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Science Teacher Education Partnerships with Schools (STEPS): Partnerships in science teacher education

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Abstract: This paper reports on the STEPS project which addressed international concerns about primary teachers' lack of confidence to teach science, and on-going questions about the effectiveness of teacher education. The five universities involved had each independently established a science education program incorporating school-based partnerships between the university and local schools to enable primary pre-service teachers (PSTs) to teach science.

The diversity of the programs enabled an examination of the relevant literature underpinning the approaches and comparison of data from participants to identify key features and success factors for establishing and maintaining working relationships with schools.

This preliminary analysis of learning from STEPS uses case studies and feedback from PSTs who participated. These findings indicate that authentic teaching experiences build the confidence of PSTs to teach science. Ultimately, the project will develop an Interpretive Framework which will articulate the characteristics of partnerships to be validated through feedback from other science educators from Australia and overseas.

Introduction

This paper introduces and reports on preliminary findings of a significant curriculum renewal project, the Science Teacher Education Partnerships with Schools (STEPS) project[1]. The Project began which began in 2013 and will conclude at the end of 2014, explores the use of partnerships between schools and universities to make links between theory and practice in primary science teacher education in Australia.

STEPS was formed as a collaboration between five universities, each of which had independently developed science education programs based on pre-service teachers (PSTs) teaching science in schools. The five programs had evolved in response to specific opportunities needs and constraints within each context.

Concerns about the state of science education and its importance to national prosperity have been expressed in a number of reports both within Australia and internationally (Dobson, 2003). Studies consistently have reported that students are 'turned off' science across the middle years of schooling, and that, in the primary years, science is approached in a disconnected fashion or not at all (Keys, 2005; Tytler, Osbourne, Williams, Tytler, & Cripps Clark, 2008). Questions have been raised about the pedagogies adopted by teachers of science and indications are that science is seen by many young people as irrelevant to their lives (Tytler, 2007).

Other studies have shown that many primary teachers lack the confidence and content knowledge to teach science effectively (Akerson, 2005; Hackling, 2006; Tytler, 2007). This, combined with an increasingly "crowded curriculum", dominated by literacy and numeracy concerns, driven by external testing (Kenny, 2009; Kenny & Colvill, 2008), leads many primary teachers to avoid teaching science or to adapt inappropriate teaching strategies from other disciplines to compensate for a lack of science pedagogical content knowledge (Appleton, 2003). In addition, as universities have had little control over what PSTs teach while on practicum, PSTs report they have few opportunities to teach science or observe it being taught during their normal teaching practicum (Kenny, 2010).

Authentic teaching opportunities are essential to building PST confidence to teach science (Howitt, 2007). Research has indicated that programs designed around PSTs teaching science in local schools are an effective way to improve the confidence of PSTs to teach science (Jones, 2007; Kenny, 2010, Murphy, Beggs, Carlisle & Greenwood, 2004). Initially, therefore, STEPS drew on the range of approaches adopted by the five participating universities to identify the factors associated with school-based approaches that made them effective. In doing so was STEPS also able to explore the school-based partnerships more generally as a means to compensate for the lack of science teaching during practicum mentioned above and improve teacher education through building university-school-community relationships as called for in numerous reports on teacher education in Australia (ACDE, 2004; House of Representatives Standing Committee on Education and Vocational Training, 2007; Parliament of Victoria, Education and Training Committee, 2005).

In teacher education programs, effective approaches to develop the pedagogical content knowledge (PCK) (Shulman, 1987) of PSTs are critical, especially when considered

[1] An Office for Learning and Teaching funded project called "School-based pedagogies and partnerships in primary science teacher education"

along with other studies showing that the development of children's learning is fundamentally tied to the quality of teaching (Darling-Hammond, 2000; DEST, 2003). Further, Bandura (1977) purported that mastery experiences, those providing a sense of personal accomplishment, are very influential sources of self-efficacy. An individual's perceived efficacy is highly influential in: the types of activities and settings individuals elect to participate in (Bandura, 1977); their resilience and perseverance to overcome perceived barriers (Goddard, 2003); and the types of teaching strategies which they choose (Jones & Carter, 2007).

However, other research has suggested that the provision of mastery experiences alone is not sufficient for a meaningful understanding of science teaching and learning to be achieved. Korthagen et al. (2006) argued that deep learning occurs through reflection on experience and through interaction with others. Loughran (2002) argued that reflective practice, using real examples has the potential to bridge the theory practice divide, an element that teacher education courses are often criticised as lacking (Darling-Hammond, 2006; House of Representatives Standing Committee on Education and Vocational Training, 2007; Parliament of Victoria, Education and Training Committee, 2005).

Darling-Hammond (2006) also suggested that the integration of course-work and field-work helps PSTs to better "understand theory, to apply concepts they are learning in their course-work, and to better support student learning" (p. 307).

In summary, these studies together suggest improved science teacher education is tied to approaches that promote positive attitudes, personal efficacy and opportunities for PSTs to teach science in authentic settings, with support and an opportunity to reflect on the experience. It is claimed this approach will better prepare PSTs to "handle the problems of everyday teaching through theory-guided action" (Korthagen et al., 2006, p. 1021). Darling-Hammond (2006) went further and asserted that teacher education programs need to provide opportunities for PSTs to analyse and apply theory; reflect on their subsequent practice; and have further opportunities to retry and improve their practice.

Formal practicum arrangements in teacher education offer obvious partnership opportunities and have been studied in a number of projects, for example, Smith (2011) noted that work-readiness is underscored by the need for strong links between universities and the profession. However, as alluded to earlier, there are a range of tensions and ambiguities inherent in traditional practicum partnership arrangements. In addressing these, Ure, Gough & Newton (2009), made a number of recommendations including the need for closer collaboration between universities and schools to clarify the purpose of the practicum; and to better conceptualise effective teaching and teacher development and to undertake further research into "increasing the links between the placement experience and the academic content of programs to create more informed knowledge about the application of pedagogy" (Ure et al., 2009, p. 56).

