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Inquiry in science classrooms - rhetoric or reality?

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Denis Goodrum has been in involved in many national and international activities in science education. In 1998, Professor Goodrum was a visiting scholar at the National Research Council in Washington DC working on a project examining inquiry and the National Science Education Standards.

During the 1990s, he was Project Director of the National Primary School Project that was underwritten by the Australian Academy of Science. This project resulted in the curriculum resource *Primary Investigations* and an associated professional development model and package.

In 2000, he led a research team that completed a significant and extensive national study for the Federal Government into the status and quality of teaching and learning of science in Australian schools. Recently he was Project Director of the *Collaborative Australian Secondary Science Project* (CASSP) which evaluated a teacher change model through the development of integrated curriculum and professional development resources. Presently he is responsible for two national projects *Science by Doing* and the *Australian Science Education Framework*.

He has extensive administrative experience in so far as he has carried out the roles of Head of Department, Head of School, and Dean of Faculty within the university sector. He has served on numerous state and national Boards including Board of the Australian Deans of Education, Scitech and the ACT Curriculum Renewal Taskforce.

Besides managing large national projects, he has also been responsible for a variety of international projects including a Mauritius teacher education project. Other countries with which he has had professional involvement include Thailand, China, Malaysia, Singapore, Nigeria, the Seychelles, Burma, the USA, the Maldives, the Philippines, Botswana, Canada and the UK.

Abstract

If one scans the science curriculum statements of the Australian States and Territories, one will find a consistent theme of inquiry and inquiry pedagogy pervading these documents. With the rhetoric of these policy documents and our sense of science education history, one would expect to see inquiry as an integral part of our secondary science classrooms. Unfortunately, this is not the case. Many secondary students are taught science that is perceived by them to be neither relevant nor engaging. Furthermore, traditional didactic teaching methods that offer little challenge, excitement or opportunities for engagement are common. There is a considerable gap between the intended curriculum as described in the various curriculum documents and the actual curriculum experienced by students. This presentation describes a national pilot study, the *Collaborative Australian Secondary Science Program* (CASSP), which attempts to provide better information for responding to the challenge of converting the inquiry rhetoric into classroom reality.

Introduction

If one scans the science curriculum statements of the Australian States and Territories, one will find a consistent theme of inquiry and inquiry pedagogy pervading these documents. This theme is also strongly reflected in the new national Science Statement of Learning. Such a fact should surprise no one, since the importance of inquiry has resonated through Australian science education circles for the past 40 years. The curriculum resources of the 1970s like Web of Life and ASEP were developed from an inquiry pedagogical perspective.

With the rhetoric of these policy documents and our sense of science education history, one would expect to see inquiry as an integral part of our secondary science classrooms. Unfortunately, this is not the case. In the 2001 review of science teaching and learning in Australian schools, a disappointing picture of secondary science is described (Goodrum, Hackling, & Rennie, 2001). Many secondary students are taught science that is perceived by them to be neither relevant nor engaging. Furthermore, traditional didactic teaching methods that offer little challenge, excitement or opportunities for engagement are common. There is a considerable gap between the intended curriculum as described in the various curriculum documents and the actual curriculum experienced by students.

How do we convert rhetoric into reality?

The key to educational innovation, reform and improvement is the teacher. It is now generally accepted that to improve learning in our schools we need more and better teacher professional learning.

Professional learning and development cover a wide range of courses and training activities as well as a variety of 'on the job' experiences. Loucks-Horsley, Hewson, Love and Stiles (1998) in their book, Designing Professional Development for Teachers of Science and Mathematics, outline 15 different strategies that are used to undertake professional learning.

Using a meta-analysis approach Tinoca, Lee, Fletcher and Barufaldi (2004) suggest that the professional learning strategies outlined by Loucks-Horsley et al. (1998) impact on science student learning to different degrees. On the basis of an analysis of 37 professional learning studies, there was evidence of different effects on student learning of

science. The results of this research are summarised in Table 1.

