

## ALLAN HARRISON & DIANNA NICHOLS

### Enhancing science teachers' pedagogical content knowledge at Biloela SHS

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#### **Abstract**

*When adventurous teachers at Biloela primary and secondary schools decided to implement the new science syllabus in 2000, they realised that they needed to enhance their science knowledge and teaching strategies. They committed to a professional learning partnership with CQU over two years whereby 11 primary and secondary teachers met regularly for professional science discussions with a CQU expert. Using a consultative process, each teacher designed a content and pedagogy study program to meet his/her needs. The CQU adviser provided intellectual resources and critical and formative feedback. Biloela teachers have surmounted the barriers of isolation, found ways to utilise local resources, and made changes to their teaching that anticipated "productive pedagogies". The Year 6 10 teachers now are studying material outside their teaching area and have heightened enthusiasm for science teaching. Initially, teachers sought content knowledge and said they would need substantial on going tutelage. Once they started learning, however, they realised that they could sustain their learning provided critical support was available when needed. The paper demonstrates the benefits that accrue to teachers when they are supported in learning new content and pedagogies. Indeed, we recommend that the Queensland Government provide on going funds that enable teachers to undertake content and/or pedagogical in service education of their choosing. Enhancement of teachers' pedagogical content knowledge has the potential to revolutionise science teaching and help us achieve the goal of a Smart State.*

#### **Introduction**

The changing face of science in Queensland schools presents teachers with many challenges. For instance, the outcomes oriented 1999 QSCC Science Years 1 10 syllabus encourages teachers and students to investigate their physical and living world by thinking and working scientifically in real life contexts. Teachers are unused to teaching in such open ended ways (Hackling & Fairbrother, 1996) and many feel that the lack of prescriptive content within the syllabus statements leaves them unsure about what to teach. Three responses are possible: first, teachers audit the previous syllabus and their teaching plans and simply reorganise their teaching under new headings (Zipf & Harrison, 2002); second, teachers choose a new textbook and teach from it (Sanchez &

Valcárcel, 1999); or third, they reflect on their pedagogical content knowledge (Shulman, 1987), step outside their comfort zone and embark on a science content and pedagogy learning journey. This response is rare but it is the most productive.

This paper describes the learning journey taken by science teachers at Biloela SHS and Biloela SS. First, the paper explores what we know about in service teacher learning; second, it samples the participants' learning experiences and comments on school characteristics that promote and constrain teacher learning; and closes with a reflection on the knowledge needs of the isolated science teachers.

## **Discussion of main issues**

### **Previous research findings**

Pedagogical content knowledge (PCK), was proposed by Shulman (1987) as one component of an effective teacher's professional knowledge. PCK is "that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding" (1987, p.8). It is derived from knowledge of content and pedagogy, and enables the teacher to present subject matter in a way that is comprehensible to others. But PCK it is more than knowledge of content and teaching pedagogy: it involves teacher knowledge and beliefs about "pedagogy, students, subject matter and the curriculum" (van Driel et al., 1998, p.674).

Shulman differentiated content knowledge, pedagogical knowledge and PCK. This conceptual distinction has been explored by many researchers, resulting in important additions to what Shulman included in PCK. For example, Cochran, de Ruiter and King (1993) claim that "transformation of subject matter for teaching ... occurs as the teacher *critically reflects* on and *interprets* the subject matter; finds multiple ways to represent [it] ... *adapts* the material to students' abilities, gender, prior knowledge, and preconceptions ... and *tailors* the material to those specific students to whom the information will be taught" (p.264). The view that PCK is dynamic and interactive led them to call it *pedagogical content knowing PCKg*. Veal and Makinster (1999) argue that PCKg incorporates "four components: knowledge of subject matter, knowledge of students, knowledge of environmental contexts, and knowledge of pedagogy" (p.5). Consequently, we expect that teachers will choose to enhance their science content knowledge only when and if they perceive a shortcoming in their teaching knowledge.

While teachers learn to help their students, they face a dilemma. Science often is seen as a discipline for preparing the best students for careers in science, medicine and technology; while on the other hand, a compelling case has been made that "science is for all the community". University preparation still drives many senior science courses and senior science futures dominate Year 8 10 content and pedagogy. Consequently, teachers need flexible PCK to enable them to promote interesting and relevant "science for all" alongside rigorous courses for a few. University preparation and the education of a scientifically literate community are compatible provided teachers are educated in the areas where their needs exist. Available models of science teacher education (Wallace & Loudon, 2002) insist that for such education to be successful, the locus of learning control must rest with the teacher.

Another teacher dilemma is how to reverse the continuing per capita decline in senior school science enrolments (Dekkers & de Laeter, 2001). How can we fashion the knowledge, critical thinking and rigor needed in a smart state when we have fewer science candidates? Enhancing teacher expertise is an essential ingredient in improving science learning in Queensland. Research shows that supportive peers, professional

education and time to practice new pedagogies improves science teaching and learning (Bell & Gilbert, 1996). Professional education should be sustainable in the long term and customized to its recipients.

