CHAPTER 4

A PRELIMINARY STUDY OF UNIVERSITY PHYSICS FOR SECONDARY SCIENCE TEACHERS: WILL CONTENT BE ENOUGH?

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Abstract

This chapter examines continuing teacher professional development through a university level physics course. The study was conducted in a regional university and focused on working teachers' perceptions of the benefits of the course and the effectiveness of its mode of delivery. The course was face-to-face, fast tracked, and held outside school hours, funded on a 'one off' basis. Case study methods were employed to collect comprehensive and detailed data throughout the course and were used to frame the outcomes and recommendations. Teachers were stimulated by the challenge of university study. They appreciated the mode of presentation of the course, but found the pace problematical. Teachers with physics classes indicated changes in their teaching practice. If ongoing teacher development at this level is to continue, employers will need to match the teachers' willingness to give their time, with formal systems of support, reward and recognition.

OVERVIEW

During the Autumn term of 2004, Central Queensland University’s (CQU) James Goldston Faculty of Engineering and Physical Systems (JGF EPS) launched a physics course, aimed at meeting the continuing professional development (CPD) needs of a group of secondary science teachers. The course was based on first year Physics, with changes in presentation made to accommodate the teachers' needs. The teachers' aim was to increase their physics content knowledge in areas covered by the Senior Physics syllabus. Funding was provided for this course only by the Queensland government's Spotlight on Science initiative, and JGF EPS, with some contribution from the teachers' schools and, in a few cases, from the teachers themselves. Any continuation of this program, or future courses, would require further funding applications or standard university fees would apply.

Participation was driven by teachers' perceptions of their own needs to improve their knowledge of physics content. The teachers believed that they would then be able to build on that content knowledge, using their
existing pedagogical content knowledge (PCK) and their personal contacts with experienced physics teachers. Initially, the teachers' evaluations of the effects of the course on their development may enhance understanding of teacher CPD. Future research will focus on how the teachers integrate the newly acquired physics content knowledge into their science pedagogical knowledge (PK).

A key purpose of CPD should be the enhancement of teachers' PCK. Successful CPD that enhances PCK benefits not just teachers but also their students, and therefore the schools and systems within which the teachers work. The consequences of classes being taught by teachers lacking a high level of understanding of the content they teach have been well documented (Darling-Hammond & Sykes, 2003; Goodrum, Hackling & Rennie, 2001). Fully trained teachers with university level qualifications in their subject area are the strongest predictor for high student achievement (National Commission on Mathematics and Science Teaching for the 21st Century, 2000).

PURPOSES AND DESIRED OUTCOMES
This research is the initial stage of an exploration of the teachers' perceptions of the value of this course to their teacher CPD and PCK. The pilot study seeks to understand the appropriateness of the course delivery mode, aimed at meeting the needs of working teachers, and to begin to examine the effects of university level enhancement of science teachers' content knowledge on their development as teachers. The significance of this study is that this CPD was based on a premise that is not supported by the literature—that CPD focusing solely on content will enhance teachers' PCK. Other university level programs aimed at teachers' CPD, such as Masters degrees in education, or professional development such as that offered by Deakin University's Consultancy and Development Unit, are offered by Education faculties and include 'educational' components.

The research questions asked:
1. Was this mode of course delivery optimal for working teachers?
2. What was the effect, if any at this stage, of this course on teachers' CPD and PCK?

In order to provide some answers to these research questions, we have begun to develop a case study based on the perceptions of the teachers who completed the course. Case study was chosen as the research questions were exploratory, the context was contemporary, and I had little control over the events on which the study focused (Yin, 1994). The case documents and interprets the impact of this experience on the teachers' perceptions of the benefits to their CPD. The case offers valuable insights into science teacher development that is particularly pertinent given the
ongoing shortage of science teachers (Department of Education, Science and Training [DEST], 2002).

