PD and ICTs: We have a ways to go

ABSTRACT

The last 20 years have seen immense gains in computing power available to schools and a wide variety of useful educational software and services. Professional development in the computer area, however, has not resulted in the widespread use of computers in classrooms. This article reports on the use of the Charles Sturt University Remote Telescope by both primary and lower secondary classes and the educational outcomes obtained.

Twenty years ago, Associate Professor Ken Sinclair and the first author (McKinnon & Sinclair 1986) wrote about what was happening at the NSW Primary Correspondence School that had been loaned 10 portable computers by IBM. The computers were used to see if telecommunications could help reduce the ‘tyranny of distance’ for both students and teachers. The computers were supplemented by spinning-drum facsimile machines that by then had achieved the remarkable speed of transmitting one A4 page every four minutes and modern that operated at both 300-baud full duplex and 1200/75 half duplex.

In the article written ten years ago for Australian Educational Computing (McKinnon, 1996), the first author argued that education needed better models of professional development that are context bound and sensitive to the concerns and needs of teachers. Two professional development endeavours were reported: one at the NSW Correspondence School and the other at a New Zealand high school where staff and students were faced with learning how to use computers and associated software for educational purposes.

Recent studies funded by the Federal Government highlight the central importance of professional development in our education system (DEST, 2001, 2002 & 2003). The research study PD 2000 in Australia (DEST, 2001) reported that “[T]he most common current professional development topic with the highest level of participation is the educational use of ICTs” (p 11). A second study examined models of teacher professional development for the integration of information and communication technology into classroom practice (DEST, 2002). It examined ways that teachers and others were being supported “to acquire the skills and knowledge to ensure the effective use of information and communication technology in schools” (p1). A third study, yet to be reported, examines whether participation in PD co-varies with changes in what teachers do in the classroom (DEST, 2003).

Over the past 10 years, we have seen even more remarkable improvements in computing power, communications technologies, high-speed Internet access, and powerful software and, consequently, an even greater need for professional development. Yet, in our travels around classrooms supervising students on their teaching practicum, there is still little evidence that teachers are making use of the technology (Wilsmore & McKinnon, 2003). While the reasons for this state of affairs are many and complex, professional development in our schools remains a contentious and expensive issue.

The purpose of this paper is to report on a project we are conducting at Charles Sturt University (CSU) involving a remotely controllable telescope accessed over the Internet. The project delivers educational services and professional development both nationally and internationally. The project deliverables appear to achieve outcomes both in professional development and in student learning that are highly significant. Not all is rosy, however. We still see and experience the lack of facility that teachers have with the technology that is supposed to be integrated into teaching and learning.

The Project

The literature about children learning astronomy at school shows that a central problem lies in misconceptions held by adults (teachers) that may reinforce those held by students. Skamp (1998) has shown that adults, including teachers, carry misconceptions about astronomical phenomena, such as gravity, phases of the Moon, the seasons and distances in space. Skamp argues that unless these ideas are replaced with scientific explanations, teachers cannot help students understand the phenomena. Skamp also observes that students have problems understanding scale and distance and postulates that first-hand experiments that help them explore these concepts are much more effective than textbook diagrams, poorly scaled models or other second-hand learning experiences commonly found in many of our classrooms. Dunlop’s (2000) survey of the literature on
adult misconceptions agrees with Skamp's findings, especially where adults become teachers. Like Skamp, Dunlop postulates that one source of children's misconceptions could be those held by the teacher.

Dunlop (2000) studied the pre- and post-visit knowledge demonstrated by children who went to a planetarium in Auckland, New Zealand and found that children's ideas about astronomy are better expressed by tests that require them to make drawings to illustrate their answers compared with the use of multiple-choice questions, especially in the 7-14 age group in his study. Dunlop (2000) suggested that specific interventions to help children understand phenomena, e.g. the occurrence of day- and night-time, are not completely successful with students loyal to their personal intellectual models that differ from the demonstrations provided by 3-D models, especially when their beliefs are supported by out-of-school experience. The use of this assessment model is described in the Method section below.

As Hollingworth & McLoughlin (2001), Selley (1999) and Tinkler (1993) have shown, pedagogical methods should centre on constructive methods for both in-class and on-line work so that students are exposed to well- and ill-structured situations and can explore these in social ways.

