instructions Given by Teacher	Mean	4 57	4.75	4.43	4.54	4.91	4.50
	Std dev	1.13	0.84	1.05	0.85	0.55	0.98
Students Design Problem. Teacher helps to plan expt	Mean	3.71	2.80	2.13	2.66	3.40	1.53
	Std dev	1.89	1.55	1.39	1.39	1.72	0.93
Teacher gives Problem, Students design expt	Mean	3.14	2.59	2.45	3.05	2.98	1.94
	Std dev	1.68	1.39	1.42	1.46	1.65	1.26
Teacher Prepares Extra Experiments for Advanced Students	Mean	2.00	2.16	2.21	1.95	2.02	1.46
	Std dev	1.15	1.52	1.39	1.18	1.64	1.00
All Students do Same Experiment	Mean	4.86	4.75	4.46	4.57	4.94	4.36
	Std dev	0.38	1.06	1.04	0.81	0.28	1.16

There are some questions could be asked about the procedure followed when doing experiments. Table 2 also shows that science teachers feel it is important that students always do the same experiment at the same time and carefully follow instructions given by the teacher. The table also indicated that no allowances appear to be made for different students needs or different methods or approaches. But does the science teacher explain how to do the experiment? The teacher seem to explain how to do the experiment step-by-step (see Table 3) and all the students do the same experiment at the same time with Table 2 showing that the students virtually never doing experiments by themselves with or without directions from the teacher nor do they make up their own problems to solve. It seems it is the teacher who presents the problem to be solved to the class. Is the fact that teachers explain how to do the experiment step-by-step, part of the earlier reference to the teacher wanting to remain in control of the class? Does explaining step-by-step fit into cultural norms?

Table 3: Degree to Which Science Teacher Explains Step-by-Step How to Do Each Experiment

	Cook Islands		Fiji		Papua New Guinea		Solomon Islands		Tuvalu		Vanuatu	
	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.
Science Teacher explains step-by-step how to do the experiment	4.71	0.49	4.68	0.74	4.62	0.84	4.86	0.40	4.76	0.85	4.26	1.07
Sample Size	7		44		3100		121		87		109	

From the teachers' point of view and based on lesson observations and informal teacher discussions with the researcher, student experiments appear to follow a recipe type format with the science teachers stating the experiment to be performed, explaining how to do the experiment, and all students performing the same experiment, using the same method. But what actually happens when students do experiments? Based on lesson observations and anecdotal evidence, the usual scenario seems that within each group, one student will collect the equipment and one or two students will actually do the experiment. The rest of the students will watch and/or sit and talk about anything irrespective as to how much the talk relates to the lesson. Near the end of the allotted time for the experiment, the passive group of students then will copy the answers about the experiment from those students who performed the experiment. At the end of the lesson, the teacher will ask if students have obtained the results that the teacher has usually written on the chalkboard. Both science teachers and students claim that the results of the experiments are discussed after the students have completed the experiments. A short discourse is then given about the experiment and what it was supposed to teach. Evaluation often consists of whether the students can give the answer the teacher has just stated or has written on the chalkboard.

Table 4: Degree to Which Teachers Demonstrate Experiment First

	Cook Islands		Fiji		Papua New Guinea		Solomon Islands		Tuvalu		Vanuatu	
	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.
Teacher demonstrates the experiment first, then the students do it	4.00	1.53	3.73	1.59	4.53	0.88	4.41	1.09	3.13	1.75	2.80	1.44
Sample Size	7		44		3082		121		87		109	

A typical science lesson lasts for one or two forty minute periods. Schools are somewhat divided with some schools opting for three single and one double while other schools opted for one single and two double science lessons per week. In the schools visited, it was rare to find any teacher teaching five single periods per class per week. Usually each double science lesson is taught in the science laboratory irrespective as to whether student experimental activity or teacher demonstration has been planned. Often the other science periods are also taught in the science laboratory. But do science teachers prefer to demonstrate or let the students do the experiment? Does this mean that the teacher demonstrates the experiment first to the students and then the students do the experiment or does it simply mean that the teacher prefers only to demonstrate? It appears to be common practice that before students do an experiment that teachers demonstrate the experiment to the students. Table 4 suggests that teachers like to use demonstrations to show students how to perform the experiment before students commence the experiments except for Tuvalu and Vanuatu. This could be because these countries are not as affected as the other countries by equipment shortages.

