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Collaborative Partnerships : A Model for Science Teacher Education and Professional Development

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Abstract: This paper proposes a collaborative partnership between practicing and pre-service teachers as a model for implementing science teacher education and professional development. This model provides a structure within which partnerships will work collaboratively to plan, implement and reflect on a series of Science lessons in cycles of action-reflection adapted from Korthagen's (2001) ALACT model. Issues within Science education, teacher professional development and teacher education are considered in the development of the model which attempts to deepen constructivist approaches to teachers' professional learning. It attempts to address issues with teacher professional development in the science area and improve professional experience practice for pre-service teachers. The nexus between theory and practice is the focus of the model which hopes to inform both teacher education and professional development for science teachers in the primary sector.

Learning takes place through the active behaviour of the student: it is what he does that he learns, not what the teacher does.

Tyler, 1949, p.63

Introduction

This paper reviews issues surrounding the status of Science education and its links with teacher preparation programs and professional development opportunities for practicing teachers. In light of this review, an innovative model is introduced where it is proposed that collaborative partnerships between practicing and pre-service primary teachers as a model of pre-service teacher education and teacher professional development might assist in addressing concerns about the status of Science education in primary schools. Issues surrounding the professional development needs of teachers and a call for tighter integration between theory and practice for pre-service teachers (Darling-Hammond, 2000b) are considered. The model then takes these challenges of teacher professional development and pre-service teacher education and examines them together in a model of joint professional learning. The model adopts an action-reflection praxis based on Korthagen's (2001) Action, Looking back at the action, Awareness of essential aspects, Creating and then Trialling alternative actions (ALACT) cycle and considers the place of the university setting in facilitating teacher education and professional development for primary Science teachers in the new professional learning mode.

The model is unique in its attempt to establish a partnership between practicing and pre-service teachers that is collaborative in nature. Collaboration between teachers has been a model of professional development in the past but these partnerships tend to be restricted to partners within each sector, ie. teacher with fellow teacher or student with fellow student. Partnerships between practicing and pre-service teachers traditionally follow a mentor type model. The model being proposed in this paper is based on the premise that professional learning can take place for both the practicing and the pre-service teacher through a collaborative partnership with one another that values both the 'expert' and the 'novice' partners' knowledge and contribution equally.

Collaborative partnerships for learning between practicing and pre-service teachers can be a challenging notion depending on how the term 'collaborative' is viewed. UNESCO (2000) defines collaborative learning as 'the act of shared creation and/or discovery' (p.1) and this best fits the application of the term 'collaboration' in the model being proposed in this paper. The proposed model depends on teachers and pre-service teachers being able to work in a collaborative manner to plan, implement and reflect on integrated Science lessons within the practicing teacher's classroom. The lessons are the result of shared knowledge and ideas and implementation and reflection is a result of the combined effort of both practicing and pre-service teachers in the partnership. This collaboration can be viewed in a similar way to that of collaborative learning in the classroom which Ehrlich (2000) defines as involving learners working together in small groups to develop their own answers through interaction and reaching consensus. Both the practicing and pre-service teachers are considered learners in the model as the teachers are pursuing professional development within the context of Science and pre-service teachers are actively contributing to their pre-service education course. The term professional learning is thus adopted to describe the learning that both partners are undertaking specific to the partnership, and represents the learning that would otherwise be considered part of professional development for teachers and part of coursework for pre-service teachers.

One might argue that the practicing teacher brings more experience to the partnership and thus the collaboration will really be a mentoring of the pre-service teacher. This can certainly be the case for the practicing teacher who is not able to step out of the 'expert' role. The advantage of using this model for teacher professional development, however, is that it provides an opportunity for both partners to bring some expertise to the partnership. The teachers bring their expertise and experience in classroom management, class dynamics and personal pedagogies. Pre-service teachers are involved in the model as a part of their science education in their pre-service coursework and thus bring current knowledge of strategies and theories being discussed in lectures and tutorials and ideas for lessons that are being explored in the university setting. It is then with the shared goal of producing a Science lesson in a school setting, that the partners share their ideas, delegate roles for preparation and implementation, and through their close interaction, reach a consensus for the lesson's delivery.

