THE IMPACT OF AN IN-SERVICE COURSE FOR PRIMARY SCIENCE TEACHERS

Rowena H. Scott
Central Queensland University, Rockhampton, Australia
and
Darrell L. Fisher
Curtin University of Technology, Perth, Australia

This study preserved the voices of teachers who had participated in curriculum reform. Recently, science has been included in the primary curriculum. Teachers from twelve Project schools were selected to become Specialist primary science teachers. These teachers attended a unique, four-week, in-service course and regular school-based workshops. It was anticipated that the ability of participants to use questioning techniques to probe students' understanding would improve and that teaching methods would become less traditional and less teacher-directed. Male and female Specialist science teachers, experienced and less experienced, and teachers from Project schools who were not involved in the Specialist science teaching course were interviewed to seek out and capture the essence of different participants' experience.

INTRODUCTION

Reform is now common, with people from nearly every nation engaging in improving science teaching as political leaders recognise that knowledge of science has economic consequences (Gallagher, 2000). The country of Brunei Darussalam in South East Asia is no exception. Showing an awareness of the need for improvements in the teaching and learning of science and mathematics, Brunei has given science and mathematics education an important status in the school curriculum, aiming to create the foundation of a technologically-oriented work force in line with the needs of national development (Ministry of Education, MOE, 1999).

Keywords: curriculum reform; science teaching; elementary teaching; professional development;

Accepted methods to increase academic achievement in science include the promotion of more effective teaching strategies and creation of more positive attitudes towards the learning of science (Poh, 1996). Also, an emphasis on the development of more active and creative learning environments in classrooms and greater reflectivity in teachers and pupils is needed (Zaitun, 1999).

If science teaching is to move from rigid, didactic methods commonly associated with a past era, and if science examination results are to improve, information is first needed about what is currently happening in classrooms (Thorp, Burden, & Fraser, 1994). However, little comprehensive research on science teaching and learning has been conducted in schools in Brunei. The research study described in this paper is part of the first comprehensive study focusing on upper primary science teaching in representative government schools in the main city district of the country of Brunei.

TRADITIONAL AND INNOVATIVE SCIENCE PROGRAMS

Many innovative programs for the teaching of science with more hands-on approaches stemmed from the science curriculum boom initiated by the 1957 successful flight of the Soviet Sputnik (Stohr-Hunt, 1996). Many of these programs involved teaching students the process of science advocating the incorporation of enquiry in science teaching (Klopfer, 1976, 1990). Rather than viewing science as a body of facts to be learned, science was viewed as a structured and directed way of asking and answering questions about the world around us. Opportunities for active involvement in planning practical laboratory investigations, collecting data, and interpreting results may initiate and enhance students' curiosity and interest. Traditional science courses concentrating on the knowledge of scientific facts, laws, theories, and technological applications, attempting to cover a wide range and great number of topics mainly by lecture and recitation mode, and seeing confirmation of phenomenon in the laboratory (Shulman & Tamir, 1972) were common. Whereas, modern courses emphasising the nature, structure, and unity of science as well as processes of enquiry, employing discovery investigations as the basis of course development (Shulman & Tamir, 1972) have been advocated for the past 30 years.

Following this trend, a group of selected Specialist science teachers in Brunei were taught some of these modern methods and ideas in a university course.

Exemplary Primary Science Teaching

Exemplary teachers were found to create and maintain a learning environment that students perceived as favourable (Tobin & Fraser, 1988). They had well-ordered classes and taught in a relaxed manner which was characterised by pleasant interactions, concern for the individual in the class, and subtle use of humour. Despite quite different teaching styles, the focus was clearly student learning and teaching for understanding. Encouraging students' active involvement, prescribed activities ensured that students were also mentally active. Good management practices were essential, such that exemplary teachers monitored for understanding and consistent student engagement rather than spending their time correcting misbehaviour. The key to teaching for understanding was verbal interaction as an informal assessment strategy to monitor student understanding of science concepts throughout lessons. Exemplary teachers were effective because of their strong content knowledge, concern for meaningful learning, and consistent monitoring of student understanding of science concepts (Tobin & Fraser, 1988).

