Out in the field: Examining the role of school-based experiences in preparing primary pre-service teachers as confident and competent teachers of science

Journal:	*International Journal of Science Education*
Manuscript ID	TSED-2019-0058-A.R2
Manuscript Type:	Empirical Research Paper
Keywords:	pre-service teachers, science, technology, society, elementary/primary school
Keywords (user):	school-based experiences

Out in the field: Examining the role of school-based experiences in preparing primary pre-service teachers as confident and competent teachers of science

At a basic level, it makes sense to involve pre-service teachers in school-based experiences (SBE) as a way of preparing them for the teaching profession. Little is known, however, about how SBEs might prepare pre-service teachers as future teachers of particular learning areas. The purpose of this study was to explore the impacts and highlight the implications of school-based experiences on primary pre-service teachers' confidence and competence in relation to the learning and teaching of science. Detailed questionnaires were completed by 146 primary pre-service teachers enrolled in a science education curriculum and pedagogy unit; a face-to-face core unit in either their undergraduate and postgraduate initial teacher education (ITE) program. In making further sense of this snapshot, 18 pre-service teachers participated in one of four focus group interviews to share their insights of this experience. Key findings revealed that SBEs have an important role to play in breaking down barriers to the formation of a science learner/teacher identity and provide a lived experience of science learning/teaching that is ultimately critical in empowering primary pre-service teachers to teach science in the future. Overall this project clarified the value of incorporating SBE into teacher education, particularly in relation to the learning area of science, but raised questions about this approach could be innovated to ensure equity and accessibility for pre-service teachers regardless of mode of study.

Keywords: school-based experiences, science teaching, initial teacher education, confidence, competence

Introduction

The quality of teachers and of teacher education remains a subject of ongoing public debate, both in Australia and internationally (Gauthier & Dembélé, 2004; Bahr & Mellor, 2016; Rickards, 2016; Education International, 2017). Increasingly, research suggests that one way to improve the confidence and skills of both pre-service and graduate teachers is through opportunities for more extensive professional experiences in schools (Watson, Hay, Hellyer, Stuckey, & Woolnough, 2008). This proposal includes moving beyond relying solely on the

school placement model as an only source of professional experience that pre-service teachers are exposed to (see Author, 2018a). In Australia, over the past decade, several government inquiries have urged initial teacher education (ITE) providers to develop strong and enduring links with schools to promote authentic professional learning experiences for pre-service teachers (Jones, 2008; Rowley, Weldon, Kleinhenz, & Ingvarson, 2013).

In more recent times, the recommendations identified by the Teacher Education Ministerial Advisory Group (TEMAG), known widely as the TEMAG report in Australia, (Craven et al., 2014) in regards to professional experience have sharpened this focus. In brief, the TEMAG recommendations cited the need to ensure timely, high-quality, structured and supported practical experience for pre-service teachers to support them in developing the knowledge and skills they require to be effective future teachers. Similarly, pre-service teachers have echoed this call with their desire for more direct, practical experiences in classroom settings as part of their ITE (Moseley, Ramsey, & Ruff, 2004).

Specifically, this study intended to examine the impact of school-based experiences (SBE), embedded as a meaningful part of coursework in an initial teacher education program based at a large university situated in an Australian capital city, on primary pre-service teachers' levels of confidence and competence in teaching science. The focus of this paper was determined by the following research question: How do school-based experiences contribute to the development of primary pre-service teachers' confidence and competence as future teachers of science?

Literature review

Conceptually, this research is informed by three key areas: confidence, competence and school-based experiences. These areas will be explored in relation to primary pre-service teachers learning to teach science.