Supporting this call, Howitt (2007) and Kenny (2010) argued that the university lecturer plays a crucial role in supporting PSTs. Kenny (2012) pointed out that, due to the lack of science PCK of many primary teachers, PSTs who engage in authentic science based learning experiences in a school may not otherwise have access to science PCK expertise and support (Kenny, 2012).

The value of these school-based approaches in science is underscored by further evidence suggesting that in-service teachers who participate in partnerships arrangements with PSTs view their participation as professional learning opportunity and may also benefit from the experience, especially where the relationship between the PST and in-service

teachers is framed as one of mutual professional learning rather than supervision. (Jones 2008; Kenny 2012; Murphy et al., 2008).

More recently, in Europe, Alake-Tuenter, Biemans, Tobi, Wals, Oosterheert & Mulder (2012) reviewed current literature on competencies required by primary teachers and recommended that PSTs "need mentoring and support within the context of their internship" and that "[s]trong partnerships between teacher training institutions and primary schools might contribute to achieving this goal" (p.27).

Based on this research, the authors argue that STEPS may also offer an effective solution to a question currently occupying the minds of teacher educators and key policy makers around the globe: How to promote more effective teacher education? The STEPS team argue this outcome relies on establishing positive and informed relationships between universities and schools. Thus, a key strength of STEPS the authors argue is that it provides potential solution to two key areas of national and international concern: the promotion of effective practical teaching experiences that bridge the theory practice gap evident in many teacher education programs; and builds the confidence and competence of PSTs to teach science through the provision of authentic science teaching experiences.

The researchers in STEPS do not suggest that traditional practicum arrangements in education programs should be abandoned, but rather advocate for partnerships as an opportunity to strengthen the links between the theory and practice, initially in science education, but potentially for other areas of the curriculum. STEPS can be considered as an adjunct to current teaching practice by suggesting organisational models that may make the practicum experience more effective.

As each university in the STEPS Project had independently developed their own program, different organisational structures and processes were likely to be evident and provide an opportunity for a comparison of the pedagogical approaches and partnership arrangements adopted. When considered together, however, this diversity should offer greater insight into the various structures and processes unique to each school-based partnership approach and enable the identification of critical success factors. Ultimately, STEPS intends to develop a coherent theoretical framework that underpins effective school-based partnerships in science education for PSTs and possibly other discipline areas as well.

In the following section, we provide a more detailed description of the Project, including its aims, a description of its phases and the methodology used to generate the data used in this preliminary analysis.

An introduction to the STEPS Project

The common interest in using partnerships to address the weak connection between school-based experiences and the theoretical components of teacher education courses, led the participants from Deakin University, Australian Catholic University (ACU-Ballarat), RMIT University, University of Melbourne and University of Tasmania, to come together in 2012 to form the STEPS project team and develop a proposal.

While some research had been done of individual programs included in the Project (Kenny, 2009, 2010, 2012; Jones, 2008), STEPS aimed to examine the five programs to identify key factors involved in the partnership approaches and to draw out any general principles for success. A meta-analysis of the methodologies, informing theories, and principles associated with each approach will enable comparison of the nature and benefits of

each and identify the critical success factors. Specific intended outcomes of the STEPS project are to:

1. Synthesise the teaching practices and informing theories used in the school-based 5 science teacher education programs.
2. Document the range of pedagogical approaches adopted at each university which result from the constraints and affordances in place in each context and reflected in the structure of the school-based partnerships.
3. Develop an *Interpretive Framework* that: documents key stages in the formation of school-based partnerships; and provides strategies for establishing and maintaining them.
4. Guide the development of more effective science teacher education programs, and improved teacher education outcomes more generally.

There are 4 phases in the STEPS Project over a two-year period:

- Phase 1(2013)-Sharing of current practice within the team (duration-1-6 months)
- Phase 2 (2013)-Situating the models into the contemporary literature and practice (duration-3-7 months)
- Phase 3 (2013-2014)-Analysis of current programs of the research team (duration-5-15 months)
- Phase 4 (2014)-Examination of approaches employed by other universities (duration-16–22 months)

As indicated above, Phases 1 and 2 are now complete. Further detail is also available on the STEPS project website (http://www.stepsproject.org.au/).

In Phase 2, the project team developed a database of programs employing school-based delivery of curriculum content published in the research literature or represented on the Internet. This database collated contemporary frameworks, theories and pedagogies associated with this practice from which the project team were able to identify four key themes in the existing literature: partnerships; science teaching in primary schools; reflective practice and; dealing with the theory-practice gap between universities and schools.

Phase 3, currently underway, involves an analysis of current practice based on evidence collected from participant PSTs, teachers, teacher educators and principals in the various programs. This paper presents a preliminary analysis of these data from PSTs. The aim is to explore how individual PSTs value their school-based experience and determine how it affected their confidence and attitudes towards teaching science.

A later paper will explore the perspective of other participants involved in STEPS such as teachers, principals and science education tutors to give a fuller account of the school-based science teacher education programs and to inform the development of the *Interpretive Framework* by revealing the critical elements of practice.

In phase 4, STEPS will research instances of partnership based programs at other universities around Australia and overseas to validate and further develop the *Interpretive Framework*. Round table discussions and workshops are planned with colleagues at conferences and seminars, both nationally and internationally, in an effort to provide a wider range of perspectives and practices to further inform and validate the *Interpretive Framework*. Ultimately, the aim is for the *Interpretive Framework* to capture a wide-range of practices so it can be used to guide school-based approaches to teacher education in science and perhaps even teacher education more broadly.