THEORETICAL FRAMEWORK

SHORTAGE OF SCIENCE TEACHERS AND OECD STUFF

In Australia, a science teacher shortage exists and is expected to continue, in the physical sciences, and in rural and remote regions (DEST, 2001; 2002). Research in the United States, has shown about 44% of middle school are taught by teachers without tertiary qualifications in the subjects they teach, while 22% of secondary school students are taught by teachers who are uncertified in their teaching area (Academic Improvement And Teacher Quality Programs Office Of Elementary And Secondary Education, U.S. Department Of Education, 2003). Australian conditions appear similar, although the picture is less clear. A Tasmanian Department of Education survey in 2000, cited 34% of secondary science classes taught by teachers who had no tertiary science training (Melville, 2004).

Attempts to resolve the shortage of science teachers often consisted of recruiting science graduates who have the required content knowledge and then providing pedagogical training. Another strategy has been to recruit teachers, who have PK, and provide education in science (see Ritz, 1993; Watson, Steele, Aubusson & Vozzo, 2003). These contrasting approaches nevertheless demonstrate the need for both pedagogical and content knowledge. This study is important because it begins to investigate the merits of enhancing PCK by teachers grafting content knowledge gained from CPD onto their existing PK knowledge.

PEDAGOGICAL CONTENT KNOWLEDGE

The synthesis of content and pedagogical knowledge for teaching was explicated by Shulman (1986) as 'pedagogical content knowledge' (PCK) to describe the amalgamation of content, pedagogy and context into "ways of representing and formulating the subject that make it comprehensible to others .... includ[ing] an understanding of what makes the learning of specific topics easy or difficult: [and consider] the conceptions that students of different ages and backgrounds bring with them" (p. 9). Just exactly how PCK can be defined and developed and how useful it is as a concept/construct in describing forms of teacher knowledge, has been considered by a steadily increasing range of researchers (e.g., Cochran, 1997; Veal and MaKinster, 1999). Shulman's (1987) view was that PCK was one of seven knowledge bases required for teaching and multiple conceptions of PCK have been posited (Veal, 2001, p. 2). An important development was Cochran, De Ruiter and King's (1993) constructivist view of PCK, "pedagogical content knowing (PCK)" (p. 263), which added to Shulman's integration of content and pedagogy by emphasising the importance of teachers' knowledge of students and the learning context.
In 1999, Veal and MaKinster drew on the existing literature to create a general taxonomy of PCK, in which topic specific PCK drew hierarchically from domain specific PCK, general PCK, and pedagogy. They also suggested that PCK integrated ten attributes, which for most secondary science teachers, begins with development of content knowledge. The foundational attributes were firstly content knowledge and secondly a knowledge of students. These formed a basis on which an interrelated knowledge of context, environment, nature of science, assessment, pedagogy, curriculum, socioculturalism and classroom management built to become PCK. Teachers must then understand “the importance of the student component of teaching” (p. 10), before developing the other attributes.

![PCK Diagram]

Figure 1: Vale and MacKinster’s taxonomy of PCK Attributes (1999, p. 11)

The graphic representation of Veal and MaKinster’s (1999) taxonomy of PCK attributes (see Figure 1) seems to suggest the possibility that the three upper levels could be lifted and transferred to sit, initially, on top of new content knowledge (see Figure 2) and perhaps over time, to become integrated with that new content knowledge. In an analogous situation, Perry’s (1970) investigation of intellectual and ethical development posited that these abilities ought to be transferable to new areas of knowledge; however, all his research showed that they were not.
Figure 2: Transferral of nine attributes of PCK to new content areas

Turner-Bisset (2001) includes PCK as one of the knowledges required for expert teaching, and builds on Shulman's work by adding categories of empirical and cognitive knowledge of learners, along with self knowledge (the importance of a personal identity as a teacher, beliefs about subjects, and about teaching and learning). Beliefs about a subject, which will "inevitably shape one's teaching of it" also were seen as part of PCK (p. 29).

Many researchers identify PCK as the hallmark of an effective teacher (e.g., Appleton & Kindt, 1999), yet we "know very little about how to enhance pedagogical content knowledge" (Cochran, 1997, unpaged). Indications are that PCK needs to develop in relation to specific content or topics (Loughran, Gunstone, Berry, Milroy & Mulhall, 2000).