Confidence in learning to teach science

The early 1990s sparked a series of seminal research papers in primary science education focusing on pre-service teachers and the impact of their confidence levels in both science and science teaching on their subsequent relationship with this learning area (Yates & Goodrum, 1990; Skamp, 1991; Appleton, 1992). A concern with this research agenda has been its potential deficit focus highlighting what is not happening in primary science education in ITE programs? rather than exploring the possibilities and successes that primary pre-service teachers can experience when exposed to the right conditions (Author, 2012). Despite this concern, the reality in terms of classroom practice remains undiminished. A key barrier to positive and productive engagement with science education for many primary pre-service teachers is their own confidence levels (Appleton, 1995). These concerns have been identified as stemming from a range of areas, including not participating in formal science learning experiences for a period of time, less-than-optimal experiences of science in secondary school, and/or not strongly connecting with science as part of their own identity (Harlen & Holroyd, 1997; Tosun, 2000). In relation to science education, however, these factors run counter to commonly-held beliefs that primary pre-service teachers' lack of confidence is largely attributed to their limited subject matter knowledge (Appleton, 1995; Holroyd & Harlen, 1996), which suggests that self-efficacy and self-image are major influences (Cartwright & Atwood, 2014). While relatively little research has been undertaken in this field in more recent times (e.g. Anderson, Bartholomew & Moeed, 2009), confidence remains a significant blocker to primary pre-service teachers' participation in science learning and identification as a teacher of science (Author, 2018b). This outcome suggests that confidence remains an area worthy of examination.

Competence in learning to teach science

Compared to studies in the area of confidence, research exploring primary pre-service teachers' competence in teaching science is relatively emergent (e.g. Hudson, 2014; Bannister-Tyrrell et al., 2018). This change in research focus potentially reflects a shift from focusing on individual's personal characteristics (e.g. their own levels of confidence) to better understanding individual's skills and knowledge (e.g. knowledge of how to teach), which aligns with moves in educational policy and curriculum to integrate 21st century learning skills and capabilities (Larson & Miller, 2011). The notion of competency in relation to current studies has predominantly focused on pre-service teachers' knowledge of the field, in this case science, both conceptually and pedagogically (e.g. Alake-Tuenter, 2014; Naylor, 2015). Therefore competency to teach in science is not simply about having an adequate knowledge of science, but being knowledgeable about how to teach science effectively to support students' science learning which connects with developing an understanding of science pedagogical content knowledge (Bannister-Tyrrell et al., 2018). Essentially, pre-service teacher competency has a direct influence on the quality of the science education experience and the subsequent learning outcomes achieved by students (Hudson, 2014), whereas pre-service teacher confidence, while still influencing learning outcomes, is more likely to impact on the frequency and nature of the science teaching that occurs (Anderson et al., 2009). Given these understandings of competency and its role in practice, it is perhaps not surprising that there has been significant research into the impact of various innovations embedded in ITE programs and how they equip pre-service teachers with the knowledge required to be effective future teachers. Recent research has investigated initiatives like peer teaching (e.g. pre-service teachers delivering science activities and lessons to other pre-service teachers) and the use of inquiry-based approaches (e.g. use of the *Primary Connections* program (Australian Academy of Science, 2019) and the 5E model of inquiry (Bybee et al., 2006) in primary science education courses in terms of their influence on pre-

service teachers' science teaching competencies. Positive outcomes from these studies, such as increased pedagogical knowledge of teaching science (Hudson, 2014) and quality approaches to inform practice (Alake-Tuenter, 2014), suggests that competency remains an important area of research if we are to ensure that quality science education practices are enacted in all primary school classrooms.

The role and potential of school-based experiences

Hybrid spaces have been noted as allowing more broadly for the meaningful connection between coursework and field experiences (Zeichner, 2010). In considering this this paradigm shift, SBEs would play a significant role (Darling-Hammond, 2006). SBEs are situated within the workplace learning agenda and move beyond the historical practicum model to enable pre-service teachers to experience more frequent and targeted experiences in the classroom (Hill, 2008). SBEs can be broadly defined as experiences that provide opportunities to directly and actively engage with learning and teaching in school settings though in a different way than provided by the more usual practicum opportunities (Kenny, 2009; Author, 2018b). SBEs tend to take place over shorter periods of time, often with pre-service teachers collaborating in small groups and with a particular or more focused purpose in mind (Author, 2018b). Some ITE programs nationally (Watson et al., 2008; Hudson, 2010; Kenny et al., 2014) and internationally (see Hanuscin & Musikul, 2007; Moseley et al., 2004) have incorporated SBEs into their approaches to support teaching practices in general as well as for science teaching specifically. Moseley and her colleagues (2004) discovered that pre-service teacher participation in their version of SBEs was beneficial in the construction of pedagogical content knowledge (PCK) related to science teaching and learning, but also fostered positive attitudes towards science and science teaching. Likewise, Hudson's (2010) research showed that SBEs facilitated authentic teachable moments that enabled pre-service teachers to become more confident in their role and identity as a teacher as well as build their

knowledge and skills in relation to both science and science education. This project builds on this previous research by examining the role of SBEs in preparing primary pre-service teachers for science learning and teaching in the Australian context. Findings from this research have been previously reported, but were through the lens of the teacher educator and their experiences of adopting and adapting this approach as part of their own practice (see Author, 2018a).