Background:

Science education is targeted as the context for this model as it is considered very important to the future of Australian society (Department of Education, Science and Training (DEST), 2002). Scientific knowledge and understanding underpins the economic and technological growth and development of a nation. The future of any emerging information economy and knowledge-based society such as Australia requires that a proportion of the population has expert knowledge and ability in the Sciences (DEST, 2002). Sustainable development and ethics are also essential emerging facets of scientific progress and technological development (Hodson, 2003). This requires preparation of scientific experts who are able to find ways to protect and repair the environment, and further the knowledge economy of the nation (DEST, 2003). As well, there is a requirement for scientifically literate citizens who can make informed decisions about the environment, their health (Rennie, Goodrum & Hackling, 2001; DEST, 2002), the way science and technology develops, and the future of the world, i.e. citizens who can engage in the ethical and value based decisions that need to be associated with development and progress through and in Science. Together these requirements highlight the importance of Science teachers being equipped with the means to prepare the young people of today for life in such a society.

High quality teachers are essential for significant and lasting contributions to the education and lives of young people (DEST, 2003). Given the significance of Science in a milieu where the Western World is increasingly dependant on technology and is held largely responsible for an environmental climate that is becoming critical for sustaining life on Earth, it is alarming to see that reports reveal that educators are in fact not always well-equipped to guide students into a scientifically literate view of the world (DEST, 2002; DEST, 2003; Goodrum, Hackling & Rennie, 2001; Hackling & Prain, 2005; Lyons, Cooksey, Panizzon, Parnell & Pegg, 2006). Part of the reason for this is tied to the poor attitudes towards Science held by both children and teachers at the primary and secondary level (Lyons, et al., 2006; Dobson, 2003; McInnis, Hartley & Anderson, 2000; Goodrum, Hackling & Rennie, 2001; Dobson & Calderon 1999; Martin, Mullis, Gonzales, Gregory, Smith, Chrostowski, Garden & O'Connor, 2001). These reports indicate that many teachers lack confidence and knowledge in Science and consequently approach its teaching in a manner that is content laden, disconnected to and irrelevant from students' lives (Goodrum et al., 2001), or they avoid its teaching altogether (Goodrum et al., 2001; Keys, 2005). This in turn impacts on students' attitudes and sees fewer students electing to pursue higher study in the Sciences which ultimately results in a further decline in the number of people studying Science education. In fact, McInnis, Hartley & Anderson (2000) report that those qualified in Science pursue education as a career in less than 0.9% of cases. The outcome of this sees students entering undergraduate pre-service primary education having quite low levels of interest and ability in the Sciences. This is confirmed in studies by Skamp (1997) and Schibeci and Hickey (2004).

The repercussions of this are that there are fewer teachers qualified in the Sciences, and fewer teachers who have a thorough understanding of and appreciation for Science in both secondary and primary education (DEST, 2003). This has an impact in the secondary sector where often teachers who are not qualified in Science are called upon to teach Science subjects (Sanders, 2004; Lyons et al., 2006), and in the primary sector, Science being approached in a disconnected fashion or not at all (Goodrum, 2001; Keys, 2005; Akerson, 2005). To compound this issue, Science is often not a professional development priority for schools. External testing of student achievement tends to concentrate on literacy and numeracy, thus making these more significant areas of focus. Professional development time and money is thus tagged to these areas, making it difficult to attract teachers to professional development sessions in other curriculum areas. This, coupled with the difficulties teachers themselves report in accessing time, equipment and science professional development once in the profession, is of significant concern given the level of impact high quality teachers can have on their students (DEST, 2003; Darling-Hammond, 2000a). The long term effect of an educational climate with under-qualified teachers who have low levels of scientific literacy is that children in the education system have a poor experience of science, which in turn perpetuates the problem.