Methodology

This study is underpinned by an emergent research paradigm (Glaser, 1992) as it aims to uncover the key success factors of the partnerships based on feedback from the participants resulting from their experiences of teaching science to primary students in authentic school settings.

A mixed methods approach was adopted, drawing on quantitative data in questionnaires as well as qualitative data from semi-structured interviews from a range of participants across all five institutions, thus allowing for triangulation of the findings (Zeichner & Noffke, 2001). The iterative nature of the Project enables learning from each phase of the project to feed into the next, leading to further refinement of the *Interpretive Framework* and its underlying principles.

This paper reports on data collected during the first three phases: Phase 1 (initial case studies which describe the approaches used in each of the five universities); Phase 2 (literature review); and Phase 3 (feedback from PSTs about their experiences of teaching science in the partnership).

An outline of the models of school-based partnerships in STEPS (Case studies)

This section uses the five case studies for each university to provide a brief description of each of the five programs. The key features of the five models are shown in Table 1, for comparison. This is followed by a brief description of each to elaborate.

Case study	**Deakin University**	**RMIT University**	**University of Melbourne**	**University of Tasmania (UTAS)**	**ACU Ballarat**
Course / Program	B.Ed	B.Ed BEd/Disab Master of Teaching	B.Ed Master of Teaching	B.Ed	B.Ed (Primary) B.Ed (Early Childhood)
Average number of PSTs involved each year	450	280	165	24 (Elective)	72
Time PSTs spend with children	8-9 weeks x 1 hour in a semester	4 weeks x 2 hours in a semester	1 hour lesson per week for a year in same class	Preliminary visit, plus 6-8 weeks x 1.5 hours per week in a semester	5 weeks x 2 hours in a semester
University Tutorial	2 hours of tutorial at school each week	1 hour of tutorial at school during teaching weeks, university tutorials during non-teaching weeks	2 hour lecture and 1 hour workshop at university each week during semester.	3 hour tutorial each week during non-teaching weeks	1 hour lecture at university
Core unit / elective	Core	Core	Core	Elective	Core

Case study	Deakin University	RMIT University	University of Melbourne	University of Tasmania (UTAS)	ACU Ballarat
Total time PSTs spend in school teaching students	8-9 hours	8 hours	9 hours (min)	9-12 hours (min)	10 hours
Teacher Educator present at school	Yes	Yes	Yes, Teaching Fellow or Clinical Specialist	As required, electronic communication weekly otherwise	Sometimes
Organization of PSTs- individual, pair, group teaching	Pairs of PSTs work with 6-8 children	Group of 5 PSTs work in each classroom	Individual PST with a whole class	Individual PST with a whole class	Pair of PSTs with a whole class
Classroom Teacher involved	No	Informally	Yes, mentor for placement	Yes, work collaboratively to plan	Informally
Meeting between Classroom Teacher & PSTs	No	De-briefing	Placement	Yes, initial group meeting for all PSTs and teachers	Yes
Do PSTs report children's outcomes to the classroom teacher	Yes	No	Yes	No	Yes
Recognition for PST	Unit assessment Certificate & 3 field-work days	Unit assessment, Certificate only	Unit assessment, Placement days	Unit assessment	Unit assessment

Table 1: A comparison of the key features of the five university approaches

Case study1- Deakin University

School-based PST science education at Deakin University has a 25 year history. The approach originated because PSTs were rarely given the opportunity to teach science in schools, or were not adequately supported to do so (Grindrod, Klindworth, Martin & Tytler, 1991). The partnership arrangement is currently included in the second of two undergraduate science education units and provides undergraduate PSTs with an experience of teaching science concepts to children while being supported by their science education tutors.

The weekly three hour workshop is held in a local school rather than in the university laboratories. During this time, pairs of PSTs plan and teach small groups of children for one hour each week, progressively developing a sequence of science activities. Each workshop ends with a reflection session in which students recount their experiences in a pedagogical discussion with their tutor.

This program has received consistently high satisfaction ratings from PSTs and success of the program is also demonstrated by the increased number of schools involved on all campuses; and the ongoing partnerships with schools over many years. From 2015, the

plan is to move the unit from third year to fourth (and final year) to focus more on to teacher-readiness. The partnership arrangements with schools will be re-structured to facilitate a more authentic collaborative engagement between the PSTs and the teachers they work with in schools.

Case study 2: Australian Catholic University, Ballarat

School-based approach to science teacher education has been a core component of the Bachelor of Education (Primary) and Bachelor of Early Childhood and Primary Education courses at ACU Ballarat since 2008. Over several iterations it has proven to be an effective forum for mutual professional learning of both PSTs and teachers in primary science (Jones, 2008).

PSTs work in pairs to collaboratively to plan, co-teach, report and reflect on a mini-unit of science in local schools in Ballarat. Teaching for 1.5-2 hours per week over a five-week period, they explore science ideas and processes with their class of children, basing their mini-units on the 5Es inquiry framework (Bybee, 1993). There is a focus on hands-on experiences supported by conceptual development and embedded assessment across all levels of Primary schooling. PSTs also write a report for each child in their class, which is returned to the school and often sent home to parents as a part of the school's formal reporting process.

During the 5 week teaching period, PSTs receive time in lieu of science tutorials, but still attend university for science lectures where they debrief and share ideas for improving their science teaching practice. Assessment of the PSTs is based on a reflective task, the quality of the inquiry plan and the reports they write on children's learning. They are not assessed on their actual teaching. Feedback from PSTs, classroom teachers and principals indicates they value the experience because they see how engaged the school children are.