There is sufficient evidence to suggest that teachers prefer demonstrating experiments to students in preference to giving class experiments. The use of the laboratory as a teaching tool is perceived to be effective by the students. This is illustrated by the fact that students believed that the science teachers use demonstrations to usefully explain scientific ideas as shown in Table 5. What were the main reasons for science teachers choosing not to do some form of experimentation? Lack of equipment or chemicals (PNG - 31% and SP - 39%), insufficient time available for the experiment (PNG - 23% and SP - 28%) and the teacher feeling insecure about his/her ability to perform the experiment (PNG - 18% and SP - 6%) were the main reason why science teachers choose not to do experiments. Although difficulties in obtaining science supplies is a major problem in South Pacific countries, these reasons suggest that other factors could also affect whether the teacher does any form of experimentation. The lack of equipment could also suggest a laboratory storeroom security problem. Why do teachers do experiments as demonstrations or class experiments? Teachers could choose to do an experiment because they believe it reinforces the lesson (PNG - 22% and SP - 13%), helps students to understand (PNG - 13% and SP - 26%) and stimulates interest in students (PNG - 12% and SP - 22%). This indicates that teachers perceive a benefit to learning through the use of experiments but what is the perception of student attitude and the learning environment?

Table 5: Degree to Which Teachers Use Demonstrations to Explain Scientific Ideas

Response	Cook Islands		Fiji		Papua New Guinea		Solomon Islands		Tuvalu		Vanuatu	
	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.
Teacher uses demonstrations to help explain ideas	4.43	0.79	4.55	1.13	4.25	1.05	4.73	0.59	4.57	0.79	3.91	1.11
Sample Size	7		44		3086		121		87		109	

Teachers' Questioning and Student Input

Lesson observations in Papua New Guinea science classrooms showed that the science teacher tended to ask factual questions to students such as "what is the name of this? How did we do this?" Similar observations in PNG classrooms also showed that it would be unusual to find the teacher asking any extended thought questions (0.7% of teacher observations) of the students. In fact, these observations in PNG classrooms showed that over 25 factual questions (19.0% of teacher observations) were asked for every extended thought question (0.7% of teacher observations) the teacher asked. Does this mean that science teachers don't encourage thoughtful responses from students? That students' answers are limited in range of response, seems substantiated by students' perception that teachers don't listen to their ideas and from interviews with randomly selected students (Table 6). Lesson observations revealed that for a science teacher to show his intelligence to the class, the science teacher will transmit a lot of information (14.0% of teacher observations) with little application as to how this information applies to real life. Yet all South Pacific students appear to believe that what the teacher is teaching helps them to understand what happens in real life and could be relevant to their learning.

Table 6: Degree to Which Science Teachers Listen to Students' Ideas and Questions and Use Science Experiments to Explain Why Real Things Happen

Response	Cook Islands		Fiji		Papua New Guinea		Solomon Islands		Tuvalu		Vanuatu	
	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.	Item Mean	S.D.
1.Teacher listens to students' ideas about experiments	3.86	1.46	4.39	1.22	3.31	1.46	3.88	1.43	3.43	1.53	2.73	1.43
2. Teacher likes students to ask questions about science	3.57	1.81	4.86	0.67	4.01	1.33	4.48	0.99	4.67	1.01	3.85	1.43
3. Teacher explains how experiments help students to understand why real things happen	3 86	1.21	4.48	0.93	4.60	0.81	4.71	0.73	4.85	0.54	4.30	1.24
Sample Size	7		44		3074		121		87		109	

It was interesting to note that all countries except Vanuatu and Fiji, reported similar levels of student perceptions as to whether teachers listen to students. Students overall felt that teachers did listen to their ideas but not to the degree to which teachers thought that they listen to students ideas. Vanuatu had mainly expatriate teachers (teachers whose country of origin was overseas) while Fiji also had teachers from other South Pacific (SP) countries. The Vanuatu students were more likely to feel that their teachers did not listen to their ideas about science. According to local Fijian mythology, the country of origin of the science teachers concerned was closely related to Fiji and closely connected through ancestry and as a result, these people are highly respected in Fijian society.