TEACHERS' OCCUPATION COMMUNITIES

When re-educating teachers to become teachers of science, Watson et al. (2003) found as Perry (1970) had, that the transference of existing pedagogical knowledge to a newly acquired content area was not as straightforward as either they or their participants had expected it might be. Research relating to CPD of teachers traditionally calls for a balance between provision of science content and teaching strategies (Appleton & Harrison, 2000; Bell & Gilbert, 1996), and for changes to teachers' perceptions about the teaching and learning of science (van Driel, Verloop & de Vos, 1998). Although Watson et al.'s program addressed these areas, the teachers in their study experienced difficulties caused by their lack of science specific PK, resulting in problems with their being accepted as physics teachers in their school communities.

Teacher development is a process in which teachers attain the level of competence of which they are capable, "an autonomous personal process dependant on outside support, and subject to system constraints" (Lang, Olson, Hansen & Bunder, 1999, p. 191). Teachers are just one part of the
system within which they work (Lynch, 1997). Teaching also
encompasses collaboration with other school staff and involvement in the
‘occupational community’ of subject area teachers, where informal school-
based professional learning occurs (Melville, 2004). Becoming part of an
‘occupation community’ can be a key to teachers’ ability to fit within the
system. Membership of a community of practice implies “participation in
an activity system about which participants share understandings
concerning what they are doing and what that means” (Lave & Wenger,
1991, p. 98). If teachers do “not possess, initially, the words, arguments,
and goals that would permit them to negotiate a sense of meaning in the
[subject area] department” (Melville, 2004, p. 3), their ability to develop
strong professional relationships is constrained, limiting their access to
professional learning.

Teachers who are part of their occupational community learn from: their
own practice; interactions with other teachers; informal mentoring “through
conversations in hallways, teachers’ rooms and other school settings”; as
well as systemic or school provided professional development; further
study; and informally, through experiences as parents, coaches, etc.
(Bransford, Brown & Cocking, 1999, p. 179). In particular, teachers
enrolled in “academic programs hold their professional value in high
regard” (Skilbeck & Connell, 2003 p. 59). In adopting and adapting ideas
borrowed from a range of sources, teachers create their own understandings
and synthesise these into their knowledge base (Turner-Bisset, 2001).
Experience in practice, evaluating both their own performance and students’
learning (Turner-Bisset, 2001), may be the most important influence for
change as teachers develop (de Vries and Beijaard, 1999).

SUMMARY
One possible response to the shortage of qualified science teachers revealed
in the literature may be to broaden the knowledge base of current science
teachers. CPD that leads to development of PCK in new content areas will
enhance the effectiveness of science teachers. However, whether existing PK
can be transferred onto a base of new content acquired through CPD, has
not yet been established.

Science teachers with experience in other areas of science already are
accepted within their occupation communities. They have access to
informal support (that may not be available to retrained science teachers) as
they begin to incorporate their new learning into their pedagogical
repertoires. Enhancing content knowledge by adapting a university level
Physics course to regional science teachers’ needs provides an approach to
CPD not previously thought to enhance of PCK. This study explores
teachers’ initial perceptions of the JGSFEPS course, and seeks directions
for future productive research.
METHODS
The research aim was to study the content knowledge impact and delivery mode effect of a physics course on science teachers' PCK development. Qualitative case study method (Merriam, 1998) was used to document the emic and etic aspects of the participants' perceptions (Cohen, Marion & Morrison, 2000); the teachers' perceptions of the benefits to them of the course; and the effectiveness of the presentation mode for working teachers.

Case study has proven useful in studying educational innovations and is most suitable for exploring perceptions (Yin, 1994), reaching “across from the experience of those who are the subjects of the study to those who are the audience” (Walker, 1983, p. 155). The nature of case study addresses concerns for multiple evidentiary sources, recognition of participants' perspectives, and provides sufficient ‘thick’ description that allows readers to vicariously experience the context of the CPD experience (Guba & Lincoln, 1989). The case is particularistic as it focuses on a single implementation of a course and heuristic as it allows readers to relate this experience to their own situation (Robson, 1993).