The CSU Remote Telescope program is designed to enhance a learning environment in which discussion, exploration and problem solving will take place. The program involves several curriculum levels. Each level has a learning package about astronomy with emphasis on the use of an online telescope. Each learning package includes access to, and control of, a scientific-grade telescope and two CCD cameras via the Internet. Also included is a CD-ROM containing help with the scientific study of astronomy such as advice on the location of celestial objects in the sky, control of the telescope and cameras, ways to obtain sophisticated digital images, and teaching materials appropriate for the age group. For those in Grades 5-6 or Grades 7-9, teachers' guides are also supplied that address the curriculum for those grades. The guide for years 5 and 6 shows how astronomy can be taught across all subjects (Key Learning Areas) in the curriculum. Besides access to a science-teaching specialist and a technical advisor, the University provides a website containing learning materials, resources, and technical information as well as show casing images obtained by student groups at http://www.csu.edu.au/telescope

The project exploits students' natural curiosity about things to do with space. The professional development program is embedded within the project. As the students learn how to take control of the telescope and cameras, process the images, find objects worthy of photographing and so on, the students, and their teachers, make extensive use of ICTs.

Teachers acquire the same skills as their students almost without realising that this is happening. They come to learn how ICTs can be integrated within the program of work rather than treated as an object for separate study in isolation from their classroom (Wilsmore & McKinnon, 2003). They learn to manage the environment within which groups of students use computers to process images, write about their investigations, use the Internet to locate information about celestial objects, and use planetarium software to work out what objects will be visible above the telescope when they take charge of it.

The software and hardware systems for access to, and control over, the telescope and cameras were developed using the "KISS" principle. When students access the observatory computer online, they see a desktop just like their own computer. Only four icons are displayed: one for telescope control, two for the electronic cameras and the fourth for Notepad, a simple text processor used to communicate with staff at the observatory via the keyboard. Synchronous support is thus provided, if required, during the on-line session. Some more adventurous schoolteachers also using video conferencing during the control session. Asynchronous support via email is also provided both before and after the online telescope session. In these ways, the professional development is not "delivered" in a one-off specialist session. Rather, it is delivered over time in ways that can be accommodated by the teacher.

As each school joins the project, they are issued with the resources and the instruments with which to evaluate learning outcomes. Prior to beginning the project, students' astronomical knowledge is assessed. Teachers use this information to decide on the projects that they and their students will investigate during the period of teaching and learning. This form of assessment is again repeated at the conclusion of the project to make decisions about the students' learning outcomes. Teachers provide information about what is happening in their classes and the projects they have implemented. They also provide information about their reflections on the pedagogical processes they have adopted in their classrooms.

The remainder of this paper presents one set of data from primary (years 5 and 6) and one set from secondary students (years 7-9) that illustrate the learning outcomes of the project and includes a few students' and teachers' comments about their experiences.

Method

The method employed with which to evaluate the impact on students' learning is a quasi-experimental pre-test post-test design. In the primary school, two instruments were used to tap students' astronomical knowledge: Osborne's General Knowledge about Astronomy (1995) and Dunlop's (2000) draw a picture and explain instrument.

In the secondary school, The Astronomy Diagnostic Test (2001) was modified into a 25-item instrument. Four items from Dunlop's (2000) instrument were added that require students to provide both a drawing to explain a particular phenomenon and a written explanation of what their drawing meant. The remaining 21 multiple-choice items suitably modified with southern hemisphere items, together with space to provide an explanation for their choice, were used to probe students' understandings of various astronomical phenomena. The addition of the space for students to provide reasons for their choice served to minimise guessing as well as to provide additional research data.
Students’ answers are examined at three levels: whether they are correct or wrong; the alternative scientific conceptions evident in their written responses; and an analysis of the complexity of the conceptual reasoning provided in their written responses using the Structure of the Observed Learning Outcome (SOLO) Taxonomy as an analytical framework (Biggs & Collis, 1982).

Teachers administer the instrument prior to the commencement of the project and again at its conclusion. The questionnaire is returned to the University for assessment, coding and data entry with reports being provided to teachers on what the students already know.