This has significant implications for the future of Australian society economically, technologically and environmentally. Our ability to effectively use and support scientific and technological enterprises in a socially responsible manner may also be threatened. These are critical issues and it has never been more essential that children, as caretakers of the planet, have a good understanding of Science, its issues and its ethics. This requires targeting of both Science teacher education and Science teacher professional development, to better ensure high quality of science teaching in schools is achieved.

Goodrum et al. (2001) suggest that teachers' lack of confidence, training and resources to teach science and technology to young students has a significant impact on the profile of science in the primary classroom. Issues also lie in the general view that Science is only for the elite (Goodrum et al., 2001). A possible solution to this lies in the way that Science is approached in the classroom, its connection with students' lives, and an increase in the teaching of science in the primary years. If these aspects of Science education can be improved and enjoyment and wonder of science can be fostered in students, then perhaps they will be more likely to follow Science as a course of study and a career path.

Goodrum et al. (2001) report a number of concerns regarding the pedagogy of science teaching in the primary sector. These include that while students may often be involved in investigation, it is usually teacher directed rather than student led; that science is limited to indoor classroom activities rather than outdoor activities and excursions; science speakers rarely visit classrooms, and computers and the internet are used infrequently for science work or not at all. This is in marked contrast to the guidelines for best practice in Science teaching as identified in the Science in Schools Strategy (SiS) project (Department of Edcuation & Training, 2004). Akerson (2005) further reports, that when science is taught, it is often biology rather than physical sciences, another strategy she argues that teachers use to compensate for incomplete knowledge. Speedy, Annice and Fensham, as cited in Schibeci and Hickey (2004), are concerned that primary science is in such a poor state that it might even be better if it is not offered in the primary years at all. Overall, these reports indicate that significant concerns about the teaching of primary school Science have been present for decades.

Teacher Professional Development

Rennie et al. (2001) report that there is a gap between the intended and actual Science curriculum delivered in Australian schools today. Kallery and Psillos (2002) and Levitt (2001) support this claim. While teachers support ideas behind achieving scientific literacy through student-centred, hands-on learning and thinking curriculum in their rhetoric, these expressed beliefs do not always translate into practice (Kallery & Psillos, 2002; Levitt, 2001; Keys, 2005). The content driven, transmission approaches to teaching are easier to prepare and deliver, while preparation and delivery of more student-centred approaches is considered too time consuming for many teachers to contend with, on an on-going, regular basis (Keys, 2005; Goodrum et al., 2001; Lumpe, Haney & Czerniak, 2000). This reasoning is also revealed by Rennie et al., (2001) and Keys (2005) who found that primary school teachers indicate that insufficient resources and inadequate time for preparing are the main factors that frequently limit the quality and quantity of science teaching and learning in their classrooms. Studies by Keys (2005) and Levitt (2001) suggest that provision of resources alone does not help this situation. Teaching kits provided in each of these different studies showed an uptake in only one of them, and that was where provision of resources was supported by a professional development program.

This demonstrates why professional development is so important for teachers and perhaps why one of the overarching pleas made by teachers is for professional development and on-going support in delivering Science education (Rennie et al., 2001; Sanders, 2004; Levitt, 2001; Keys, 2005). It also highlights that it is access to and practice using Science teaching resources, supported with professional development opportunities that, for teachers, results in more substantial changes in teaching approaches. This should not be limited to professional development of practicing teachers, but also needs to be a fundamental part of pre-service teacher preparation. Teachers appear to be calling for professional development programs that in fact adopt the very constructivist approaches they are being encouraged to teach. The professional learning model in this paper proposes that this can also be extended to pre-service teacher education, where constructivist approaches to teaching Science are not just referred to as a part of course work, but are put into practice in an authentic context through the collaborative partnership model, offering both practicing and pre-service teachers a constructivist framework for their joint professional learning using an in-schools mode of delivery.