## **Context and methods**

The science teacher enhancement project began with a Central Queensland University (CQU)—Biloela SHS partnership in 2000. A Quality Teacher Program grant in 2001 enabled Biloela SS to join the project and from 1999—2002, 12 secondary and 3 primary teachers participated in the program. The project was designed to enhance teachers' PCK with the express aim of implementing the new outcomes based science syllabus (QSCC, 1999). This syllabus initially raised teachers' anxiety levels causing them to reflect on their choice of relevant teaching content/concepts, pedagogy and project work, and assessment.

The project comprised consultant led workshops, unit planning sessions, a study retreat, innovative teaching, individualized study plans and reflective journal writing. Data were collected from the journals, teaching plans, discussions with teachers, interviews and three open response sheets. The teachers were encouraged, where possible, to "drive" the learning and to nominate workshop content and pedagogical activities. An interactive email network enabled teachers to question the consultant and each other and to identify "need to know" items.

## **Experiences and findings**

The data discussed here is drawn from the reflective journals, researcher notes and interviews. A summary of one teacher's (called Jim) responses demonstrate the types of learning progress made in the project. A paper this length cannot elaborate on all participant responses, however, certain themes dominated the evidence.

First, most teachers were committed to progressing student knowledge and scientific literacy. In August 2002, six out of nine interviewees stated that they were engaged in learning "that is useful to me and my students". When probed as to whether they would study for their benefit, all six insisted that they pursued learning provided it was of immediate use to their students or would allow them to teach more advanced science classes "next year". This type of learning is more instrumental than relational (Skemp, 1976) and is more procedural than open ended.

Teachers are willing to learn and positive incentives (time or reward) are needed if they are to move into uncharted intellectual territory (Prawat, 1989).

Lest these comments seem critical, positive project outcomes are provided by Jim.

Since the start of the program I identified an area I was deficient in understanding or knowledge, ... that was my choice ... I investigated genetics, that led me to discover about, micro biology, bacteria and evolution of life ... biology was my weaker subject, and I've [been] buying textbooks and books written by prominent scientists. I ... watch more programs on pay TV at home, and discuss it with my colleagues and friends who studied biology at university.

There's some excellent shows for ecology and, virtually every scientific concept and topic. I haven't [used] those, but it has helped develop my knowledge, this program gave me an opportunity to explore.

A benefit was personal learning and collaboration (at school and on the field trip):

program [gave] me an opportunity to sit down in a [quieter] environment with my colleagues and discuss issues and it's picked up my interest ... my pedagogical content knowledge, which helps me as a professional.

Like when we're doing genetics ... going back 3 4 years now I didn't know ... I can answer those questions on the spot.

Jim believed that the PCK program increased his confidence:

... having the confidence that you get from having deeper understanding where I didn't have any formal [education] beyond high school ... confidence to come up with activities I can do in my classes, that I previously wouldn't do [then, I] just referred to textbook activities, now I've got the knowledge. It's apparent if I'm anxious, and the kids pick up on it ... this program has helped me [be a less anxious] teacher.

And his critical thinking skills grew:

... and I've worked on my critical thinking skills as a teacher, you can turn around and point [students] in the right direction or clarify things ... you can't do that if you just [prepare] yourself for that one activity for one lesson, ... it's every first year teacher's nightmare, up in front of the class doing an activity, and stumped by a question.

But Jim wants to keep learning—

I think that's a challenge, in terms of knowledge I'm always going to keep my horizons open so that I won't become stagnant.

“Belonging” and “cooperating” in learning and teaching was an added benefit.

I've noticed our science classes are far more relaxed ... we've networked as a group instead of being single teachers I think we are a science department, a single entity.

I feel far more comfortable talking with everyone because we've had conversations, debates, discussed our philosophies, we've a better understanding.

## **Conclusion and recommendations**

The DETYA and TIMMS reports (Goodrum, Hackling & Rennie, 2001; Lokan, Ford & Greenwood, 1996) show that science teaching in Australia is uneven and does not yet meet community expectations nor modern needs. This study shows that with financial and intellectual support, teachers can enhance their teaching.

The Biloela experience demonstrates that *sustainable, long term, in service education* enhances teachers' professional knowledge. Such programs merit continued support. We also recommend that the *locus of control* for in service learning rest with the teacher(s) and that support should harmonise with the teacher's perceived needs.

The Biloela study shows that motivated teachers will choose to learn new content and pedagogies if the knowledge is beneficial to them and their students. Confidence, collaboration and openness are benefits that can flow from in service education programs. In other words, Education Queensland should financially sponsor teacher upskilling to achieve the goal of *Science working for a smart state*.

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