Results – primary school

The first set of results presented below reflects outcomes obtained from primary students in Years 5 & 6 in the western region of New South Wales. Data are presented for four classes two of which were composite Year 5 & 6 classes and two that were Year 5. A total of 74 students provided both pre- and post-intervention data enabling statistical analysis by repeated measure techniques to be employed. Results are presented in graphical format for brevity’s sake. School names have been changed.

Statistical procedures employing repeated measures analyses were employed to investigate the data. These have been reported elsewhere (McKinnon, Geissinger & Danaia, 2002) where the analyses show, amongst other things, that there is a significant learning effect and that girls learn as much as boys despite the fact that on entry to the project they knew less. One interesting finding that underscores the importance of adopting alternative approaches to the teaching of curriculum content is dealt with in the next section.

Teaching/learning decisions

One class, a composite of Year 5 and 6 children at Bogar Public School, had already engaged in a science unit on Astronomy during Term 1. At that time, the planets Mars, Jupiter, and Saturn were easily visible for observation with a small telescope. Their teacher described the content students had covered in that term. For example, they had undertaken projects on aspects of the Solar System and presented these on posters, made models of the planets and conducted some research on the Internet. The total
amount of time taken was approximately two hours per week over six weeks.

Because of the content already covered, the teacher at Bogar intended to use only the material in the telescope package that taught the students how to contact the telescope, take pictures, download these and process them. The teacher felt that this would be adequate given the time already devoted to Astronomy.

At Gulgar School, there were two Year 5 classes taught by different teachers, while at Colgar, a single teacher taught a composite class of Year 5/6 students. Each of these groups decided to undertake the project in its entirety though each of the teachers made decisions about the extent of the curriculum content to be covered. One of the classes at Gulgar (5M) decided to focus exclusively on the Solar System while the remaining two class teachers decided to be a little more expansive in their use of the activities covered in the projects.

Thus, because the four school classes adopted different approaches, we were able to assess students’ knowledge and alternative conceptions both when the subject had been taught in the usual manner in primary school and when it was taught using varying mixes of the learning activities.

What is evident from an examination of Figures 1 and 3 is that the entry knowledge of all four classes was approximately the same. There were no significant differences on entry to the project despite the fact that Bogar had already “done” astronomy in first term. Figure 1 shows the results of the general knowledge items. Figure 3 shows the results of four items where students had to draw a picture and then explain what their picture meant. In addition, Figures 2 and 4 show the mean SOLO level of the students’ explanations of their answers. The mean level on entry to the project was approximately at the uni-structural level where students, on average, offered an explanation containing only one piece of correct information.

The pre-intervention results stand in contrast to the post-intervention results. The pre-and post-intervention difference is highly significant in the statistical sense with students scoring better on the post-test.

The class that chose to focus on the Solar System (Gulgar 5M) did not increase its mean score significantly on the general knowledge items though they did on the items related to drawing the pictures about solar system phenomena. This was to be expected.

The class that chose to focus solely on telescope control and image processing (Bogar) did not increase their mean score on the four items related to the solar system. That is, they did not learn any additional material on the causes of day and night, phases of the Moon, orbits of the Earth and Moon about the Sun or the seasons. Their general knowledge about astronomy increased slightly. Nonetheless, as far as the outcomes of the primary science and technology curriculum are concerned, the students demonstrated no new learning, nor had their learning developed from doing their research projects during the first school term. It must be said, however, that there were other positive educational outcomes including the fact that they had been enthused by the activity and had learned many technological skills as well as achieving other associated educational outcomes such as procedural and descriptive writing, image processing, and research and presentation skills.

Clearly, while just learning how to use a telescope and do image processing does not teach much about astronomy it may teach the students and their teacher about how to use the technology. This was evident in the qualitative data supplied by the teacher and the enthusiasm generated by the use of the technology in meaningful ways. The principal of the school also mentioned that more parents had been seen on the evening when the students had demonstrated their expertise with the technology than were normally seen on parent-teacher nights.

**Results – secondary school**

We have been conducting a large-scale project on behalf of the Department of Education, Science and Training on the use of remote telescopes in junior secondary science classes in four educational jurisdictions. Over 2000 students and 127 science teachers have provided data. Only data for 500 students for whom both the pre- and post-intervention results have been processed are presented here.