High impact strategies on student learning were those associated with Curriculum Replacement and Curriculum Development, while medium impact approaches involved Curriculum Implementation and Partnerships. A range of strategies appeared to have a limited impact on student science learning including projects associated with Partnerships with scientists.

Table 1 Impact of professional learning on student learning

High Impact	Curriculum Replacement Curriculum Development
Medium Impact	Curriculum Implementation Partnerships
Low Impact	Workshops, seminars Partnership with scientists Case discussion Inquiry
No impact	Action research

Source: Tinoca (2004)

Perhaps the most surprising result was that the Action research strategies had no impact on student learning. In Australia, considerable funds have recently been invested in this approach through programs like the Quality Teacher Program. The important implication is that we need to investigate more fully the impact of these approaches before allocating substantial funds.

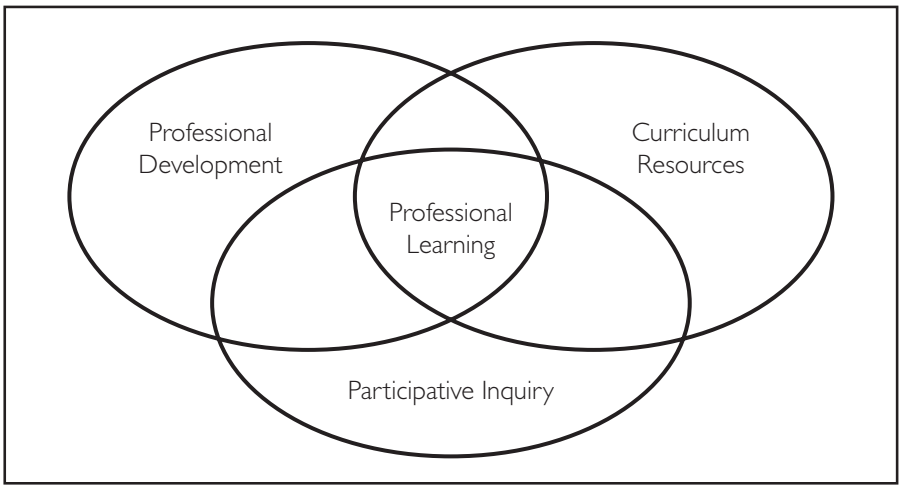

Figure 1 The role of professional development, curriculum resources and participative inquiry in professional learning

Collaborative Australian Secondary Science Program (CASSP)

One attempt to gather better information and respond to the challenge of converting rhetoric into reality was the pilot study, Collaborative Australian Secondary Science Program (CASSP). CASSP was developed through considerable national discussion among researchers and stakeholders over a number of years. It is based on a simple model.

The unique feature of CASSP was to facilitate professional learning by the implementation of an integrated set of curriculum, professional development and participative inquiry resources (see Figure 1). These resources provided a concrete basis for illustrating the methods by which a teacher could teach science in an inquiry-based manner, engaging students in relevant and engaging experiences of science and developing scientific literacy. The Australian government funded the extensive national pilot study. The project was managed by Curriculum Corporation in collaboration with the Australian Science Teachers' Association, the Australian Academy of Science and Edith Cowan University with the support of the state and territory education departments.

The CASSP project is an example of both Curriculum Replacement and Curriculum Development as outlined by the framework of professional learning constructed by Loucks-Horsley et al. (1998).

Purpose and design of CASSP project

The purpose of the pilot project was to:

- demonstrate that national collaborative procedures and processes could be used effectively to develop resources and implement them through the structures and processes in place in each of the States and Territories;
- evaluate the effectiveness of the CASSP model in changing and improving teaching and learning in science.

To meet this purpose, it was decided to develop an *Energy and Change* unit with three modules of *Light, Electricity*

and *Energy* with a flexibility of structure and content that enabled teachers to choose from these modules. It was also decided that the focus of the pilot project would be:

- student-centred approaches to learning;
- inquiry and investigative approaches; and
- formative and authentic approaches to assessment.