Similarly, Lacy (1987) showed that exemplary primary science teachers seek contributions from students, using divergent focus questions, followed by a series of more convergent related questions, posed by the teacher to initiate class discussions. Such questioning techniques, to promote step-by-step understanding of a complex concept and to gain immediate feedback on students understanding, were taught as a new teaching strategy in the course for Specialist science teachers. Hence, teachers were not necessarily selected to become Specialist science teachers because they were noted as exemplary teachers. Yet such previous studies of effective teaching provide a useful framework to view the effect of this innovative program.

Teaching and Learning in Brunei Classrooms

In government schools in Brunei, the medium of instruction in lower primary school (years 1, 2, and 3) is Malay (except for the study of English language). Upper primary (years 4, 5, and 6) schooling is bilingual. Students

study Malay language, Islamic religion, physical education, arts and handicrafts in Malay. They study English language, geography, history, mathematics, and science in English medium. Since 1992, upper primary students have been taught three lessons (25 minutes each) of science each week. The upper primary science syllabus is content-based, emphasising recall of knowledge covering a wide range of topics in biology, chemistry, and physics. At the end of primary schooling, all students sit five external, pen-and-paper Primary Certificate Examinations (PCE) in the subjects of Malay language, English language, mathematics, science, and General Paper, the latter four examinations being in English language. Results on these PCE are used to select and stream students for secondary schooling.

Numerous observations of science classes and numerous discussions with teachers in Brunei verified local educators' observations that traditional teaching as the trend (Zaitun, 1997, 1999). Classrooms were commonly characterised by teacher-centred and procedural approaches, lacking "minds-on" or expressive activities, and with little development of thinking or communicative skills. Learners in Brunei were generally viewed as passive recipients of an instructional program. Teachers, the unquestioned authoritarian purveyors of accepted knowledge, were responsible for students' learning. Teaching was the simple transmission of facts. Verbal interactions between teachers and students were uncommon. Students were seated at separate desks facing the teacher at the front of the classroom. Rather than being encouraged to ask questions, students were mostly required to listen and copy exactly what was on the board without necessarily understanding the topic. Strict dress code and rules of behaviour followed the Islamic tradition and discipline was generally not a problem. The curriculum was composed of superficial, unconnected content that must be learned. The one reason given for lesson format being very rigidly structured and classrooms being teacher-dominated, was that the primary goal of education was for students to pass external examinations. Schools and teachers were often judged by the performance of "their" students in public examinations. Concern about poor performance on these examinations, especially in science and mathematics, has been expressed in forums, seminars, speeches, and reports by educators, planners, principals, and teachers (Zaitun, 1997).

Attempts to improve the quality of teaching through pre-service and in-service courses at Universiti Brunei Darussalam (UBD) have been a goal since its establishment in 1985. Teachers admitted that they were not confident with the content of the subject, hence they sought courses that might enable them to learn the content of the science syllabus as well as methods to enable them to transfer this content into the classroom. Lecturers and inspectors of teachers agreed that teaching methods were, as they described, "chalk and talk", "traditional", "overemphasis on drills and practices", and "lots of copying on the blackboard". The culture of the society in Brunei may be an influencing factor contributing to the unselfconscious, routinised habits of teachers and students (Zaitun, 1997).

Curriculum reform

Tobin (1987) lamented that variations in science teachers' knowledge about science and teaching may influence the way that science programs are implemented. Interpreting his research findings, Tobin (1987) showed that the root cause for the problems in science classes may not be external examinations or prescriptive curricula, but rather it may be related to teachers' beliefs about what to teach, how to teach it, and how students learn. An amalgam of factors affecting the implementation of any educational innovation includes the characteristics of change, local characteristics, and external factors (Fullan & Stiegelbauer, 1991). As is common in many countries, the initiation of formal change in Brunei did not come from schools or teachers' search for improvement. Rather, the advocate was the Ministry of Education (MOE).