An ‘in-schools’ model of professional development that limits the impact of time away from the classroom and money spent by the school, might also help address the professional development focus on literacy and numeracy discussed earlier. This makes Science an ideal context through which to incorporate professional development in the school setting. It allows the professional development to be, as much as possible, a part of ‘normal’ day to day practice. The ‘in schools’ professional learning model also ensures that the teachers’ time is not impacted upon too significantly by removing them from the classroom for the purposes of professional learning.

Another important facet of professional development is tied to reflective practice. The idea of the importance of reflective practice for professional development has had significant growth in the past decade and has already been linked implicitly to other components of effective professional development (

Ingvarson, Meiers & Beavis, 2005). One of the significant components of reflective practice is the examination of the theories underpinning action and practices (Brookfield, 1995; Korthagen, 2001; Osterman & Kottkamp, 2004).

Opportunities to reflect on and practice new ideas and strategies, and receive feedback on performance, are identified as vital components in effective professional development (Ingvarson et al., 2005). This feedback may come from a mentor or a supporting teacher and links to elements of Brookfield's 'lenses' used in critical reflection (Brookfield, 1995). Brookfield argues that educators should endeavour to examine their practice from a variety of sources, which he links to four different 'lenses' (Autobiographical, Colleagues Experiences, Students' Eyes and Theoretical Literature). For Brookfield, it is through this critical reflection that teachers can identify and consider the appropriateness of the assumptions that guide their behaviours. The links made to reflective practice from Ingvarson et al.'s (2005) active learning align with Brookfield's lenses. In particular, Ingvarson, et al. discuss the importance of feedback which aligns well with Brookfield's lens that adopts peer review through drawing on our colleagues' experiences. Collaboration is a strong element in achieving this, and as explained by Osterman and Kottkamp (2004), is the key factor that separates reflective practice from reflection:

> While reflective practice clearly involves analysis, it is distinctly different from reflection. In contrast, reflective practice involves a systematic and comprehensive data-gathering process, not simply a recollection of events. Similarly, while reflection often relies solely on personal resources, dialogue and collaborative effort enrich reflective practice.. (p65).

Further, reasons why teaching activities need to focus on collaborative approaches to professional development are highlighted by Goodrum et al. (2001). Teachers frequently report that they lack 'the time and opportunity to share ideas, collaborate, reflect, evaluate, adequately prepare and participate in ongoing learning/professional development' (Goodrum, et al., 2001, p. 87). Collaborative professional development can help to provide this time. Other reasons are tied to the nature of collaboration in reflective practice which has been argued as an effective form of professional development in its own right (Korthagen, 2001; Osterman & Kottkamp, 2005) and the implicit and explicit links it has with the elements of effective professional development reported by Ingvarson et al. (2005), and specifically to Science teacher professional development as discussed by Goodrum et al. (2001) and Hackling and Prain (2005).

Reflective practice is considered by the teaching profession as 'a generic component of good teaching' (Korthagen, 2001, p. 51), and Parsons and Stephenson (2005) explain that new teachers in their very first appointment are expected to be reflective practitioners. It is essential then, that teacher education courses also build in experiences of reflection and strategies for being critically reflective in order to equip students with the skills required by their profession. Kreber and Cranton (2000) indicate that reflective practice is 'developed through a combination of reflection on theory and research and experience-based knowledge on teaching' (p. 478) and may include success and difficulties in a particular lesson, selection of content, questioning, selection of teaching and organisational strategies, classroom management and behavioural modification techniques, assessment tasks, selection and use of resources. However, this will remain only a model of experiential reflection, and will not become critical until it is linked with research and literature, and action on the reflection is taken. Brookfield (1995) would also add that to be critical, the reflection must also address the pedagogical assumptions informing the teaching behaviours and selection of activities/resources. This approach was taken by Korthagen (2001) in the development of the ALACT model: Action, Looking back on the action, Awareness of essential aspects, Creation of alternative actions, and Trialling of the new action. The ALACT model highlights 'an alternation between action and reflection' (Korthagen, 2001, p. 43) where problems are identified in a particular action. 'Looking back on the action' then enables critical thinking, research and problem solving approaches to be developed to address improvement in the new action that is consequently planned (Creation and Trialling of alternative actions).