Data were collected using interviews (see Appendix A) conducted with willing teachers and the university coordinator who organised implementation of the course. Mindful that participation in this course was already imposing time constraints on the participants, we developed pre- and post-course questionnaires (see Appendix A), which teachers voluntarily completed. Some university classes were observed, and interviews with selected teachers and the university coordinator were held following course completion. Interviews were audio-taped and fully transcribed by the first author. Member checks (Merriam, 1998) with teachers and university staff, further interviews and classroom will be conducted in the next stage of this project.

Constant comparative techniques (Glaser & Strauss, 1967) were used to clarify themes from the ‘case study data base’ (Yin, 1994). From these data themes generalised patterns emerged to become the interpretive commentary (Erickson, 1986). An understanding of teacher development as an autonomous personal process dependant on outside support (Lang et al., 1999) underpinned the analysis. The first author initially analysed the data before ongoing discussions with the other authors helped transform the categorisations into their final iteration (Guba & Lincoln, 1989).

DATA AND EVIDENCE
CONTEXT OF THE STUDY
A staff room discussion about science teacher shortages, the employability of physics teachers, and teachers’ feelings that they were ready to consider further study, led to the Science Head at a regional secondary school approaching the JGFEPS staff to negotiate provision of a physics course for
science teachers. The course was funded through the state government’s *Spotlight on Science* initiative with help from the faculty. Each participant’s school was asked to contribute $200 per teacher (Int).

Using the regional science teacher network, details of the course were provided to science staff at every school within the area. With an estimated pool of 50 science teachers in the area without formal physics backgrounds, it was hoped that 10 teachers would nominate (Int). Nineteen teachers with minimal physics backgrounds committed to the course.

**PLANNING PERCEPTIONS UNDERLYING THIS CPD**

The initial conversation leading to the development of this course involved a Science Head and three of her school’s science teachers who were teaching aspects of physics in the junior school. These teachers wanted a face-to-face course. External university study lacked the practical component that they valued and they felt that they would be more likely to remain committed to a contact course. The teachers felt capable of reading content from a book but wanted ‘hands on’ experience and teaching (Int).

The course was to be purely physics content. During the initial discussion that lead to implementation of this course, teachers decided that they “weren’t interested necessarily in pedagogical study which appears to be all that’s really been offered. They were more interested in broadening their knowledge base in areas that they felt were weak” (Kelly, Int). As Mark commented later, “The pedagogical part, if they are recently graduated teachers like myself, we should be up to date on our pedagogy. If they are well established, then they need to have the attitude where they will accept that they might have to update themselves in pedagogy. If they have to write programs or unit outlines they must be up to date. For schools to go through accreditation they must show they’re up to date with pedagogy” (Int).

Funding of the course was mentioned as a reason for involvement by more than half of the participants (S1). Under the Australian university system operating at that time, people with graduate qualifications were required to pay full university fees for any further study. The cost was in the vicinity of $1600 per course, and so effectively precluded additional university study for many teachers.

The teaching time for the course was compressed to accommodate the maturity and experience of the teachers, with the understanding that teachers would fully prepare for all classes by reading the study guides and practical procedures. Teachers were “really nervous about going back to study, but really committed” (Kelly), “looking forward to the challenge” (Maureen), acquiring greater conceptual understanding (Mark) and increased confidence (Angela) (S1).
THE PARTICIPANTS
Of the 19 teachers who enrolled in the course, 11 volunteered to be involved in this research. The teachers’ experience ranged from two to 32 years of teaching, and all but one had formal science qualifications (S1). The teachers were expected to have extended experience with students. Only two teachers had less than five years teaching experience, while four had more than 20 years (S1). Of the teachers with less teaching experience, one, Mark, had been involved in a weekly community program for disadvantaged children for several years (Int). Two of the participants were Heads of Science in their schools, and another is currently studying a Masters in Applied Science by research.