Not merely rhetoric, innovations had been made to emphasise science and mathematics teaching. One of the major recent developments in science education has been the inclusion of science in the elementary curriculum. In 1992, science was added to the compulsory curriculum in all government primary schools. The primary science syllabus, based on the secondary science syllabus, was developed by the Curriculum Department of the MOE.

Specialist Science Teaching Project

In October 1994, a program was launched for the training of Specialist teachers in primary science as an initiative of the Ministry of Education and coordinated by its Department of Planning, Research, and Development

(Zaitun, 1999). Twelve schools from the main city district were selected and requested to choose primary teachers for special professional development in primary science. The 17 selected teachers attended a unique, four-week, in-service course at the Universiti Brunei Darussalam (UBD) and regular school-based workshops. The course promoted teachers' use of strategies that incorporated active teaching and learning (Zaitun, 1999) and student participation in practical group work in science lessons (Ferrer, 1996). It was hoped that teaching methods would become less traditional and less teacher-directed. Also, it was anticipated that rote learning and memorisation would be reduced, and that the ability of participants to use questioning techniques to probe students' understanding would improve (Zaitun, 1999). The main purpose of the program was to improve students' PCE science results (Ferrer, 1996; Zaitun, 1999). Another important objective was to provide policy makers with information on how to promote the development of good quality teachers within the Bruneian perspective (Zaitun, 1999).

Project schools received extra laboratory equipment and most principals allocated one room as a science Specialist room. Mostly, non-Specialist classroom teachers were not scheduled to use this room but many took advantage of the resources and expertise of their colleagues. Principals decided the timetables of all teachers, such that several Specialist teachers in small schools taught all the science in upper primary while others taught all the year 4 science one year then continued with these students for the three years to their PCE.

This study marked the beginning of investigations into the teaching and learning of primary science in Brunei Darussalam, aiming to interpret findings of educational practices in a particular cultural context, preserve the voices of the participants, and generate rich insights to guide improvements in the teaching of primary school science. Evaluating the impact of the Specialist science teaching project, where students commonly engaged in participatory practical lessons, comparisons were made with the more traditional classrooms of non-Specialist teachers. In order to begin to understand the educational and practical significance of the science Specialist teaching project, aspects of school culture and classroom environment in Brunei have been described with reasons offered for some common patterns.

METHOD

There is a need in much education research to avoid Anglo-Saxon bias and, thus, to eliminate the generalisations from research conducted in Western countries to developing countries (Wubbels, 1993).

A marked change in the nature of research in science education has been an increasing acceptance of interpretive approaches designed to seek out and capture the essence of different participants' experience, preserving their voices, and allowing the improvement of the researchers' own emic (culture-specific) (Brislin, 1983) constructions through progressive subjectivity (Schaller & Tobin, 1998). To go beyond a descriptive account of events and behaviour, a researcher may seek reasons for an observed phenomenon from the perspectives of the participants in the study. Employing such a hermeneutic-dialectic circle in the design of an investigation, the researcher would approach participants from within the critical stakeholder groups to identify valid assertions and offer deconstructive commentary associated with the focus of the study (Schaller & Tobin, 1998).

A purpose of this study was to describe the forces that shaped teachers' classroom behaviour after they had participated in a university course as a "special treatment" program with those of "control" teachers. Rosenshine (1970) cautions researchers attempting to evaluate a special curriculum as opposed to a control treatment. It is often assumed that all classrooms using the same curriculum materials constitute a homogeneous "treatment variable". However, teachers vary widely in what they select and how they implement it. It is understood from the outset of this study that what teachers implemented in their classrooms may not be indicative of what the university course program taught or intended to teach.