Methodology and methods

Mixed methods research represents an approach that involves collecting, analysing and interpreting both quantitative and qualitative data as a way of investigating the same underlying phenomenon (Creswell & Plano Clark, 2017). Combining philosophical assumptions with methods of inquiry, this approach offers multi-faceted understandings of research problems that are corroborated and triangulated by taking advantage of the use of different vantage points, methods and techniques (Tariq & Woodman, 2013). Mixed methods research was deemed appropriate for this study as a way of firstly challenging assumptions about the value of science-focused SBEs (using a quantitative data set) before uncovering in-depth insights into what this perceived value is and why (supported by a qualitative data set). In keeping with this rationale, a sequential explanatory design was used; an approach which collects and analyses quantitative data before gathering and interpreting qualitative findings (Shorten & Smith, 2017). This design enabled the contextualisation of the quantitative findings as well as the opportunity to delve further any unexpected or unexplained results from the quantitative data set. This section goes onto explain some of key contextual features and identify the participants in this study, then describes the data collection and analysis processes employed.

Context and participants

The 146 participants who engaged in the quantitative components of this study were enrolled in either one of two compulsory primary science education curriculum and pedagogy units. A total of 206 pre-service teachers from across the two units formed a convenience sample (Lavrakas, 2008) and were invited to participate in this study with nearly three-quarters (71%) voluntarily opting in. These units comprised of 10 three-hourly workshops over a semester with five taking place in a primary school setting and the other five at the university. The SBE involved the pre-service teachers working in pairs to implement a sequence of hour-long science activities with small groups of students (between three to five) from Prep (the first formal year of schooling) through to Year 6 (the final year of primary education). Before and after their time in the classroom, the pre-service teachers were involved in their own science learning experiences, working collaboratively to prepare lessons, and debriefing their experiences. One primary science education unit was for pre-service teachers enrolled in a Bachelor of Education (Primary) program (n=50) and the other for pre-service teachers in a Graduate Diploma of Education (Primary) program (n=96). In terms of this study, the key difference between these two programs was that the Graduate Diploma required a previous Bachelor level qualification for entry, whereas the Bachelor accommodated secondary school leavers and those without previous tertiary study. Both units within these programs had school-based experiences at their core and took place across three primary schools located within a 15-minute drive of the university campus. See Appendix 1 for a detailed snapshot and description of the demographic and contextual features of these cohort.

Of these 146 participants, 18 volunteered to engage in the qualitative component of this research. Specific demographic information was not gathered, other than 13 participants were from the Graduate Diploma of Education (Primary) and 5 were from the Bachelor of Education (Primary).

Data collection

Survey responses informed the quantitative data set for this research, whereas focus group interviews shaped the qualitative data. In both cases, the author was not directly involved in the data collection processes because of their role as teacher educator in the two primary science education units. To avoid any potential bias or imbalances, a research assistant facilitated this aspect of the study.

146 pre-service teachers completed a pen-and-paper survey at the start and end of their science education unit to capture their perceived levels of confidence and competence to teach primary science pre- and post-engagement in a series of school-based experiences. This approach was used as it is effective in gathering baseline insights from large cohorts (Davis, Baral, Strayer, & Serrano, 2018). Rating scales and rankings were used by the participants to assess their own perceived levels of confidence and competence to teach science in comparison to other key learning areas as well as in particular science content areas and with specific science education pedagogies. These scales were developed by the author rather than being based on or adapted from existing tools and were intended to be a tool to gather baseline data to provide a holistic overview of perceived confidence and competence levels. Unique identifiers were developed to ensure participants' anonymity was protected and each survey took about 15 to 20 minutes to complete. It is acknowledged that the self-reporting aspects of this study could be viewed as limiting and problematic because in using this approach participants may overstate their experiences, report in ways that establish them as 'good', or share what they think researchers would want to know. Research does suggest, however, that self-reporting is an effective approach to gathering opinions in ways that are replicable, reliable and quantifiable (Khatri, 2015). As the surveys consisted of 20 questions, many with multiple components to consider, they have not been appended to this paper.