<table>
<thead>
<tr>
<th>Teachers</th>
<th>N=</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enrolled in the course</td>
<td>19</td>
</tr>
<tr>
<td>Participating in this research</td>
<td>11</td>
</tr>
<tr>
<td>Teaching Physics</td>
<td>4 at the beginning, now 6</td>
</tr>
<tr>
<td>Not completing the course</td>
<td>5 (2 found it too hard, 1 school would not fund, 2 other commitments arose.)</td>
</tr>
<tr>
<td>Awarded a High Distinction</td>
<td>8</td>
</tr>
<tr>
<td>Awarded a Distinction</td>
<td>4</td>
</tr>
<tr>
<td>Awarded a Credit</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 1: Description of teacher participation

Four of the teachers participating in this research already were teaching Senior Physics, and three expected to teach Senior Physics (Years 11 and 12 are university entry level) in the future (S1). During the course, an additional two teachers did commence teaching Senior Physics. Reasons for doing the course included its affordability, personal challenge, and fact that the classes were face-to-face and held in the evening. Participants hoped to increase their understanding of physics and their confidence in teaching it, even if only in the junior school. They were interested only in studying content, as they felt their existing science PK could be adapted to physics. Only three teachers were interested in receiving a formal certification on completion of the course (S1).

THE PHYSICS COURSE
Adaptations made for the teachers included changing the content available in a single course, reduced contact hours, and timetabling as evening classes. Assessments relating to the modules taught were unchanged. The course was the equivalent of a full first semester course in Physics, a composite of modules taken from Physics 1A and 1B (standard first year
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Modules that best matched the Senior Physics syllabus were chosen: Mechanics, Waves and Optics, and Electricity. These focused solely on the outcome of increased teacher content knowledge.

Although the teachers were generally concerned about the course's rigour rather than a qualification, the course coordinator was keen that the teaching and assessment would be such that if the teachers completed the other first year modules, they could be accredited with the two first year subjects. The possibility of a future four subject Graduate Certificate course was considered (Int).

The course was presented in a three-hour lecture plus tutorial format, from 6-9pm weekly over 16 weeks. The course was condensed from the usual contact time of 84 hours, to 48 hours. Seven assessment activities were conducted during the course. Teachers needed to commit at least 100 hours to attending the course, studying, and preparing assignments (Int).

Five teachers did not complete the course. Two found it too difficult and for two, other commitments intervened. One teacher was unwilling to proceed when her school would not contribute the $200 towards the cost of the course (Int). Of those who completed the course all received a Credit or higher, with more than half receiving a High Distinction.

TEACHERS' PERCEPTIONS ON COMPLETION OF THE COURSE

Teachers found the course “mentally stimulating and genuinely challenging” (Maureen and Anita – S2) and “extremely time consuming” (Ken – S2). Teachers drew support from other teachers doing the course and from teachers at their schools to “check ideas and understanding of concepts” (Paul – S2), “compare responses, check calculations and keep on task” (Kelly - S2), and “talk over assessment requirements” (Anita – S2). Mary, a part-time teacher, felt that she missed many of the informal opportunities that other teachers from her school used to discuss their learning (Int).

Most thought the level of content was appropriate to teach Senior Physics competently, although Jacqui had hoped to experience “some more modern applications, to see some more equipment and ideas we could use for practicals” (Int). They found the difficulty of the course to be much as expected, although the time commitment was higher than some had anticipated. Danielle and Jacqui felt that “a certain level of background content was assumed”, a level that Danielle lacked (S2). Mary, too, lacked both the physics and mathematics background required for the course, so she worked through Year 11 and 12 texts until it “clicked”, resulting in a High Distinction for the course (Int). Several teachers are seriously considering taking on further university study in science, though not until
next year, and would like to study in “a face to face format, similar to this
course” (Danielle – S2).

While some teachers felt that the pace of the course compromised their
ability to “consolidate the content” (Maureen), Jacqui felt it “gave us time
to digest the information and relate it to assignments” (S2). Paul felt that
“the face-to-face kept me motivated and on schedule” (S2). Assessment
requirements were problematic for Danielle and Anita who felt there was
“too much for working people, and some marking schemes didn’t match
the format” and “requirements were not communicated clearly” (S2).
However, unlike a professional development offered by Deakin University,
where Skilbeck & Connell (2003) found “only a tiny proportion for
teachers undertaking linked modules in fact opt to do the assessment
component” (p. 59), most felt the assessment was integral to their learning.
Kelly considered that the ongoing assessment “meant I was continually
learning, rather than cramming at the end” and Mary, Mark and Jacqui
would have chosen to do the assessment if it had been optional. Several
teachers believed that a reduced school load would have allowed more
access to the school physics teacher (Maureen) and to prepare for the exam
(Jacqui) (S2).