Parsons and Stephenson (2005) report on research with pre-service teachers where reflection was built into school experience. One of the critical points that they make is that pre-service teachers' professional experience in schools is usually so pressured and demanding on time that they spend most of their time thinking about 'what should I do next' rather than 'why am I doing it' (p. 103). It becomes critical then that the time and need for reflection is formally built into the experience in some way. It seems that this will occur best when theory and practice are closely linked and students are provided with scaffolded opportunities to engage in different levels of reflection. Working in collaborative, professional learning partnerships using a framework such as the ALACT model would seem to provide such opportunities.

Pre-service Teacher Education

There has been mounting criticism in the last few decades (Korthagen, 2001; Srikanthan & Dalrymple, 2002) of the ability of teacher education to have any significant influence on teachers and the improvement of education, and that 'traditional approaches to teacher education do not function well' (Korthagen, 2001, p. 4). Darling-Hammond (2000b) also acknowledges the criticisms towards teacher education but contends that there is a body of evidence that 'indicates that teachers who have had more preparation for teaching are more confident and successful with students than those who have had little or none' (p. 166). Concerns about the quality of teacher education coupled with the perception that teachers are a key determinant of the quality of schooling and student learning (DEST, 2002) led the former Australian Prime Minister in conjunction with state and territory governments, to launch a review into teaching and teacher education (DEST, 2002; DEST, 2003). Given the central role universities have in preparing teachers (DEST, 2003), it must be considered how this might best be achieved.

Biggs (2003) reminds us that even in higher education, 'learning is the result of the constructive activity of the student' (p. 11), a notion supported by Ramsden (2003), and yet most university level courses apply a transmission approach to learning, a consequence no doubt of the large numbers of students who are situated in a lecture-style environment. Ramsden (2003) reveals that poor learning is often inadvertently encouraged in universities through the use of 'teaching methods that foster passivity and ignore the individual differences between students' (p. 98). This largely describes lectures delivered in the traditional format which have been found to be largely ineffective because they fail to stimulate higher order thinking skills (Biggs, 2003).

Ramsden (2003) also indicates that the quality of students' understanding in higher education is 'intimately related to the quality of their engagement with learning tasks' (p. 40). Two main approaches appear in the literature as promoting or inhibiting the effectiveness of teaching and learning, these being 'deep' and 'surface' approaches (Biggs, 2003; Ramsden, 2003). Table 1 illustrates the difference between these. Critical elements that can be construed from this information include that 'student-based factors are not independent of teaching' (Biggs, 2003, p. 17). The approaches taken by lecturers can have an impact on the approaches a student consequently adopts. This links to Biggs' notion that 'motivation is a product of good teaching, not its prerequisite' (p.13). It is also evident from this model, that assessment is a critical component of effective learning.

What students learn is not only connected to how they learn and how they are assessed, but is also linked to satisfaction and enjoyment. Deep approaches to learning promote understanding and retention (Biggs, 2003; Ramsden 2003). Biggs (2003) reports that students describe the experience of understanding as satisfying. Understanding relates to confidence, self-efficacy and self-esteem. Deep approaches also promote personalised meaning of learning to be constructed (Ramsden, 2003). So if learning is the result of constructive activity as purported by Biggs (2003), a deep approach to teaching, learning and assessment where constructive alignment is evident, would seem to be critical to achieve.