Case study 3: University of Melbourne

The Primary Science Education program (MGSE) is a master's program which adopts a clinical model and grew out of the former B.Ed. program which ran school-based science programs in the 1990s in which PSTs taught science units in classrooms. The program provides knowledge, experience and skills to teach science through an in-class teaching requirement, combined with campus-based workshops and lectures.

The PSTs teach a sequence of lessons and develop a unit of science teaching. They are expected to teach science education to a whole class and are encouraged to be diagnostic, interventionist teachers responding to learners' identified needs and to use student work as evidence that informs the sequence of science teaching.

Science education is a core unit in the first semester of their second year program for the Master of Teaching Primary. Each PST works two days a week in the same school for a year. They also participate in 2 x one-hour lectures and 1 x two-hour campus-based workshops per week while they are teaching their science units in classrooms.

PSTs are supported by their classroom based Mentor Teacher, a school-based Teaching Fellow and a MGSE Clinical Specialist. The Teaching Fellow and Clinical Specialist meet with the science education academics leading the subject before each semester. The Teaching Fellow and Clinical Specialist source a Mentor teacher who has

planned to teach science to their class. The PSTs work with these class teachers to develop a unit and adapt it to the science learning needs and interests of the students. The unit keeps the science focus uppermost, but blends technology, literacy and numeracy into the class based experiences.

Case study 4: RMIT University

The RMIT Science Program was originally designed in 2007 to provide PSTs with authentic opportunities to engage primary children in science. The program has evolved into a compulsory two semester sequence, where the first semester is designed to provide PST's with appropriate PCK to create and deliver effective inquiry units. The second semester, PSTs construct units with support from the university tutors and deliver them in primary classrooms at the close of the semester.

The assessment of the program focuses on developing professional practice through reflection on professional identity surrounding science and science teaching. Furthermore, PST's must provide evidence for 'student learning' through targeted assessment, and how that relates to their curriculum development through planning, implementation and critique of curriculum. PST's involve in the RMIT science program have rated their 'overall satisfaction' as 100% over the last five semesters. Classroom teachers and the school community at large have reported good outcomes for the primary students. Their satisfaction is demonstrated by the fact that the same schools have continued their involvement in the program since its inception, which speaks to the positive outcomes for all the stakeholders. Over the years, the RMIT school-based science program has grown to involve seven primary partner schools in the greater Melbourne area.

Case study 5: University of Tasmania

A partnership approach to science teacher education was offered as an elective in the Bachelor of Education (Primary) at the University of Tasmania in 2007, with iterative improvements in 2008 and 2010. In the unit, PSTs in their final (fourth) year worked collaboratively with a local volunteer primary teacher as their partner, to plan and teach a science based unit of work to be delivered to the class of their teacher partner.

During the first four weeks of the unit, the primary teachers met with the PSTs to establish the partnership. Following this meeting, with the support of their university science educator, the PSTs planned and developed a science lesson sequence in collaboration with the partner teacher, their peers and their science educator. The sequence, which was to consist of at least six lessons of 1.5 to 2 hour each week over a six-week period, was then taught to the class with the classroom teacher and science educator taking a supportive rather than supervisory role.

The PSTs were also required to assess several of the children in the class, do a weekly reflective exercise after debriefing with their partner teacher. Finally they prepared a science portfolio as part of their assessment. They were not assessed on their actual teaching. PSTs did not attend tutorials during the teaching period but had regular contact through email with their science educator. They returned to university after the teaching phase to debrief, share experiences and complete their portfolio.

Feedback from PSTs, classroom teachers and principals indicates they value the experience because they saw the engagement of the children and clear multiple benefits for everyone involved (Kenny, 2009, 2010, 2012).

Preliminary findings from Phase 1 to 3 of the STEPs program (PSTs):

A common thread in the project is the commitment to link theory and practice by providing authentic science teaching experiences, where PSTs take responsibility for planning and implementing curriculum, supported by academics in partnership with practising teachers, and then reflect on their experience.

In each case, the school-based science teaching programs are additional to the normal teaching practicum arrangements and the PSTs develop and teach authentic science classes in primary schools. Each program also acknowledges the centrality of reflective practice, focuses on the development and implementation of curriculum, the relational and instructional elements of the science pedagogy.

The reflective component has been shown to be critically important in assisting PSTs to develop their science pedagogical content knowledge and professional identity as teachers of science (Kenny, 2009, 2010).

As the five different models of school-based delivery had emerged independently in response to particular contexts and each was shaped by local constraints and the knowledge and beliefs of the teacher educators who initiated the programs, it is not surprising that there is a degree of diversity. A scan of Table 1 reveals variations in:

- the way PSTs interact with school children, which ranges from working with small groups through to teaching a whole class;
- reflective practices, ranging from teaching team reflection to individual teachers, with the reflective focus on individual students, small groups or whole class analysis;
- how theory informs the approach and positions the students;
- assessment focus and purposes; and the nature of the partnership and the degree to which teacher professional development is incorporated into the partnership.
- whether PSTs attend schools as a group or individually.
- the time period that PSTs are actually involved in the schools.

Impact of partnership experience on PSTs as revealed through their feedback

A total of 146 PSTs responded to the online questionnaire conducted after their teaching had been completed. Table 2 provides an overall summary of the responses at each University. PSTs who agreed were followed up later for interview; these data are also discussed below.

Institution	No of responses	Total population by university	Response rate % by university
ACU	11	72	15%
Deakin University	39	450	9%
Uni Melb	12	165	7%
RMIT	43	280	15%
Sub total	105		
UTAS*	41*	360	11%
Overall response rate	**146**	**1049**	**14%**

* **Table 2: Summary of survey responses by university**

Note: the UTAS questionnaire was conducted separately because it focussed on former PSTs who were now teaching in schools.