Who controlled what occurred in the science classroom? Classroom observations showed that the teacher gives directions as to what the students should do, what they should learn, but rarely does the teacher seek their comments as to how a task should be done unless they are revising some past material. Lesson observations showed that giving directions was one of the most common teacher activity (18.4% of teacher observations). If the science teacher feels that they must direct the class and mainly uses factual questions during this process. what are the science teachers' perceptions about welcoming new ideas? If science teachers feel that student input is welcome, then it could be expected that a similar result could be observed as to whether the teacher likes students to ask them questions about science. Table 6 shows that teachers felt that they liked to be asked questions by the students. There was a distinct difference between the perceptions of Vanuatu and Fijian students. This could be due to the fact that Vanuatu students were being taught by non-South Pacific nationals while the Fijian students were being taught by a South Pacific Islander. The data from Cook Islands were ignored because of low sample size. Lesson observations in PNG schools showed that teachers in less academically achieving schools showed less inclination to ask students questions or listen to students ideas about science. It was rare to find during any lesson observation, the student asking any questions other than clarification type or permission seeking questions. On the rare occasion a question was asked, the question was almost always a factual question.

After considering the above points, it should not be surprising to find that the most common students activities during lesson observations were students observing and listening to the teacher (45.3% of observed student activities). Since students are not asking or answering questions during class times, what activities are present during this time? Based on discussions with science teachers and students, it appears that since both teachers and students believe that the students have to learn a lot in order to pass the final nationally set examinations, the teacher endeavours to instil this information into the students. Lesson observations showed that the accepted way to achieve this would be to write copious notes about the experiment that has just been performed, demonstrated, on the chalkboard. Copying notes was the second most frequently observed student activity (32.1% of observed student activities). Occasionally, students will be given duplicated, or less frequently, photocopied material to be read instead of copying from the chalkboard. Typically this material will be read word for word by the teacher with the occasional comment. This duplicated material seems more often than not, taken from word for word from some reference book. Since the science teacher tends to be so busy writing notes on the chalkboard, asking recall questions or giving directions, there seems little time to listen to what the students are actually saying when they are answering a teacher's question (Table 6). Time seems short and so the teacher expects to hear back what he has taught. Lesson observations showed that with some teachers, the teacher could not recognise the answer as being correct if it is worded too differently from what has been taught.

Students (45.3% of observed student activities) are expected to sit and observe whilst the teacher is talking. Lesson observations showed that these students who are not listening (7.2% of observed student activities) appear often to be involved in non-lesson behaviour, especially in lower academically achieving schools. This non-lesson behaviour tend to include such activities as talking, looking out the window, daydreaming or reading some non-science related material. This was the third most common student activity. Students were unlikely to ask their science teachers a question as the student believes that the teacher usually does not listen to and is not interested in their ideas (Table 6). But does the science teacher resent questions being asked because such student activity could be seen as challenging their authority? Since the teacher usually has the respect due to age and learning from the local society, the students normally accept the belief that the teacher must know what to do next in a learning situation. This could imply that their ideas will be better than the students' ideas. The teacher knows best. Students rarely challenge what the teacher is saying.

PERCEPTIONS ABOUT THE SCIENCE LABORATORY FACILITIES

Perceptions about science laboratory facilities are important as these perceptions could affect science teachers and students real or apparent use of the facilities. If there is a perception that the science laboratory facilities are inadequate, then it could be that these teachers are not maximising the use of the facilities and this could affect the optimisation of educational productivity. The data which formed the basis of these results, were obtained from the teachers' and students' version of the classroom teaching activities and specific laboratory questions in the teacher questionnaire. Science teachers and sometimes their students, were asked about their perceptions of the science laboratory as a facility. They usually rated their responses on a five-point Likert-type scale.

A significant proportion of science teachers felt that the level of laboratory storeroom security was inadequate, and so it should not be surprising if there is also a shortage of science equipment for experiments or demonstrations. Table 7 shows quite clearly that a significant but low proportion of science teachers felt that class experiments (PNG - 28.2%, SP - 33.3%) and teacher demonstrations (PNG - 23.9%, SP - 22.2%) were always or mostly affected by the shortage of equipment on science teaching. This is also supported by the reasons given in the last section as to why science teachers choose not to do experiments with classes.