All Specialist science teachers worked in the 12 Project schools. Some of these teachers worked collaboratively with each other and also assisted their non-Specialist teaching colleagues. Thus, there may have been an impact from the Specialist science teaching Project on non-Specialist science teachers' classroom behaviour in the Project schools.

The excessive involvement of a teacher in an innovative program may produce negative effects in the classroom environment resulting from the teacher exerting constant pressure on students to ensure success of the

program (Suárez, Pías, Membiela, & Dapía, 1998). Specialist science teachers in Project schools were monitored more closely, being under more pressure to attain "good" results than teachers in non-Project schools. They were also more likely to use group laboratory work as a teaching strategy, enabling students to perform specified experiments, requiring close attention to safety and probably maintaining close control.

Three male and three female Specialist science teachers, experienced and less experienced, were chosen from various Project schools for interview including one male and one female teacher from the same school. Four teachers from Project schools, who were not involved in the Specialist science teaching Project, including two from the same school, were also interviewed. In Brunei, it is common practice for formal letters to be sent requiring attendance at short notice without giving any choice. This procedure was followed as the normal practice. Teachers were assured confidentiality and interviewed by the researcher individually in an MOE office where they felt comfortable enough to speak honestly since they were away from their Principal and colleagues. Individual structured interviews were deemed appropriate, specifically questioning qualifications, experience, current work, specialist courses, resources, teaching, and student learning. Questions for these individual structured interviews were similar to those of the Specialist science teacher interviews. Teachers were encouraged to describe their concerns, recommendations, and actual teaching practice. The interviews were audio-taped and transcribed for ease of analysis.

DISCUSSION AND RESULTS

The qualitative data obtained from the interviews clearly indicated that improvement and enjoyment of teaching and learning in science lessons could be attributed to the Specialist science teaching Project. The provision of a Specialist science room, supply of appropriate resources, and the opportunity for teachers to learn new teaching skills and methods during a course that also enabled teachers to collaborate with other primary science teachers proved beneficial to both teaching and learning. Several relevant issues became apparent throughout interviews with the six Specialist and four non-Specialist science teachers from Project schools.

The impact of the Specialist science teaching Project on teachers and teaching

The curriculum reform and, more importantly, the professional development program impacted positively on teachers' confidence and enjoyment. One teacher explained that she liked the new teaching methods:

> I like doing practical and using the equipment in science. I like to do the experiments. ... then the students also enjoy doing the practical. When they do the experiment, I think, they are very happy. ... We do it together. We discuss together with the pupils.

A Specialist science teacher believed that his teaching and his science content knowledge had improved because of the Project:

> I feel more confident teaching and I also am surprised when I saw some teacher teaching science and I feel they miss a lot of things. … Probably there are some things I learned from past courses.
>
> (Specialist teacher 2)

Once teachers set up a science room and implemented the new teaching strategies, students' enthusiasm and interest in science was enhanced. In turn, this impacted positively on their confidence and enjoyment:

> I'm hearing some parents are saying "My children like to study science because the school has science lab and when he come home he always tell story to his nephews that 'I love science' ...". By bringing them to the labs, already making them interested in science. So if they have a good teacher they will be good science pupils. Most of my pupils were sort of look at me as a scientist which I think to them we all are scientists, not just me. I just teach you what the use of science in our daily life. … They respect me very much and they look so interested when they come to see me. They will bring something to me. They ask me what happens with this and I was surprised to see since I had my own lab, they keep on bringing things they know but they just give me and they ask me. … Pupils are sort of motivated when I teach so I feel I have done something right here. … I learned a lot actually from my course.
>
> (Specialist teacher 2)

Teachers' enjoyment and enthusiasm were obvious:

> Because if no Project I think I cannot do the activities. I cannot do my teaching properly because, before I attend the course, I usually use the book, just write *on the board. (not) Doing the asking questions, (not)* show picture, no activities, nothing, but now I really like to do activities with the pupils so that they can see, they can know. Not only me but also them, they enjoy…. When we have the science specialist we really know what we are teaching. We know what the pupils need.
>
> (Specialist teacher 4)