While the overall response rate of 14% was disappointing, as a preliminary analysis the results below provide some insights into the PST experiences which are broadly consistent with earlier research conducted at particular universities involved in STEPS (Jones, 2008; Kenny, 2010).

Analysis survey data

A summary of responses is shown in Table 3 for all programs that ran in 2013, that is all programs except the UTAS program, which is reported separately in the next section. These Likert scale items are based on the experiences of the PSTs teaching science to primary children and relate to the effects on their confidence, interest, and capability to teach science.

The vast majority of PSTs indicated a high degree of confidence in all items, especially items 2 (93% confident or very confident) and 4 (91% confident or very confident). These two items involve generic teaching skills related to organising student activities and managing the classroom environment, however, the science teaching context is recognised as presenting specific challenges, such as: high degree of activity; and working with potentially complex materials which other studies have shown can also present problems for experienced teachers (Kenny & Colvill, 2008; Mulholand & Wallace, 2003) .

The PSTs reported very high levels of confidence with learning science content (85.5%), planning science lessons (88%), managing behaviour (84%), undertaking critical reflection on their science teaching (84%) and being excited about the science they teach (89%).

Response to questionnaire (Deakin, UniMelb, ACU & RMIT)/ How confident do you feel about doing the following?	Very under confident	Under confident	Neither confident nor under confident	Confident	Very Confident
1. Learning science content	0	2 (2%)	13 (12%)	59 (56%)	31 (29.5%)
2. Undertaking and supervising experiments with children	0	1 (1%)	6 (6%)	57 (54%)	41 (39%)
3. Planning science lessons	0	3 (3%)	9 (9%)	59 (56%)	34 (32%)

4. Creating an engaging classroom environment	0	1 (1%)	8 (8%)	56 (53%)	40 (38%)
5. Managing the behaviour of a group of children	0	4 (4%)	13 (12%)	60 (57%)	28 (27%)
6. Undertaking critical reflection on my science teaching*	0	4 (4%)	11 (10%)	54 (51%)	35 (33%)
7. Establishing and building on students' science understandings	0	4 (4%)	21 (20%)	58 (55%)	22 (21%)
8. Being excited about the science I am teaching	0	6 (6%)	6 (6%)	49 (47%)	44 (42%)

Table 3: Overall summary response to online questionnaire
(PSTs from Deakin, RMIT, University of Melbourne and ACU- 2013 only)
*Note there was a total of 105 respondents to all questions except question 6 which had 104 respondents.

Although still very positive, the item indicating their least confident response was establishing and building on students' science understandings (76%), which in all of the models was addressed by an emphasis on the PSTs conducting some assessment of their students. The assessment of students by the PSTs relies on them having a good knowledge of their students' abilities and being in a position to monitor growth in their science understanding. This aspect is likely to be linked to the time spent in schools, getting to know the students and the level of interactions of PSTs with their teacher partners. As the degree of this interaction varies from one program to the next, these variations offer points of comparison between the programs in STEPS to be explored in future studies.

Analysis interview data

An analysis of the nine PSTs interviews identified six emergent themes across the various models: the chance to put theory into practice; effect on PST confidence and identity; increased awareness of what good science teaching looks like; the development of PST professional identity and teaching skills; the importance of mentoring and support to take risks; and feedback about the how to improve the school-based experience.

The opportunity to put theory into practice was recognised by the PSTs as a very valuable aspect of the experience:

> Engaging, challenging, and rewarding course -the application of theory and the opportunity to practise it in a real classroom with our peers is an invaluable experience. (Rodney-RMIT Student)
> ...you might have an idea that something will work but having that direct relationship between learning about it one week in uni and then going straight out and actually giving it a go, you can see that connection and it's allowing you to put it into place straight away (Emily W- Deakin)
> I absolutely loved it, it was probably one of the biggest highlights of my past four years of study. ...I think it was a fantastic experience I think ...it links the theory with the practice and it just makes it all real and relevant (Kaitlin ACU)

The immediate and authentic nature of the experience of working with children brought the theory to life for them and built their confidence to teach science:

> we've learned about the kids reactions towards science because if we just did this ...at uni ...you wouldn't get the pure experience of working with kids. You get their true reactions and reflections on things as opposed ...the theory ... we actually get to see it for ourselves (Emily B- Deakin)
> …before coming into this unit I was a little bit …unsure when it came to teaching science and I probably had that sort of scary critical view … It was really good to be able to show … students … they can be a scientist when they explore and when they work together and find things out...that's definitely made me a lot more aware...and honestly much more excited about teaching science... it was very much a really positive experience of science teaching and learning. (Lucy ACU)

Students reported becoming more aware of the learning potential of doing science with children:

> ... it showed me that science teaching and learning how engaging it can be and how exciting it can be for the students and also how lots of different parts of the curriculum can be integrated with it. (Lucy ACU)
> I have a four year old daughter and it's amazing the day to day things that she notices that are science concepts... she'll talk about the weather, ... about how windy it is or about seeds when they fly through the air or ...about dandelions and ...she'll talk about when things float or when things sink ... all of these are teaching moments and I have really never thought about it before (Catherine Melb)

The experience led PSTs to become confident enough to trust the process of inquiry based science teaching and take what they had learned and try it out in other contexts:

> ...I think that the model that we used was really important…to let students learn by doing and asking questions and being given the time to work things out for themselves…I've been able to apply that to other lots of other subjects…even maths (Julie-Anne- Deakin)
> ...seeing all those lessons work so well was the most encouraging part for me and that gave me confidence going into my (teaching) rounds as well… I actually did a science unit just recently ...and that worked really well because I had that experience (Gary ACU)