Table 7: Effect of Shortage of Equipment on Demonstrations or Experiments (Teachers' Perceptions)

Response	Class Experiments		Teacher Demonstrations	
	PNG (%)	SP (%)	PNG (%)	SP (%)
No experiments done at this school	2.2	0.0	2.2	0.0
Never Affected	2.2	0.0	15.2	0.0
Sometimes Affected	67.4	66.7	58.7	77.8
Mostly Affected	21.7	33.3	19.6	22.2
Always Affected	6.5	0.0	4.3	0.0
Sample Size	46	9	46	9

These findings about the problems of the science laboratory should be noted in conjunction to various relationships with outcomes. Considering only PNG data, Table 8 shows that the shortage of equipment on class experiments and teacher demonstrations affects the practical mark. The practical mark was a measure of students' performance in a Science Process Test. Schools that reported a shortage of equipment also had students who achieved a lower result in the Science Process Test compared with schools that did not report a shortage of equipment.

Table 8: Results of T-tests on Effect of Shortage of Equipment on Class Experiments and Teacher Demonstrations to the Science Process Test.

Item	Low effect of shortage			High effect of shortage			*t* value	Degrees of Freedom	2-Tail Prob
	n	Mean	S.D.	n	Mean	S.D.			
Class Experiments	871	6.16	2.99	452	5.15	2.47	6.17	1321	.000
Teacher Demonstrations	989	6.01	2.99	431	5.40	2.57	3.66	1418	.000

If the shortage of science equipment on class experiments and the teacher demonstration affects students' performance on a Science Process Test, then it could be possible that this lack of resources could also affect the students' performance in an external science achievement examination. Similarly Table 9 shows that the PNG science mark is affected by the shortage of equipment on class experiments. Students from schools with shortages of equipment tended to be disadvantaged in the external science achievement examination.

Table 9: Results of T-tests on Effect of Shortage of Equipment on Class Experiments to the Science Achievement Test.

Item	Low effect of shortage			High effect of shortage			t value	Degrees of Freedom	2-Tail Prob
	n	Mean	S.D.	n	Mean	S.D.			
Class Experiments	1633	25.96	8.45	823	25.07	8.25	2.49	2454	.013

This effect of shortage of resources seems confirmed when one considers the relationship of the level of laboratory resources to science achievement results. The level of resources measured refers to such items as the availability of electricity, gas and water, the effect of shortages of equipment on class experiments or teacher demonstrations, and the level of laboratory storeroom security. There is a positive correlation between the level of laboratory resources and the science process test or the science achievement test (Table 10).

Table 10: Correlation of Science Process Test and Science Achievement Test to the Level of Laboratory Resources

Item	n	Availability of Lab Resources	Level of Significance
Science Process Test	987	.242	<.001
Science Achievement Test	1707	.193	<.001

SCIENCE LABORATORY LEARNING ENVIRONMENT

The physical facilities is only one aspect of the science laboratory classroom, and the learning environment is another important aspect. A modified version of the SLEI, the Science Laboratory Environment Inventory (Giddings & Fraser, 1990) was prepared for Papua New Guinea secondary schools. Field testing the seven scale version of SLEI involved 3182 students from Grade 10 science classes in 44 Papua New Guinea secondary schools. Table 11 clarifies the meaning of each of the five scales in the final version of SLEI by providing a scale description and sample item. The data was subjected to item analysis in order to identify items whose removal would improve each scale's internal reliability. This was achieved by removing a small number of items with low-remainder correlations. This item analysis procedure resulted in the final version of SLEI for Papua New Guinea secondary schools containing 25 items in 5 scales.

Table 11: Descriptive Information for Each Scale in Personalised Science Laboratory Environment Instrument (SLEI) Scales

Scale Name	Description	Sample Item
Student Cohesiveness	Extent to which students know, help and are supportive of one another.	I work well with others during experiments
Open-Endedness	Extent to which the laboratory activities emphasize an open-ended, divergent approach to experimentation.	I can do experiments by myself
Integration	Extent to which the laboratory activities are integrated with non-laboratory and theory classes.	What I learn in class doesn't help me to do the experiments.
Rule Clarity	Extent to which behaviour in the laboratory is guided by formal rules.	I have certain rules to obey in the science laboratory
Material Environment	Extent to which the laboratory equipment and materials are adequate.	Laboratory equipment is in poor working order

Table 12 contains the internal consistency (alpha reliability coefficient) data for the SLEI for when the sample is school or individually based. It shows that for the sample of students as individuals, the alpha coefficient ranged from 0.48 to 0.58 for PNG schools and 0.48 to 0.63 for South Pacific schools, and on a school basis, the alpha coefficient ranged from 0.57 to 0.82 for PNG schools. It is not surprising to note that the alpha reliability was consistently greater with the school being the unit of analysis rather than with the individual being the unit of analysis. This is because the aggregation that occurs when the school mean is the unit of analysis, results in the variance being less and the consequential improvement in reliability.