INITIAL IMPACTS ON TEACHING PRACTICE

As a result, most teachers felt more confident in their teaching, whether in
Junior or Senior Physics. Paul had “refocused my teaching methods” (S2).
Mark had been teaching physics as an ‘outfielder’ (Bulman & Harrison,
2003), and felt that the “group learning experience increased confidence” so
that he was “able to take the students a bit more in-depth in
investigations” (S2).

Kelly, another outfielder, was “no longer terrified at the thought of teaching
momentum and energy. I am finding my Senior Physics class far more
enjoyable and less stressful and my preparation time has been slashed” (S2).
“I can be more creative about how I’m teaching the material because
I’m not just trying to survive with the content. We do creative writing,
drama skits, lots of hands on activities, experimental design, a whole range
of things, not just chalk and talk” (Int).

Mary was not teaching physics when she enrolled in the course, but has
since been required to teach *Waves and Optics* in Senior Physics. She has
re-used some of her lecture notes as theory notes for her students. Mary
believes that “the types of things you do transfer from one subject to
another. It’s just the content… I use lots of hands on, let’s explore this,
and then do theory and some practice questions.” (Int).

Jacqui commented that she had changed the style and depth of her teaching
and her assessment methods. Jacqui has a background in physics and has
taught it for many years. For her, the most important learning experience
from the course was the realisation of the differences between school and university expectations for physics students. Jacqui now feels more confident and secure in what she is teaching, and has a clearer idea of her students' needs for further study. She also commented that she will be able to use what she has learnt about light and lasers when writing the new senior school physics program required to meet the new syllabus to be implemented next year (S2 & Int).

Mark felt that he was able to transfer pedagogical approaches that he had used in other science content areas. He considers that with a "firmer foundation it is much easier to teach conceptually and relate physics to biology, chemistry or mathematics". He is "teaching physics much more effectively now, so that at the end of the topic, the students really do have a much better appreciation of the concepts." Mark has "directly used some of their [university course] examples, some of their problems, adapting them to where my students are". He believes that he has been able to transfer pedagogical approaches of investigation and conceptual change to the teaching of physics. Now that he is more confident in his "foundational knowledge" of physics, Mark feels more free "to pull out an experiment, design and make an experiment to follow an idea that a student might have". But without sufficient content knowledge, he "wouldn't have that latitude to play or experiment" (S2 & Int).

**IMPORTANCE, CONCLUSIONS AND RECOMMENDATIONS**

The study indicates the value that teachers place on their own CPD. Forty percent of potential participants were willing to commit to an extensive and challenging course in their own time. The course results confirm that the teachers maintained their level of commitment. These teachers were already employed and received no financial benefit for completing the course. The incentive was to better themselves, a benefit that will flow to their schools and students. Also, the major funding for the course was not provided on an ongoing basis. Federal government changes to be implemented in 2005 will allow graduates to a further entitlement of courses at the reduced HECS (government subsidised) rate (DEST, 2004), but this is still $670 per course for science (DEST, 2003). If government or independent school systems want more teachers to develop to reach their full potential, they will need to contribute "support, reward and recognition" (Mayer et al., 2003, p. 22) to show that the teachers' time commitment is valued by the employer. This could be in terms of reimbursement of university fees. Also an appropriate reduction in workload would partly compensate teachers for their time expended and, more importantly, allow more time to consolidate their learning. We believe this could further enhance the PCK growth of participating teachers.

The high levels of interest and completion of the course also suggest that provision of a course developed to meet teachers' perceived needs, rather
than CPD imposed by employers, will encourage teachers to commit time and energy to their own development. Although the course content was difficult, teachers felt stimulated by the challenge presented by an assessable university course. Most professional development is “related to social issues” (Jacqui – S2) where teachers “just sit and take in information” (Danielle – S2). Teachers considered the presentation of the course, with face-to-face contact and evening classes, more suited to their needs than external study. They did however, have some problems with the pace of the course, and would have preferred more time for reflection on their learning and to prepare for assessment (S2). This could be overcome by reduced teaching loads, but may also require more flexibility in programming by the university. The increased confidence in teaching, and indications that eight of the 11 participants now plan to undertake further university study, indicate a very positive effect on their development (S2). Continuing cooperation between universities and teachers to negotiate internal courses that are accessible to working teachers can only enhance science teacher CPD.