The pilot program was designed for implementation over a time scale of one school term with a whole-of-department approach to professional development. Each State identified the schools within that State that should be considered for involvement in the project. The project took place in term three of 2002 with 28 schools from six States involving 122 teachers and approximately 3,000 students.

There were three face-to-face professional development sessions during the course of the project. The initial professional development activity took place over two days towards the end of term two in each State, with the exception of Tasmania which has a three-term year and therefore undertook the initial PD activity in the middle of term two. The aim of these sessions was to acquaint the teachers with the teaching practices that were the focus of the pilot and with the resources and the skills necessary to implement these changes in teaching practice.

The second PD session occurred mid-term with an emphasis on assessment and developing skills for assessing student work in terms of conceptual development. The full day of activities also provided an opportunity for teachers to examine common concerns and devise strategies for meeting these concerns. A final half-day debriefing session was held in the last week of term three.

Evaluation and results

At the beginning of each of the three professional development sessions a questionnaire was completed by the participating teachers. A simple questionnaire was also completed by students at the end of the unit. In Western Australia, four teachers agreed to allow a researcher to observe their lessons throughout the trial.

Data from the first questionnaire suggested that the initial response to the project by the majority of teachers was positive. As in all innovations, there are inevitable concerns but these seemed to be balanced by the perceived potential benefits. Approximately one-fifth of the teachers appeared to hold traditional views about science teaching. These views included didactic approaches to teaching, significant amounts of memorisation of facts and explanations, and a concentration on summative forms of assessment.

The driving forces for change were identified as the initial professional development sessions and the student resource. A number of teachers, however, felt that the student resource required more theoretical or factual information. The teacher resource was considered less useful with a quarter of teachers not using the book at the initial stages of the project.

The project generated much discussion and collegial interaction among teachers at an informal level, however, the suggested formal participative inquiry sessions did not occur in many schools because of the pressures of time. Where formal participative inquiry discussion occurred, they were very useful in supporting teachers to resolve difficulties.

Data from the questionnaires indicated there was a change from teacher-directed teaching to more student-centred learning:

- 50% of teachers said that their students copied less notes from the board; and
- 33% of teachers spent less time on teacher explanation.

The decrease in teacher-directed activities was offset by an increased use of student-centred strategies initiated by the teachers. These included:

- small group work and discussions (63% of teachers);
- cooperative learning groups (53%);
- open-ended questions and wait time (51%);
- conceptual explanation after activity and experience (57%);
- investigations (53%);
- more exposure to fewer concepts (55%) and
- greater use of formative (39%) and diagnostic assessment (61%).

The response of the teachers was very positive with 90 per cent wanting to see the project continue. A large majority (88%) wanted curriculum resources developed for other topics. From discussions with teachers, it was obvious that the project was demanding both in terms of time needed to develop student understanding and the added stress of classroom management in unfamiliar student-centred activities.

Most teachers expressed a preference for the traditional print form for student resources and were less inclined to use electronic forms of delivery. This was mainly due to the fact that many schools did not have adequate computer hardware or facilities to handle electronic delivery of curriculum materials.

Data from the student survey indicate that one-third of students reacted very positively to the science they experienced during the trial while half the students were ambiguous in their responses and the final sixth of the students were negative. In the national

review of science teaching and learning, only about 20 per cent of secondary students reported that their science was relevant or useful to them. The results of the trial would suggest the trial students' interest in science was greater than the students surveyed in the national survey.

For the four case study teachers, observations suggest the teachers and their students gained from the project. The teachers felt they had the opportunity to reflect on their classroom practice and refine their teaching skills to varying degrees. Again these feelings were borne out by the classroom observations.

The results and experiences of this study highlight a number of issues.