Table 12: Scale Mean , Item Mean, Cronbach Alpha Reliability and Discriminant Validity (Mean Correlation with Other Scales) for SLEI, and Ability to Differentiate between Classrooms

Scale	Unit of Analysis	No of Items	Alpha Reliability	Mean Correlation with Other Scales	Sample Size	Scale Mean	Item Mean	ANOVA Results (Eta^2)
Student Cohesiveness	PNG School Mean	7	.59	.34	43	30.07	4.30	0.30*
	PNG Individual		.49	.27	2,771	29.42	4.20	
	SP Individual		.63	.46	310	30.52	4.36	
Open-Endedness	PNG School Mean	5	.57	.15	43	11.60	2.32	0.14*
	PNG Individual		.48	.09	2,824	11.49	2.30	
	SP Individual		.48	.20	310	13.01	2.60	
Integration	PNG School Mean	5	.73	.27	43	22.32	4.46	0.30*
	PNG Individual		.48	.24	2,843	22.33	4.47	
	SP Individual		.63	.45	310	22.88	4.58	
Rule Clarity	PNG School Mean	4	.77	.37	43	17.95	4.49	0.39*
	PNG Individual		.58	.26	2,823	17.89	4.47	
	SP Individual		.58	.44	310	18.16	4.54	
Material Environment	PNG School Mean	4	.82	.27	43	16.77	4.19	0.28*
	PNG Individual		.57	.21	2,961	16.76	4.19	
	SP Individual		.60	.41	310	16.74	4.19	

*$p<0.001$

The eta^2 statistic (which is the ratio of 'between' to 'total' sums of squares) represents the proportion of variance explained by class membership.

The reliability data in Table 12 suggests that the refined version of each SLEI scale has acceptable reliability, especially for scales containing a relatively small number of items when either the individual student or the school is used as the unit of analysis. As expected, Cronbach's alpha reliability was higher when the unit of analysis was the school instead of the individual because of the effects of aggregation. The overall reliability of SLEI scales was measured by determining the reliability of the scales when the unit of analysis was the individual (α = 0.56 (PNG), = 0.58 (SP)) and when the school mean was the unit of analysis (α = 0.62). Data about discriminate validity was generated by using the mean correlation of a scale with the other scales on both an individual and school basis. Comparable results were obtained in both cases. Comparing school and individual perceptions, there appears to be no significant differences. The mean correlation shows that each scale is largely independent of each other and so are measuring different entities.

A desirable characteristic of the SLEI is that it is capable of differentiating between perceptions of students in different schools. This characteristic was explored by analysis using one-way ANOVA, with school membership as the main effect and using the individual as the unit of analysis. The results in Table 12 indicated that each scale differentiated significantly ($p<0.001$) between PNG schools. The eta^2 statistic represents the amount of variance in environment scores accounted by school membership and in this study ranged from 0.14 to 0.39.

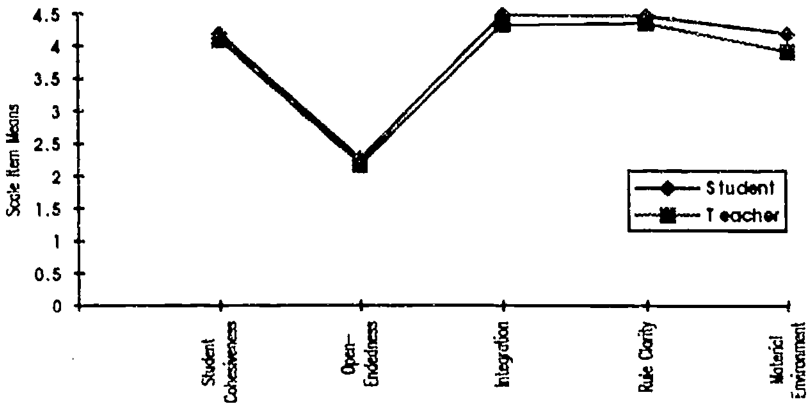

Figure 1: Plot of SLEI Scale Item Means for Students and Science Teachers

Students' scale item means and science teachers' scale item means were plotted in Figure 1. The pattern of this plot was consistent with past research. (Fraser, 1982a, 1982b, 1982c, 1986b; Fraser, Giddings and McRobbie, 1991). Table 12 showed that integration and rule clarity were clearly the most favourable SLEI scales. It is also very clear that open-endedness was the least favourable SLEI scale. As well, Table 13 shows that the SLEI scale means were similar for both students and science teachers. Except for the material environment scale, male and female teachers appeared to perceive the SLEI scales similarly. Figure 1 indicates that PNG students perceived a slightly more favourable laboratory classroom than the one perceived by teachers. Only the material environment showed that the difference in perceptions were significant, students perceiving a more favourable environment.