Clearly the experience of being responsible for planning for a real classroom environment and working with peers/colleagues helped to build their professional identify as teachers and the ability to adapt and modify their plans:

> I'd never really done any planning ...week to week, this is what they've learned this week, that means that next week I've got to build upon that with this. I...and I guess that really helped with having a plan. (Rebecca- Deakin)
> I actually worked collaboratively There were three other Grade 5 teachers so I worked with them for the brainstorming, they talked about stuff that they had done in the past and I was able to bring some of what I had and what I knew, sort of things from my own background so we sort of designed it together. (Catherine Uni of Melb)

The shift from a supervisory to a more collaborative role, which emphasised the supportive aspect of the partnerships was seen to be important for the PSTs to feel they could take a risk and learn:

> ...this has been the only subject where we've been explicitly able to put those things into practice and we've had the okay from our teacher to support us and a mentor

> because... even though we often see great things sometimes it really difficult to put them into practice because the mentor will have a different idea (Julie-Anne- Deakin)
> …so I think you just need to have the support of your mentor completely so that they understand what you're going to do and they're willing to support you. (Emily B-Deakin)

Some of the PSTs called for more emphasis to be placed on collaboration in the partnerships, with opportunities for mentoring by, or feedback from, their tutors or the classroom teachers whose students they were taking for science and university lecturers:

> …the teachers …wander around ... they would stand there and see what we were doing and move on ... if we could have had an opportunity to talk to the teachers more we would have got a better sense of how the students are or ... they could give us hints on what things work with those students or what they're doing in class already (Emily B-Deakin)

Where collaboration and mentoring occurred, the students clearly appreciated it:

> ... the main thing for me was having a role model like (science educator)... I think she made the world of difference because she came in and she was so passionate and she asked all the questions that we were thinking she took the fear out of it and just made it fun. (Catherine Melb)

In terms of feedback on the programs, the PSTs identified some organisational issues concerning the programs that would improve the experience. Of particular note was the opportunity to meet the students and teachers beforehand to get a better sense of the context:

> if we'd had an opportunity to meet with the school and the teacher beforehand and see the classroom that we were going to be using would have made things a lot easier …. (Julie-Anne Deakin)
> ...I met my teacher but I really didn't meet my students, I think maybe an introductory session beforehand even if you just meet them for a couple of minutes and talk about who you are first ...(Gary ACU)

Some PSTs also mentioned how demanding the workload was and suggested that more time was needed to plan and collaborate:

> ...the planning was huge. We had to plan each week and I had to plan with other people ... I had to get together with somebody else and we had to hash out what we all wanted to do and work out a compromise. (Rebecca-Deakin)

Some also mentioned that the length of the sessions they had with students was too short and limiting:

> I think timing was a bit of an issue, the hour long lessons ...was never quite enough time to get everything done …the only other thing was at the start of the term …it would have been nice to get a bit more time at the beginning to get our heads around what's expected and plan a little (Beck-Deakin)

UTAS data analysis - an exploration of the enduring effect of school-based partnerships

The program at the University of Tasmania (UTAS) did not run in 2011-13 due to changes in the science program and other institutional constraints. However, several studies have already been published on the effectiveness of this program (Kenny, 2010; 2012) and these findings reported are consistent with much of the evidence reported above.

The opportunity was taken, for this study, to investigate the impact of the partnership program on the former PSTs who were now teaching science in schools by comparing them

to the former peers who had not undertaken the partnership program in their education studies. A longitudinal pilot study was conducted in which former education PSTs, who had graduated at least two years earlier and who were teaching in schools at the time of the study were contacted and provided with a questionnaire. Those who agreed were followed up for an interview.

As the case study indicates, at the time, the UTAS science education program consisted of a compulsory half science unit in year 2 for all PSTs and the elective (in year 4) in which the partnership program was offered. The UTAS program was the only one of five STEPS programs in which the partnership experienced was offered as an elective. For comparison purposes, an attempt was made to contact both former PSTs who had done the elective and those who had not. From Table 1, of the 41 former PSTs who responded to this questionnaire, 13 (34%) had completed the science elective and 28 (66%) had only completed the compulsory half unit.

Contacting former PSTs was problematic as many had moved interstate, so the response rate was low. An online questionnaire designed for this group was made available so the former PSTs could provide feedback about their recollections of their science education program at UTAS and how it had influenced their teaching after they had graduated. Those who agreed to be interviewed were followed up later. In the discussion below, the response to the eleven Likert scale questions are summarised in Table 4, on a five-point scale ranging from "Strongly Disagree" (SD) to "Strongly Agree" (SA). The interview data is discussed afterwards.

In exploring the Likert results, overall 68% of the former PSTs reported they felt very prepared to teach science after graduating due to their science education program. However, the proportion of the former PSTs who had done the science elective was higher (86%) on this question compared to those who had not done the elective (59%).

While those who said they felt confident to teach science was similar for both groups (71% and 70% respectively), the proportion of those who had done the elective was consistently higher when reporting that they regularly plan sequences of science lessons to develop conceptual understanding (79%-63%); regularly plan and conduct inquiry based science classes (79%-64%) and felt confident to assess student progress in science (79%-62%).