Interviews play an important role in qualitative research as they serve as a rich source for exploring people's attitudes, beliefs, and insights into experiences (Cohen, Manion &

Morrison, 2007). Focus group interviews (FGI) tend to be a more naturalistic data collection tool as they provide "a more natural environment than that of individual interview because participants are influencing and influenced by others - just as they are in real life" (Casey & Kueger, 2000, p.11). Interviews allowed the research assistant to discuss with a group of participants their encounters of school-based experiences and their perceptions on how this may have impacted (or not) on their confidence and competence to teach science. With this purpose in mind, a FGI format was an appropriate data collecting choice as participants were encouraged to not only respond to the research assistant, but interact with each other to support the emergence and discussion of a range of perspectives (Dilshad & Latif, 2013). The FGI questions were developed to gain insights into and understand the lived experiences that emerged from the survey data. Four FGI were conducted with between two to six participants in each group (18 participants in total). Each FGI was about 30 to 45 minutes in length, conducted by the research assistant in a meeting space at the university, at a time convenient to the participants, and was audio-recorded before being transcribed. See Appendix 2 for the full list of interview questions used to inform the FGI discussion.

Data analysis

The two data sets were analysed in keeping with their different research traditions. The quantitative data from the pre- and post-surveys were created through author created rating scales (e.g. Likert) and rankings. Descriptive statistics were applied to generate frequencies of responses and percentages, which provided an adequate overview of the findings and a number of comparison points. Two non-parametric statistical tests, the Wilcoxon signed-rank and Mann-Whitney U, were used to assist in determining the level of influence of the SBE on individuals as well as between cohorts respectively. While more detailed statistical examination could ascertain in more depth the statistically significance of the SBE as an intervention of sorts, the survey tools are of an uncorroborated nature and therefore could

skew the subsequent results. This lack of wide ranging quantitative statistical rigour is acknowledged as a potential limitation of this study, but the intention of using a mixed methods research approach was to provide an overview of the cohort. The qualitative data from the FGIs resulted in a set of interview transcripts which were scrutinised by the author using the following four steps by way of thematic analysis. Before detailing the grounded approach to analysis, it is important to note that while the FGI discussion included several questions that the following two became the focus of this research paper.

- What are the aspects of the SBEs that helped you in developing confidence and competence in teaching primary science?
- What do you think is the single most important way that the SBEs impacted on you as a teacher and your perceptions of science teaching and learning?

These questions were chosen because they best connected with the research question framing this particular paper and had the potential to offer meaningful insights in this context. The sense making process involved the following steps as detailed below.

1. Reading the transcripts with a particular focus on the two questions outlined above and using note taking to identify key ideas in direct response to the research question;
2. Re-reading the transcripts to articulate the key themes that would assist in organising similar ideas into distinct groups;
3. Returning to the literature to further clarify these themes by looking for existing similarities and differences in previous research findings;
4. Re-engaging with the transcripts to locate quotes that would exemplify these themes in an articulate and coherent way as well as represent the voices of a range of participants; and
5. Scanning the transcripts a final time in search of disconfirming evidence that could be used in juxtaposition to the emergent themes.

The intention of this approach was to showcase the range of emergent themes and their subsequent impact on the participants' lived experience of SBEs rather than identify the frequency of these ideas and rank the themes in order of prevalence. This level of detail was not required to respond in an informed and insightful way to the research questions. While a large number of themes did emerge (15 in total), they were maintained rather than reduced to retain a nuanced understanding of the participants engagement and interaction with SBEs.

From this process, two outcomes eventuated. Firstly, the responses from the survey relevant to the research question were summarised to provide an overview of the impact of SBE on pre-service teachers' confidence and competence in teaching science. Secondly, the FGI drilled down to reveal themes that are organised around two key interview questions.