Table 13: SLEI Scale Item Means of Students and Teachers

Scale	Number of Items	Student Mean	Teacher Mean	Male Student Mean	Female Student Mean	Male Teacher Mean	Female Teacher Mean
Student Cohesiveness	7	4.18	4.09	4.21	4.19	4.11	4.03
Open-endedness	5	2.27	2.18	2.36	2.20	2.19	2.16
Integration	5	4.47	4.32	4.54	4.48	4.35	4.20
Rule Clarity	4	4.46	4.35	4.47	4.48	4.32	4.45
Material Environment	4	4.19	3.91	4.21	4.16	3.84	4.12

Male students scale means and female students scale means were plotted in Figure 2. The pattern was similar with previous research in both developed and developing countries (Fraser, 1982a, 1982b, 1982c, 1986b; Fraser, Giddings & McRobbie, 1991, 1992; Waldrip, 1993) in that Open-endedness was the least favourable SLEI scale. Female students perceived Integration and Rule Clarity slightly but not significantly more favourable whereas male students perceived student cohesiveness, open-endedness and material environment more favourable. There was no significant difference in male and female students' perceptions of the SLEI. The student perceptions of the science learning environments for all South Pacific countries were plotted in Figure 3. Considering the size of some samples, there was a strong similarity between each learning environment scales.

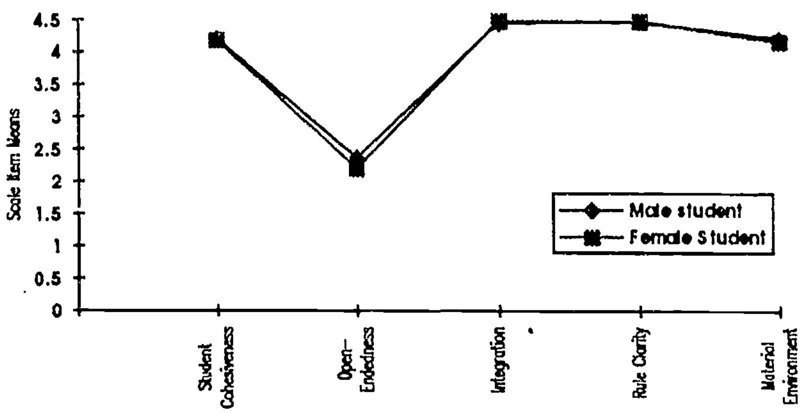

Figure 2: Plot of SLEI Scale Item Means for Male and Female Students

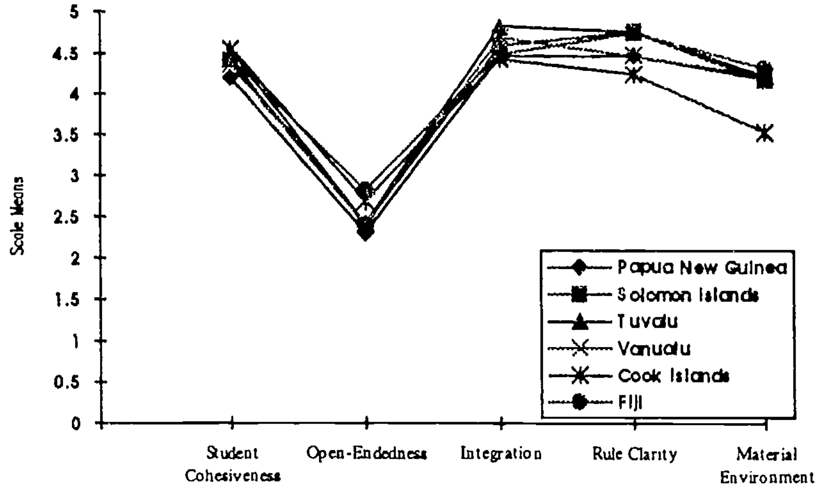

Figure 3: Plot of SLEI Item Means for Students in Selected South Pacific Countries.