> We have … science room, enough facilities and the reference, review curriculum…. confidence in applying what they've learned to the pupils and they make it easier for the pupils to understand rather than the ordinary teachers. … Even though they have good knowledge of science they still lack the confidence. … advice of one other teacher is expert who knows what to do can teach us. It will be very nice for teachers, once in a while … to get together. … If you have two or three or more teachers in science they won't feel alone. … If there's two or three teacher they can work together and it will be fun to work together. My idea and your idea is different. Why don't we do it this way instead of … doing the old method.
>
> (Specialist teacher 6)

The professional development initiated teacher collaboration amongst some Specialist science teachers and assisted other teachers. A non-Specialist teacher at a Project school found the Specialist science teacher to be very helpful, and would like

> a course on how to the teaching strategies … how to attract pupil's attention and their interest in learning science, maybe how to produce better teaching aids.

Another teacher would like to learn both science content and pedagogical knowledge from courses:

> techniques of presenting such topics, I want techniques. I think that it depends on explanation for whatever topics. It all depends on how we explain. It's not only, the content is one thing but the stronger is how we present that content.
>
> A non-Specialist science teacher would like courses on how to teach science properly. In the case of Specialist science teachers, they do it different than ours.
>
> If she had been a Specialist science teacher, she expected that then we are confident of ourself and then maybe it will improve and especially the understanding of the pupils. … Doing it by themselves, more activities, more questions and also the teacher will make the pupils interesting. It's the behaviour of the teacher and the pupils' interaction with each other.
>
> (non-Specialist teacher 4)

The impact of the Specialist science teaching Project on students' learning and enjoyment

One teacher confirmed that the teaching methods taught in the Project had been worthwhile for the improvement of student learning:

> because they go to special science classroom. If they do more practical they can improve. … When they do the theory they just write the notes, look at the picture but they don't know what is that. It's a good idea to have science Project.
>
> (non-Specialist teacher 3)

The novelty value of students leaving their usual classroom and teacher to go to a special science room for activity-oriented learning cannot be overlooked. Teachers described what they liked about being Specialist science teachers:

We can do the activities with pupils. They know how to make the activities. They really understand. They enjoy. … They all want to go to my class. … They always asking the teacher to go to my class because they like to see the apparatus in my room. … Everything I did in my class they like to see and everything that they do they also want to see. (Specialist teacher 4)

A non-Specialist science teacher explained that she believed that student learning could be improved by using

> group work in class and also hands-on activities
>
> because
>
> I have done quite a few practical activities in class and … I found that the pupils are interested in doing these activities and they improve the learning in science with these activities. I think this Project should be continued.
>
> (non-Specialist teacher 1)

The continuation of the Specialist science teaching Project

One teacher confirmed that the teaching of primary science was an innovation in itself in Brunei:

> three years … before, there is no science … Before we do the science is health education on … human body only.
>
> (non-Specialist teacher 3)

Hinting at the faddism of the Specialist science project, she continued, explaining that there had been one Specialist science teacher in her school:

> Before, yes, one (Specialist science teacher) last year and last two years. But now she has a new responsibility, LAP, Learning Assistant, (for students with) lower abilities, handicapped, … so I think no more science Project teacher.
>
> (non-Specialist teacher 3)

The Specialist science project was discontinued in some schools as a new computer project for schools became the next wave of curriculum reform:

> They haven't got any science room … because for this year … we use two rooms for computer rooms.
>
> (Specialist teacher 5)

Confirming this, another teacher explained that student learning in primary science

> can be improved when there is a special room … but this is from the Principal so you have to follow … the problem is two classrooms are empty for our computer.
>
> (Specialist teacher 3)