	Teaching Approaches adopted by the Teacher	Learning Approaches adopted by the Student
Surface Approaches	• Teaching piecemeal by bullet lists; not bringing out the intrinsic structure of the topic or subject • Assessing for independent facts, inevitably the case when using short-answer and multiple-choice tests • Teaching, and especially assessing, in a way that encourages cynicism • Providing insufficient time to engage the tasks; emphasising coverage at the expense of depth • Creating undue anxiety or low expectations of success	• An intention only to achieve a minimal pass • Non-academic priorities exceeding academic ones • Insufficient time; too high workload • Misunderstanding requirements (thinking factual recall is adequate) • A cynical view of education • High anxiety • A genuine inability to understand particular content at a deep level
Deep Approaches	• Explicitly bringing out the structure of the topic or subject • Eliciting an active response from students (questioning, presenting problems), rather than trying to expound information • Building on what students already know • Confronting and eradicating students' misconceptions • Assessing for structure rather than independent facts • Teaching and assessing to encourage a positive working atmosphere, so students can make mistakes and learn from them • Emphasising depth of learning, rather than breadth of coverage • Using teaching and assessment methods that support explicit aims and objectives of the course. This is known as 'practice what you preach'.	• An intention to engage the task meaningfully and appropriately. • Appropriate background knowledge • Ability to focus at a high conceptual level, working from first principles • A genuine preference, and ability, for working conceptually rather than with unrelated detail

Table 1: Deep and Surface Teaching and Learning Approaches (Biggs, 2003, pp. 15-16)

A significant aspect of effective teaching and learning and personal meaning-making appears to be linked to the extent of opportunity students have to interact with their peers (Lord, 1997; Biggs, 2003). This can be seen as an extension of the constructivist model where Vygotsky's social constructivist ideas come into play. Van Huizen, van Oers & Wubbels (2005) describe how Vygotsky considered learning to have a significant social dimension, where 'individuals develop personal meanings through being engaged in social practices' (p. 280).

Pre-service teacher education courses also need to be targeted to ensure they include sufficient effective teaching of Science and Science education experiences so that future generations of educators are well equipped to break the cycle of perpetual dislike and lack of confidence and understanding in the Sciences. Hackling and Prain (2005) recognise that 'new teachers to the profession can have a large impact if properly prepared' (p. 7) and have recently secured funding to induct university science teacher educators into their Primary Connections model. This model is based on Bybee's (1997) 5Es (Engage, Explore, Explain, Elaborate, Evaluate) approach to inquiry based learning, which is underpinned by social constructivism as a framework for learning. Facilitators have been trained in the 5Es approach and the Primary Connections resources to help professionally develop practicing and pre-service teachers in their approaches to Science teaching.

Anderson and Michener (1994) contest the idea that pre-service teacher education is the key to implementing change. They argue that it is current practicing teachers who need to be targeted, and that this needs to be done in the school context. The power of the school context is certainly a strong consideration in the proposed model of professional learning for practicing teachers, but the model is also aligned to Sander's (2004) assertion that a responsibility to change teaching in order to improve science competency and understanding also lies with pre-service teacher education. There have been many attempts to change the nature of teaching through professional development of practicing teachers, dating back to Hurd's writings in 1958 (Goodrum et al., 2001), yet research continues to produce the same findings of teaching and learning that has limited effect, is disconnected and approached haphazardly in schools (DEST, 2003; Lyons et al., 2006; Goodrum et al., 2001). The targeting of teacher education, as recognised by Hackling and Prain (2005) offers another way forward, one which, when coupled with increased opportunity for teacher professional development, may improve the impact on effective teaching in the Sciences. The proposed model brings together the views of all of these authors, by aligning professional learning for both practicing and pre-service teachers through a collaborative partnership set in the school context. This focus on the school context in the proposed professional learning model extends to yet another aspect of pre-service teacher education: the professional experience or teaching practicum.

Professional Experience: The Teaching Practicum

The practical teaching experience, or practicum, associated with teacher education programs is considered to be one of the most critical aspects of a teacher's preparation (Grundy, 2007; Zeichner, 2002; McBurney-Fry, 2002; Standards Council for the Teaching Profession (SCTP), 1995). Some of the criticisms of the professional practice experience lie in the nature of the supervision and its assessment. Paris and Gespass (2001) argue against the supervisor's teacher-centred nature of judgements of observable behaviours which 'grant authority to the perceptions of the supervisor/teacher over the experiences of the student teacher/learner' (p. 398). They suggest that in an environment that focuses largely on teaching about and through constructivist approaches to learning, the assessment and evaluation attached to the supervisor's role ought to also reflect assessment practices that acknowledge the student teacher as a constructive learner.