Unlike the teachers in Watson et al.’s study of teachers ‘retrained’ as science teachers, teachers in this study were already part of the occupational communities of their school science departments. Some participants in this course headed school science departments. Their established positions allowed them full access to the informal learning opportunities noted by Melville (2004) and Bransford et al. (1999). Extending the range of subjects able to be taught effectively by established science teachers also may have a positive impact on the shortage of science teachers. Science teachers who currently spend less than their full week teaching science could become full time science teachers. This solution to the science teacher shortage calls for more specialised knowledge such as this course provided, and less generalisation. This is a teaching assignment issue and should be debated by teachers and policy makers.

Whether or not the teachers have been able to graft their current knowledge of students and other facets of PCK onto a new base of physics knowledge, is not yet established. Five teachers (Jacqui, Kelly, Mary, Paul, and Mark) who participated in the study were teaching physics classes. All five commented on changes in their teaching practice that indicate the beginnings of an integration of the new physics content and their previous science PK, suggesting that Physics PCK may be growing. Mark’s comment that newly graduated teachers and teachers who write school programs should be familiar with contemporary approaches is worthy of further investigation. It would seem that participants willing to commit to this course could be considered as especially committed to their teaching on the evidence of their participation and completion of the course alone. That two were Heads of Science, one studying a Masters degree in science
by research, and four with over 20 years teaching experience, yet still keen to learn, is further indicative of a group of people probably above the norm. Further research will investigate the validity of these teachers’ beliefs about content and pedagogy, as the nature of growth in their physics PCK is considered.

It is recommended that further research should focus on normalising provision of university courses that meet teachers’ needs through more flexible modes of delivery. Ways of funding teacher development through university study will be a key issue. As Mayer et al. (2003) noted, the establishment of “formal systems of support, reward, and recognition” is required (p. 22)

Continuing research into the effects of this course on teachers’ teaching also will be necessary to examine whether the teachers’ beliefs about the transferability of their science PCK are well grounded. This will include in-class research on physical science teaching by participants in the JGFEPS course.

ACKNOWLEDGEMENTS
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Appendix A

Questionnaires

Pre-Course

Questions focused on:

• teachers’ background information—qualifications, physics and teaching experience
• reasons for involvement in this course and expected outcomes
• views on science, and the teaching and learning of science
• what physics concepts help to explain 14 phenomena (e.g. Moon’s orbit, police radar, sonic boom, sparkle of a diamond, washing machine spin cycle)

Post-Course

Questions focused on:

• impact on teaching practice
• support accessed during the course
• difficulty of course content and course workload
• mode of course delivery, and
• future plans for study

Interviews

Initial interviews with the course coordinator and the Science HOD who conceived the course established the background to establishment of the course, its presentation, and funding, and hopes that this could be the beginning of a Graduate Certificate program.

Interviews with teachers approximately three months after completion of the course:

Have you taught physics or aspects of physics since completing the course?
Do you think the course has had any impact on your teaching? If yes, in what way/s? If no, why not?
The course was purely about physics content. How have you been able to integrate that into your existing teaching practices?
Have you accessed any help for ideas on how to teach physics concepts?
Do you feel the need for ideas on how to teach physics?

Have your students benefited in any way from your doing the course?

What stands out for you about what you learned in the course?

The course covered mechanics, waves and optics, and electricity. A second course would include properties of matter, heat, atomic and nuclear physics. Would you be interested in enrolling in that course?

Assuming that the course was to be presented in much the same way as the previous one, what changes might improve it?

If you had a totally free choice in how to study a second unit, what would you like it to be like?

What would your ideal professional development to help your science teaching be like?

What could your school do to encourage you to undertake more study?

Would anything else encourage you to undertake more study?

Is there anything else you would like to comment on?

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Data are coded as interview (Int), pre-course survey (S1), and post-course survey (S2).