Collaboration

All six States successfully participated in the implementation of the project. The States, through consensus, determined the specific priorities of the professional development program and the nature of the curriculum resources. At each stage of development of the pilot materials, all the States and Territories were provided with draft materials and with the opportunity to provide feedback. Changes were made as a result of feedback. In the early part of the project this feedback resulted in a new approach to the development of the curriculum resources. This new approach caused a delay in the implementation of the program but schools and States were able to accommodate the delay. The program was successfully implemented in all States. No teachers in any of the States indicated that the resources were inappropriate or not compatible with what was happening within their State.

Effectiveness of the CASSP model

The results from the study showed that the trial had a significant impact on teacher behaviour with respect to the project's focus: student-centred approaches to learning, inquiry and investigative approaches, formative and authentic approaches to assessment.

The data showed that change occurred in teachers' pedagogy when they were supported with an integrated program professional development and exemplar curriculum resources and used a collegial team problem solving approach. Despite the limited time for the trial, the results indicated the value of the approach. Due to the limited time one would, however, question the sustainability of these changes and their transferability to other units.

The question of covering content versus developing understanding

There was an issue concerning, in simple terms, the perceived need to memorise content in some classes considered to be composed of identified high-achievers. Many high-achieving students felt comfortable with memorising clearly delineated science content because under current assessment regimes this could result in high grades from examinations. The less structured inquiry and investigative approach did not necessarily generate bodies of information that could be memorised. Consequently, some of these students did not believe they were learning, because they equated learning with memorisation of content.

Besides the differing views on the nature of science and science teaching that such an attitude reflects, one also needs to consider the level of skills required for student-centred conceptual learning. To synthesise the ideas that arise from student activity through questioning is a challenge. A teacher needs to bring together the understandings that emerge from inquiry through summarising class discussion and be able to generate summary statements that are meaningful to students. Such a skill is challenging but critical for making inquiry approaches effective.

While feedback suggests the project was viewed as being successful in typical classes, the perceived success was diminished in some classes of identified high-achieving students because of the preference for memorising information for exams. The dilemma between learning for memorisation and learning for understanding needs to be thought through carefully especially in terms of how a change in attitude can be achieved in classes for the high-achieving student.

The resources

All teachers in the project used the student resource that was supplied in hard copy to every participating student. Some teachers followed it without variation while most adapted it and in some cases added to it. Some teachers indicated that they seldom used the teacher resource book, which was also provided in hard copy to participating teachers. It would appear that the website was used least of all the resources. The website was mainly used to access the assessment items that were only provided electronically. The evidence would suggest that the student resource was a powerful driver of teacher change. It enabled teachers to implement and experience changed practices that were the focus of the professional development program.

The feedback from teachers indicated that 90 per cent of teachers wanted the student resource in print form while 76 per cent also wanted the teacher resource in print form. The dilemma facing those who make decisions about the format of student and teacher curriculum resources concerns the question of how long the reliance on print form will continue. Many schools

indicated that they did not have adequate computer hardware or facilities to handle electronic delivery of curriculum resources. This technological lag will change over time but it may take 5 or even 10 years before digital curriculum resources will be commonly accepted.

Leadership

Heads of departments have, in most schools, a significant influence over what happens in the school. The experiences of this project reinforced that important principle. One of the disappointing aspects of the project was that few schools undertook formal participative inquiry sessions. One of the suggested reasons was the time pressure that teachers were experiencing. The project was an extra demand on teachers who were under stress because of the numerous demands and expectations made of them. Another contributing factor was the role of the head of department. Valuable formal participative inquiry discussion occurred in one of the case study schools, as a result of leadership at the school.

Future directions

As a result of this study and other research, there is a new major project being planned. The proposed secondary science project is called *Science by Doing*. The planning is occurring during 2006 and is being managed by the Australian Academy of Science with funding by the Federal Government. With hope and a great deal of cooperation and insight, perhaps, the rhetoric may eventually become reality.

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