Questions	**Did Science Elective ?**	**SD**	**D**	**U**	**A**	**SA**	**Mann-Whitney U Significance p<0.05**
1. I felt very prepared to teach science after graduating	Yes	0 0%	0 0%	0 0%	10 24%	3 7%	U=106.00 P=0.020 Significant
	No	1 2%	7 17%	4 10%	12 29%	4 10%	
Total	**41**	**1 2%**	**7 17%**	**4 10%**	**22 54%**	**7 17%**	
2. I feel confident to teach science in my classes	Yes	0 0%	0 0%	2 5%	1 2%	9 22%	U=178.50 P=0.905
	No	0 0%	0 0%	5 12%	5 12%	19 46%	

Total	**41**	**0 0%**	**0 0%**	**7 17%**	**6 15%**	**28 68%**	
3. I have regularly taught science since I graduated.	Yes	0 0%	0 0%	1 2%	4 10%	8 19.5%	U=82.5 P=0.003 Very significant
	No	3 7%	3 7%	3 (7%	15 36.5%	4 10%	
Total	**41**	**3 7%**	**3 7%**	**4 10%**	**19 46%**	**12 29%**	
4. I have taught science as one-off activities or as a novelty for students.	Yes	6 15%	6 15%	0 0%	1 2%	0 0%	U=129.00 P=0.190
	No	7 17%	14 34%	1 2%	4 10%	0 0%	
Total	**41**	**13 32%**	**20 49%**	**1 2%**	**5 12%**	**0 0%**	
5. I regularly plan sequences of science lessons to develop conceptual understanding.	Yes	0 0%	1 2%	2 5%	8 19.5%	2 5%	U=147.50 P=0.282
	No	0 0%	9 22%	1 2%	15 36.5%	3 7%	
Total	**41**	**0 0%**	**10 24%**	**3 7%**	**23 56%**	**5 12%**	
6. I feel confident about assessing student progress in science.	Yes	0 0%	0 0%	3 7.5%	8 20%	2 5%	U=161.50 P=0.668
	No	0 0%	5 12.5%	5 12.5%	10 25%	7 17.5	
Total	**40**	**0 0%**	**5 12.5%**	**8 20%**	**18 45%**	**9 22.5%**	
7. I regularly plan and conduct inquiry based science classes.	Yes	0 0%	2 5%	1 2.5%	7 18%	3 8%	U=139.00 P=0.327
	No	0 0%	6	3 8%	14 36%	3 8%	
Total	**39**	**0 0%**	**8 8%**	**4 10%**	**21 54%**	**6 15%**	
8. I regularly integrate science with other curriculum areas.	Yes	0 0%	0 0%	3 7.5%	6 15%	4 10%	U=153.50 P=0.499
	No	0 0%	5 12.5%	3 7.5%	12 30%	7 17.5%	
Total	**40**	**0 0%**	**5 12.5%**	**6 15%**	**18 45%**	**11 27.5%**	

9. I usually teach science as a separate part of my program.	Yes	1 3%	7 18%	3 8%	1 3%	1 3%	U=147.50 P=0.618
	No	2 5%	12 31.5%	2 5%	9 24%	0 0%	
Total	**38**	**3 8%**	**19 50%**	**5 13%**	**10 26%**	**1 3%**	
10. I feel that if I lack science content knowledge, I can learn it along with my students.	Yes	0 0%	4 10%	1 2.5%	6 15%	2 5%	U=164.00 P=0.727
	No	0 0%	6 15%	8 20%	10 25%	3 7.5%	
Total	**40**	**0 0%**	**10 25%**	**9 22.5%**	**16 40%**	**5 12.5%**	

Table 4: UTAS responses to online questionnaire, PSTs

Consistent with these results, the proportion of those who had done the elective was lower when asked if they have taught science as one-off activities or as a novelty for students (93% disagreeing compared to 80%). Both groups reported similar results when it came to integrating science with other curriculum areas (71%-73%) and there were similar levels of disagreement with the suggestion that they teach science as a separate part of their program.

The area where all respondents were equally unsure was in regards to their ability to learn science content. Only a small majority overall agreed they can learn it along with their students (52.5%), with the proportion for the elective group slightly higher (57%-50%).

In analysing the UTAS data statistically, a *Mann-Whitney U test* was conducted due to the low number of respondents. It revealed a statistically significant difference between the two groups for two of the ten questions: questions one and three. For question 1, all 13 PSTs who had done the science elective agreed they felt very prepared to teach science compared to only 57% of those who had not done the elective ($U=106$, $p<0.05$). For question 3, 92% of those who had done the elective said that they have regularly taught science since they graduated, compared to 68% of those who had not ($U=82.5$, $p<0.01$).

While the data clearly shows that the majority of the former PSTs who responded felt very positive about their university science education experiences in the course overall, it is difficult to generalise from these results, given the relatively low response rates. However, as a pilot study, the pattern evident in Table 4 is encouraging as it reveals generally higher responses of the PSTs who had done the elective on a number of important questions. It is possible that only former PSTs with an interest in science responded to the questionnaire, but, even if this was the case, these data indicate that those who undertook the science partnership based elective may have had increased readiness to teach science, compared to those who did not. More data is needed to confirm this statistically. The open text response questions in the survey, however, did provide further insight into and support for these tentative claims.

Twelve former PSTs were contacted for interview, five of whom had completed the science elective and seven who had not. All five who had done the science elective confirmed that they felt very prepared to teach science and all confirmed that they regularly teach science and prepare units of work as opposed to isolated science activities. In reflecting on

their experiences during the science elective, all five who had done the elective described it as the most valuable element of their science education program due to the authentic opportunity it provided to link the theory to their practice:

> We went out into schools and taught. It was the biggest learning experience for me... We were a bit sick of theory and wanted to bring it all back and relate it. ...It was really valuable to me. (Andrew-UTAS)

Interestingly, three reported that they have since taken on science leadership roles in their schools, despite being very early into their teaching careers:

> In my first year out I got given science co-ordinator so I took on a science leadership role and went to network meetings and talked to other teachers....It's taking me in a direction I didn't expect. The experience has increased my confidence...Going in and actually teaching science. (Yvonne-UTAS)