STUDENTS' ATTITUDES TOWARDS SCIENCE

Students' Attitudes Towards Science was the score representing students' response to a simple 17-item Likert-type questionnaire which had five response alternatives assessing opinions about the science laboratory. This questionnaire was entitled Attitudes. The Attitudes questionnaire had a reliability of 0.62 based on 2754 students' responses. A plot of students' attitudes towards science was shown in Figure 4.

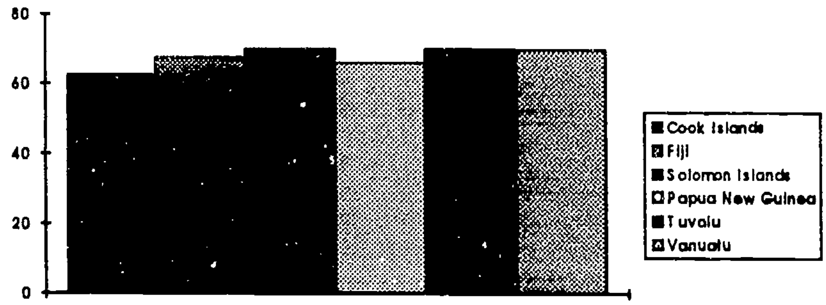

Figure 4. Plot of Student Attitudes Towards Science

Interestingly, students from all South Pacific countries had similar students' attitudes towards science. Similar to many previous studies (Gardner, 1975; Schibeci, 1984), females in this study had a less favourable attitude towards science than do males as shown in Table 14.

Table 14: Results of T-test on Male and Female Students' Attitude Towards Science

Male n	Male mean	Male sd	Female n	Female mean	Female sd	t-value	df	Prob
1718	66.36	7.81	1036	65.42	7.94	3.04	2752	.002

SUMMARY

This study has described the typical South Pacific science teacher as one who prefer to utilise teacher demonstrations rather than allow students to perform experiments in small groups. However, Tuvalu and Vanuatu science teachers were less likely to use class demonstrations. This could have been because these countries were not as affected as other countries by equipment shortages. If students were allowed to do experiments, then they were divided into small groups for the experiment. The science teacher had already decided the problem to be examine, the experiment, the method and the equipment necessary to solve this problem. The science teachers first demonstrated the experiment and explained step-by-step how to do the experiment, then the students conducted the experiment. While students were doing the experiment, the teacher believed that they were frightened to seek or give any help concerning the experiment. Students stated that confusion existed during experiments. At the conclusion of the experiment, the teacher discusses the results, wrote copious notes on the chalkboard and the students copied these notes into their workbooks. The science teachers were very didactic in their approach to teaching and there appeared very little variation in approaches to teaching and student experimentation.

This typical South Pacific science teacher often used factual questions and rarely asked thought provoking questions. Since students were more likely to perceive that the teachers did not like to listen to their ideas or questions, it was not surprising to find that it was uncommon to observe students asking the teacher a question. The greatest difference between students' and science teachers' perceptions about the teacher not liking student input occurred in Vanuatu, which co-incidently or not, had non-national science teachers. There was a strong belief amongst both students and science teachers that copious notes were an important ingredient for the success in the final external science academic examination. This study showed that the South Pacific science teacher were very stereo-typed, liked to be in control of the situation and as such did not really liked to receive student input in terms of ideas or questions. Consequently, little variation in teaching methods or approaches was displayed in South Pacific secondary science laboratory classrooms.

This study has described the typical South Pacific science laboratory as generally not well maintained or well equipped. The availability of utilities such as electricity, gas and water depend largely upon proximity to a large population centre. The shortage of resources such as the availability of utilities, availability of science supplies, and the level of science laboratory storeroom security, affected teachers' ability to demonstrate or allow student experiments. The shortage of equipment was shown to affect students' achievement in both a practical and academic test.

The adaptation of SLEI to the developing South Pacific countries context, produced a valid, reliable instrument that had adequate discriminant validity and was able to distinguish between different schools. The science learning environment was favourable overall but there was a low perception of open-endedness. Both students and teachers perceived SLEI scales similarly but students perceived Material Environment more favourably. This contrasted with previous research. This study failed to find any significant differences between perceptions of male and female students except for Open-endedness where male students had a more favourable perception. With students' attitudes towards science, male students had a more favourable attitude towards science.

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