The complex demands of the Specialist science teaching program, that aimed to achieve an increase in students' science examination marks, were voiced in teacher interviews. The Specialist science teachers were continually monitored, knowing that "their" results were under great scrutiny. The requirement of being part of an innovative program placed expectations and obligations upon teachers, students, and the administration of selected primary schools. Teaching strategies that enabled students' active participation in learning required more teacher-student interaction than the teacher-dominated classroom frequently used by non-Specialist science teachers in Brunei. Some Specialist science teachers hinted at their dissatisfaction with the authoritarian selection process of conscripting teachers. One teacher explained his unsuitability as a Specialist science teacher. When asked why he was chosen, he replied:

> For me I don't actually, because I am a physical education teacher. … I prefer PE … because I've got a lot of experience in physical education.

The following year he taught only upper primary physical education at the request of the Principal. Thus, some teachers selected by the Principals to become Specialist science teachers were not interested, but they had to follow the authority of the decision. Other teachers referred to the standard selection procedure, as in the following:

> (The Principal) gave me two choices whether mathematics or science (Specialist course). Actually I chose mathematics but he changed his mind.
>
> (Specialist teacher 3)

> I'm chosen by the Guru (Principal). Not really asked, just select me and send my name … to Ministry.
>
> (Specialist teacher 1)

The Specialist science project was phased out in several schools. Teachers noted signals, rather than open communication, that the conclusion of the Specialist science teaching Project in their schools was imminent.

> I prefer to teach only science subjects … I have my own science laboratory. I just finished putting all this stuff project in my room last year … but this year when I think I was ready to teach science with all my room and all my apparatus there and suddenly I receive my timetable … It was a fright and really, really surprised to see (no science classes) … I said this is useless. … I was trying to be good in teaching science and now they were giving me other subjects … Its useless now.
>
> (Specialist teacher 2)

CONCLUSIONS AND RECOMMENDATIONS

The research study described in this paper was part of the first comprehensive investigation of primary science classrooms in Brunei Darussalam. This paper reports qualitative data from observations and teacher interviews after a curriculum reform added science to the primary school curriculum and a professional development program enhanced teachers' science content and pedagogical knowledge. Interesting evidence of the value of this Specialist science teaching Project was furnished.

Interviews with several Specialist science teachers revealed that their classrooms were probably less traditional as they employed practical teaching strategies that facilitated group activities, with which many teachers and students were previously unfamiliar.

Specialist teachers generally became more confident with both the content of the syllabus and modern teaching strategies. They enjoyed being in charge of the science room and valued students' increased enthusiasm and learning. The Specialist course empowered many teachers with increased confidence and knowledge of science, improved their teaching as well as improving the students' learning and enjoyment of science.

Collaboration between enthusiastic Specialist science teachers was a direct result of the course and beneficial as teachers shared their experiences and learnt from one another.

Teachers interested in teaching science, rather than conscripted teachers, advocated the continuation of the position of Specialist science teachers in schools. It is also recommended that the Specialist science teachers be offered the choice to teach only science or to return to full classroom teaching duties. Several of the Specialist teachers were enthusiastic to continue to teach science exclusively. Yet, without consulting the teachers, several Principals made decisions to discontinue the Specialist science teaching Project in their schools, time-tabling their Specialist science teachers to take on new responsibilities to fulfill obligations for the next innovation from the MOE. Teaching other subjects, despite increased competence and academic results directly related to the professional development course, several Specialist science teachers became disillusioned.

The need for more courses for other pre-service, beginning, and experienced primary teachers especially for those with little background qualification in science was illuminated. Focus on both the content and process of science teaching including how to use non-traditional strategies would be particularly beneficial.

Finally, the recent inclusion of science in the primary syllabus in Brunei offered the perfect opportunity for the Specialist science professional development program. Although some conscripted teachers gained very little from the course, several primary teachers learnt both science knowledge and teaching skills, gaining confidence and competence and saw that students' learning and enjoyment of their science lessons visibly increased.