Korthagen (2001) discusses the importance of the nexus between theory and practice, indicating that 'both practice on its own, and theory alone are incomplete. I believe one can only really understand the former if one knows about the latter and vice versa' (p. xi). Zeichner (2002) highlights the importance of this when he criticises the lack of knowledge and understanding the university lecturers and the co-operating teachers in schools have of one another's programs and underlying philosophies and principles. This lack of knowledge leaves pre-service teachers trying to make sense of the theory they experience at university and the experience they have in the classroom, with little real support from anyone who understands what is occurring in each of these environments. With students left to forge their own understanding of how their theoretical experiences relate to this practice, it is little wonder that they eventually 'begin to view the placement as an assessment task in which they have to adopt particular types of behaviour that signal competence and will please the supervising tutor' (Maynard, 2001, p. 40) rather than establish their own identities and trial some of the practical applications of the theories covered in order to understand and apply them better.

The Standards Council of the Teaching Profession (SCTP) (1995) indicates that the nature of the partnership between university and school bodies needs to be 'deeply collaborative… (where)…school-based elements of the program need to be well integrated with the university-based elements' (p. 11). This notion is supported by Darling-Hammond (2000b) who highlights evidence that the more tightly integrated extended practical experiences are with university coursework, the more effective the teachers experiencing this system are, and the more likely they are to enter and stay in teaching.

Zeichner (2001) challenges teacher education institutions to adopt new ways in which schools and universities relate to each other in order to support teacher education and the professional experience of pre-service teachers. This supports Korthagen's (2001) notion of the need to develop the nexus between theory and practice. It also fits with Zeichner's (2002) observation that universities and schools need to have a better understanding and knowledge of one another's programs and philosophies to support the practical experience of the pre-service teacher. Relating this to arguments presented above for collaborative professional development experiences, reflective practice and the need in Science for ongoing professional development with supportive resources, it is clear that the science teacher educator has a significant challenge to make science teacher preparation as effective as possible.

The model proposed in this paper is an attempt to gather each of the threads of effective teaching and teacher preparation and weave them to produce a quality experience of science professional learning for practicing and pre-service teachers, with the ultimate aim of enhancing teaching and learning experiences in Science. This is done in recognition of the complexity inherent in the field of education, with its important and equally significant theoretical and practical components; which must inform each other to be successful. Goodrum et al. (2001) highlight this in particular for Science education:

> The skills required to teach science in an outcomes-focused approach that emphasises scientific literacy are sophisticated. An adequate pre-service (or initial) teacher education requires considerable face-to-face contact time, both in the training institutions and in classrooms, and an appropriate balance of science content, curriculum and pedagogy. (p. 171)

The Proposed Model

The model proposes to achieve this theory-practice nexus through a collaborative partnership between pre-service and practicing teachers who plan, implement and reflect on Science lessons together in a manner that represents Korthagen's (2001) model of action-reflection. Brookfield's (1995) and Ostermann and Kottkamp's (2004) ideas for critical reflective practice help to shape the reflective component of this action-reflection model.

It is my belief that both professional development of teachers and teacher preparation programs need to incorporate a balanced approach to practice and the theoretical underpinnings of that practice. The model includes a number of components. A professional development/teacher education program, consisting of a set number of sessions over a period of time, is shared by all partners in the model. These sessions are facilitated by the university in which the pre-service education course is delivered by the lecturer associated with the science education aspects of the course. Sessions incorporate both elements of reflective practice and frameworks for the effective delivery of Science education, for example, constructivist and inquiry process similar to those adopted in Bybee's (1997) 5Es, which are explored in the recently developed Primary Connections resource (Hackling & Prain, 2005).