Students provided both pre- and post-intervention data as described above using the Astronomy Diagnostic Test (2001). Different science teachers chose to cover different numbers of projects depending on the time they had available. These were coded into five sets. Set 1 did just those projects that involved telescope control and image processing. Those who did more projects, which also involved telescope control and image processing, have been coded as 2 to 5. The “2” represents the mix of projects involving the Moon, the “3” represents the Moon and solar system, the “4” the Moon, solar system and stars and the “5” represents Moon, solar system, stars and galaxies. The occasion of testing is shown on the bottom axis with “1” being the pre-test and the “2” the post-test. Figure 5 shows the outcomes of the analysis.

Figure 5 shows that the mean score of those classes who concentrated only on the technical aspects of using the technology actually decreased (significantly) while those classes who did astronomy projects that contextualised the use of technology all went up by approximately the same amount. These differences are highly significant.

Figure 6 shows that four of the five sets of curriculum content covered had modest gains in the SOLO functional level but which, overall, are significant. That is, students who covered these varying amounts of curriculum content improved their ability (significantly) to explain their answers to the questions in the Astronomy Diagnostic Test. One of the five sets of curriculum content covered, telescope control, image processing, the Moon and solar system, experienced a
marginal decline in students’ ability to explain the reasons for their answers.

Comments by students and teachers

Comments by students elicited during interviews tended to reinforce the issue alluded to above. That is, those students whose science teachers concentrated only on the technological aspects were dissatisfied. They did not see the bigger educational picture. The technology skill development became an end in itself rather than a tool for educational growth. As one young teacher reported, when asked how the students reacted to the skill development she paraphrased her students as saying things like:

"Why are we doing this? Why are we doing this? I don't want to do this? Can you please do this? No I don't feel like it." That was basically it.

(Female science teacher, 1st Year out)

She was constrained by what she was allowed to do by other, more senior male staff members of the science department though she had many good ideas about what to do, and expressed these at interview during which her colleague continually pointed out the “problems” with her suggestions. As he said on one occasion, "the trouble with that is though they haven't learnt enough to take the photos" (experienced male science teacher).

An additional factor that seemed to influence how some teachers used the technology was their relative inexperience in using it in the classroom. They appeared not to be prepared to relinquish control of it to let students experiment on their own. The following illustrates this issue.

"...I just thought like, thought of a suggestion that you know we could go to um the computer rooms for one of the lessons and actually um see it um do it ourselves and actually fiddle around it before the actual night because we were just sitting there with his little lap top in the middle of the room all of us just watching this slide show go on and on for the whole hour and stuff." (Female Year 7 student.)

Nonetheless, there are many positive comments from both students and teachers. One teacher clearly identified that the computer and telescope control aspects were highly motivating for the science students, and that with this interest she could address the scientific aspects of the curriculum – the astronomy.

DISCUSSION

Ten years ago when the first author wrote Professional development in context (McKinnon, 1996), the message was that one way of achieving effective and efficient professional development was “to support schools and teachers in professional development endeavours that are initiated from within the school and which involve the school community in collectively determining the path that these endeavours should take” (p 16). That is to say, the context for professional development is the class of students whom the teacher teaches and the class is located within a school and within a wider community.

Professional development involving the use of ICTs for educational purposes has been clouded by the very fact that to get to the pedagogical issues of classroom ICT use, professional developers have had to up-skill the teachers. One unfortunate side effect of this is that the skill development has become the message rather than the vehicle for confronting the multiple issues related to better curriculum delivery, student-centred pedagogy and assessment tasks that are deep, rich and authentic.

This article has demonstrated that it is possible to address many of these issues with teachers to prepare them for new forms of curriculum, pedagogy and evaluation as evidenced by the data presented in Figures 1 – 6 above. Nonetheless, there are still many teachers in the system who have yet to enter the post-industrial age and implement constructivist approaches in the science classroom. Unlike primary teachers who teach children, many secondary teachers construct themselves as teaching subjects. This perhaps, is the most important issue in the use of ICTs in the secondary school.