REFERENCES

Brislin, R. W. (1983). Cross-cultural research in psychology. *Annual Review of Psychology*, *34*, 363-400.

Ferrer, L. M. (1996, July). *B.E.S.T. (Building Effective Strategies for Teaching) of science: An exploration into the culture of collaboration.* Paper presented at the joint AARA and ERA conference on Educational Research: Building New Partnerships, Singapore.

Fullan, M. G., & Stiegelbauer, S. (1991). *The new meaning of educational change*. (2nd ed.). New York: Teachers College Press.

Gallagher, J. J. (2000, January). *Implementing needed reforms in science education: Research and development to enhance understanding and application of knowledge.* Paper presented at the second international conference on Science, Mathematics and Technology Education, Taipei, Taiwan.

Klopfer, L. E. (1976). A structure for the affective domain in relation to science education, *Science Education*, 60, 299-312.

Klopfer, L. E. (1990). Learning scientific enquiry in the student laboratory. In E. Hegarty-Hazel (Ed.), *The student laboratory and the science curriculum* (pp. 95-117). London: Routledge.

Lacy, T. W. (1987). Exemplary primary science teaching. In K. Tobin & B. J. Fraser (Eds.), *Exemplary practice in science and mathematics education* (pp. 95-111). Perth: Curtin University.

Ministry of Education (1999). *The education structure and school system*. Brunei: Ministry of Education.

Poh, S. H. (1996). A study of biology laboratory learning environment in Brunei Darussalam. In M. Quigley, P. K. Veloo, & W. K. Yoong (Eds.), *Assessment and evaluation in science and mathematics: Innovative approaches* (pp. 272-281). Brunei: Universiti Brunei Darussalam.

Rosenshine, B. (1970). Evaluation of classroom instruction. *Review of Educational Research*, *40*, 279-300.

Schaller, J. S., & Tobin, K. (1998). Quality criteria for the genres of interpretive research. In J. A. Malone, B. Atweh, & J. R. Northfield (Eds.), *Research and supervision in mathematics and science education* (pp. 39-60). New Jersey: Lawrence Erlham Associates.

Shulman, L. S., & Tamir, P. (1972). Research on teaching in the natural sciences. In R. M. W. Travers, (Ed.), *Second handbook of research on teaching* (pp. 1098-1148). Chicago, IL: Rand McNally.

Stohr-Hunt. P. M. (1996). An analysis of frequency of hands-on experience and science achievement. *Journal of Research in Science Teaching*, *33*, 101-109.

Suárez, M., Pías, R., Membiela, P., & Dapía, D. (1998). Classroom environment in the implementation of an innovative curriculum project in science education. *Journal of Research in Science Teaching*, *35*, 655-671.

Thorpe, H. S., Burden, R. L., & Fraser, B. J. (1994). Assessing and improving school environment. *School Science Review*, *75*, 107-113.

Tobin, K. (1987). High school science. *The Australian Science Teachers Journal*, *32*, 22-30.

Tobin, K., & Fraser, B. J. (1988). Investigations of exemplary practice in Australian science classes. *The Australian Science Teachers Journal*, *34*, 23-29.

Wubbels, T. (1993). Cross-national study of learning environments. In D. L. Fisher (Ed.), *The study of learning environments Volume 7* (pp. 112-120). Perth: Curtin University of Technology.

Hjh Zaitun bte Hj Mohd Taha (1997, January). *Focus on the teacher: The transfer of knowledge from teacher education into the classroom.* Paper presented at the international conference on Science, Mathematics & Technology Education, Hanoi, Vietnam.

Hjh Zaitun bte Hj Mohd Taha (1999, June). A school-based primary mathematics and science specialist teachers' project. In M. A. Clements & Y. P. Leong (Eds.), *Cultural and language aspects of science, mathematics and technical education* (pp. 216–223). Brunei: Universiti Brunei Darussalam.