The partners in the model are firstly encouraged to discuss ideas for lessons and enter the initial planning stages of lessons or a unit of work in these sessions. The model then requires a commitment no shorter than one school term (or approximately 10 weeks) during which partners implement science lessons, and reflect on critical components of these lessons which then informs further planning and implementation. This process continues in cycles for the committed duration.

The idea of committing to the partnership experience for an extended period of time helps to address a number of issues associated with teacher professional development. Primarily, it helps move away from the injection-type nature of single day/single session professional development programs, and it also offers an ongoing support for teachers which Tytler and Griffiths (2003) found important in professional development research associated with the Science in Schools project. Another significant feature of the model is that it brings the professional development into the school setting and is strongly linked with the day-to-day classroom program of the teacher. It certainly provides a great deal of autonomy for the teacher, so individual school nuances can be incorporated easily into the structure of the program, such as availability of resources, structure of the school day, and learning environments available for the delivery of lessons. There is also scope to integrate other programs that might be operating at the school. As such, the model provides authentic experience for both partners.

During the partnership, pre-service teachers would regularly attend lectures and tutorials in Science Education, although some of the timetabled classes may be given in lieu of the time spent in schools. Students are encouraged to attend all lectures to ensure pre-service teachers' further learning in theoretical underpinnings and science pedagogical content knowledge. Tutorials, conducted every three to four weeks, focus on students sharing their experiences. This enables the tutor to adopt a facilitator's role by asking questions that encourage links to be made between the practical experiences and the theories being examined in the lecture time. This process is similar to Brandenburg's (2004) round table discussion model used in pre-service teachers' education in mathematics.

The collaborative nature of the professional experience, rather than the traditional mentor and assessor type role the practicing teacher usually adopts in professional experience situations, is essential for the success of the professional learning aspect of the model. Here the practicing teacher has an opportunity to put into practice the ideas presented in the professional development sessions run for the partners by the university's science educator. It enables both partners to collaborate on ideas and reflect together, helping them experience an action-reflection practice that meets both Osterman and Kottkamp's (2004) and Brookfield's (1995) notions of critical reflective practice. This is achieved firstly through the collaborative nature of the action-reflection, and secondly because of the ongoing links the practice has to theory through the professional learning sessions conducted for both partners, along with the regular sessions held for pre-service teachers throughout the partnership timeframe. This is one of the critical aspects that the pre-service teacher can bring to the partnership throughout the collaborative period that distinguishes this model from a mentor model of partnership.

Another novel feature of the collaborative nature of the partnership is its potential to remove the artificial teaching experience pre-service teachers often find in professional experience rounds. The shared responsibility for the planning and the teaching and the shared reflection helps the pre-service teacher move away from the act of teaching to please the supervising teacher (Maynard, 2001) and can reduce the pressure felt through the assessment regime that accompanies a supervised session (Jones & McLean, 2006). Collectively, this could help to improve the scaffolding of pre-service teachers' learning in the classroom setting as they draw on their partner teacher as a valuable resource.

The school-based component of the model also promotes and strengthens the relationship between the school and the university. By focusing university tutorial sessions on teaching experiences of the pre-service teachers, a deeper understanding of the school setting can be achieved. The concurrent university and school-based experience may also enable a more constructively aligned learning experience to be achieved for the pre-service teacher, which is consistent with Bigg's (2003) and Ramsden's (2003) deep approaches. This is because the theoretical notions underpinning the coursework are directly related to the real classroom experiences rather than examples contrived by the lecturer, or through artificial lessons pre-service students conduct for each other.

The phase to follow this background and description is clearly the trialling of the model and determining methods of measuring its effectiveness for professional learning of practicing and pre-service teachers in Science education. However, the concurrent time spent in schools and university during the period should help both the practicing and pre-service teacher better experience the nexus between theory and practice. The model adopts a constructivist approach to both the pre-service teachers' education and the practicing teacher's professional development. By allowing access to university equipment and the expert knowledge of lecturing staff, better understandings can be forged between the school and university settings and professional learning can be conducted in an ongoing, supportive and authentic manner for both partners in the model.

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