. Two of the five recommended the unit should be part of the program for all students and not an elective, as it allowed them to build their confidence by learning from experience and provided an opportunity to develop skills in areas such as assessing students:

> I think all teachers should do it, it's so vital, especially for when we start assessing science. I did it because I had no confidence… I was scared… but the class gave me confidence ...The classroom experience was good because it was ok to make mistakes, and be supported to learn.. (Pearl-UTAS)

The previous comment is consistent with the results from the survey conducted in the other universities in the STEPS project and underscores the importance of the program focussing on support and mentoring of the PSTs with the support of both the university lecturer and the classroom teacher. The focus on supporting and working with the PSTs rather than supervising encouraged risk taking:

> [We] wanted to be out there and make mistakes that you learn from, so you know what to do when you get employed. (Andrew-UTAS)

> The classroom experience was good because "it was ok to make mistakes, and be supported to learn. (Pearl-UTAS)

Having the two layers of support for the PSTs was also useful for mediation when the teacher and PST relationship was not quite right:

> My teacher was quite directive but the way (my uni lecturer)... taught ...was helpful, he'd come over and ask how it was going and take an interest…I got confidence from his encouragement and he was supportive. (Mary-UTAS)

. By contrast, only four of the seven interviewees who did not do the science elective said they regularly prepare science sequences and said they felt very prepared to teach science. Two of these former PSTs pointed to other aspects of their teacher education course, such as positive science teaching experiences during the practicum, as influential on their attitudes to teaching science:

> In my 3rd year Prac the teacher I had enjoyed teaching science and we did a fair bit of science and it built my confidence. Watching how other people do it gives you confidence. That combined with the unit we did gave me enough confidence. (Rosemary-UTAS)

Others noted exposure to exemplary resources during their course, such as *Primary Connections*, was very beneficial, which is consistent with other research (Appleton, 2003; Cooper, Kenny & Fraser, 2012):

> Primary Connections methodology was good... People won't teach it if they don't feel prepared. Science should take up a bigger part of the course. (John-UTAS)

Another former PST from this group described her tendency to avoid science while at the same time holding a desire to do more because of the positive response from the children when they do science:

> ...I've tended to avoid science a bit in class. I've done some trialling with the kids, but it's not always good!... I know the children enjoy it and if there was some science PL I would probably go for it. (Bellamie-UTAS)

The UTAS feedback reflects many of the same themes as those from other universities including the value of putting theory into practice, and the importance of mentoring support for the PSTs. The data also pointed to other supportive aspects of the teacher education program for building confidence to teach science, including opportunities provided in practicum to teach science and exposure to good science teaching resources.

As a cohort of former PSTs who went on to be practising teachers, the results emphasise that an authentic science teaching experience had an impact on their confidence and preparedness to teach science. Further research is needed as part of the STEPS project to explore if there is any difference for individuals who gained their science teaching experience through a specifically structured partnership program, compared to those who gained it through the practicum, but the authors contend that the data presented here indicates the partnership approach may provide a more consistent and reliable means of building confidence to teach science. This is also supported by the literature which indicated that relying on the practicum to provide science teaching experiences does not necessarily provide the science pedagogical support for all the PSTs. A further unexpected but positive outcome indicating the potential of the partnership program was the willingness of some those who did the elective to take on science leadership roles despite being early career teachers.

The authors further contend that while this study occurred within a science education context, it is reasonable to suggest that a similar approach may build confidence of PSTs in other areas of the curriculum.

Conclusions

This paper explored the preliminary data of the PST experience of partnerships based courses to teach science in schools in the five different universities Involved in the STEPS Project. While the results of this preliminary analysis must be interpreted with caution, because it is based on a small proportion of students who self-selected to return the data, it is encouraging that the preliminary results are consistent with earlier research. On primary PSTs as they learn to teach science. With this caveat, the findings in this preliminary study indicate the partnership approach can have a powerful influence on the readiness of PSTs to teach science.

The PSTs reported greater confidence to teach science manifested in improved science teaching and planning skills and a greater understanding of how students learn science. PSTs showed some evidence of transferring their confidence into other curriculum contexts and into their own classrooms once the graduated. Indications are that the time dedicated to teaching science in the partnership programs was beneficial to the confidence of the PSTs. The vast majority of PSTs reported increased confidence with a range of generic teaching skills as well as their ability to plan and deliver effective science lessons. A key aspect of the programs for the students was the opportunity, in an authentic teaching situation, to put their science learning theory into practice. An important aspect of the partnerships, reported by PSTs, which is consistent with earlier research, was the opportunity to try out their ideas with the support of a mentor teacher.

Although there were identifiable structural differences in the programs, there were many consistencies in the experiences of the PSTs across all universities. PSTs also suggested improvements to organisational aspects of their programs such as increased time with students, more explicit support from mentors and tutors and the opportunity to meet the students before they begin teaching. PSTs expressed the desire to be able to discuss their lessons with the classroom teachers, both before and after their teaching experiences and to reflect on their experience.

Further research flowing from the Project will explore in more detail the strengths, affordances, and successes of the five school-based approaches and will try to identify key the characteristic that apply across all sites and programs, including: the nature of the partnerships between the schools and universities; the value of the partnership approach from the perspective of teachers and principals. The STEPS team will also undertake a more detailed longitudinal study that will look more deeply at the impact of the programs on the teaching practices of PSTs once they graduate and explore the application of this approach to other areas of the curriculum.

The ultimate aim of this project is to develop key principles for establishing and maintaining school-based partnership approaches that can guide universities and schools wishing to develop such relationships in future by providing an *Interpretive Framework* that is informed by this research and validated by other teacher educators.

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