Findings

The findings for this study are presented in two parts. Part 1 is drawn from the quantitative survey data and provides a snapshot of the participants' perceptions of how undertaking SBEs contributed to the development of their confidence and competence as future teachers of science. Part 2 digs deeper into these perceptions by identifying the key factors inherent in SBEs that emerged from the qualitative focus group interviews as supporting and/or hampering the development of these primary pre-service teachers' confidence and competence to teach primary science.

Part 1: Snapshot of the impact of school-based experiences on confidence and competence to teach science

At the start and conclusion of the school-based science education units, the 146 participating pre-service teachers rated their confidence and competence to teach science on a scale of 1 (not at all) to 10 (very). The frequency of responses were recorded (for each cohort and combined) and are reported in Table 1 below as percentages to provide an overall sense of

the emergent trends. The bolded figures in the table indicate the highest frequency of response for each condition and cohort.

Table 1. Levels of confidence and competence to teach science before and after participating in SBEs

	CONFIDENCE					
	Bachelor of Education cohort (n=50) %		**Graduate Diploma of Education cohort (n=96) %**		**Totals for whole cohort (with percentages) (N=146) %**	
RANKING	*Before SBE*	*After SBE*	*Before SBE*	*After SBE*	*Before SBE*	*After SBE*
1 (not at all)	8	0	3	0	5	0
2	18	0	5	0	10	0
3	**22**	6	8	4	13	5
4	14	6	11	2	12	3
5	12	10	**27**	6	**22**	8
6	4	20	18	14	13	15
7	8	**30**	20	31	15	**31**
8	12	18	7	**36**	8	30
9	0	6	1	4	1	4
10 (very)	0	0	0	1	0	1
No response	2	4	0	2	1	3
COMPETENCE						
	Bachelor of Education cohort (n=50) %		**Graduate Diploma of Education cohort (n=96) %**		**Totals for whole cohort (with percentages) (N=146) %**	
RANKING	*Before SBE*	*After SBE*	*Before SBE*	*After SBE*	*Before SBE*	*After SBE*
1 (not at all)	6	0	0	0	2	0
2	**18**	2	4	1	9	1
3	16	6	7	3	10	4
4	12	8	9	3	10	5
5	12	18	**27**	14	**23**	15
6	6	**24**	19	15	14	18
7	14	20	18	**34**	17	**30**
8	8	12	12	19	10	16
9	2	6	4	7	3	7
10 (very)	0	0	0	1	0	1

No response	6	4	0	3	2	3

The overall trend emerging from this data is that after the SBE both cohorts experienced an increase in their confidence and competence to teach science to primary school students. This claim is supported statistically by the findings from the Wilcoxon signed-rank tests, which identified highly significant positive change following the SBE ($p = 0.000$ across the four conditions). In terms of confidence, there was a positive difference identified for over 80% of participants in both the Bachelor of Education (84%) and Graduate Diploma (81%). Equally, the majority of both cohorts, 72% and 64% respectively, experienced a positive difference in their perceived levels of competence following the SBE.

In terms of confidence, the Bachelor of Education participants' levels of confidence were skewed towards low levels of confidence to teach science and increased to feeling more confidence with experience and exposure to science learning and teaching in the classroom. The Graduate Diploma participants were clustered around already feeling somewhat confident to teach science before any time in schools potentially due to previous experiences with science, but did receive a boost in their confidence levels. The findings in relation to competence were similar to the patterns noted above. The Bachelor of Education cohort identified as having very low levels in terms of how they perceived their competence to teach science, but these did shift towards feeling somewhat more competent. While the Graduate Diploma cohort experienced is shift in their sense of competence, they started feeling somewhat competent which may be connected to their previous tertiary and professional experiences. The Mann-Whitney U tests reveal some nuances between the two cohorts. While there was no statistically significant difference ($p = 0.252$) between the two cohorts in relation to confidence, there was a notable difference ($p = 0.036$) when competence was considered. A skew towards the Bachelor of Education participants experiencing a more

significant change in their levels of competence to teach science was also reflected in the frequencies detailed in Table 1 and the findings from Wilcoxon signed-rank tests above.

For the entire cohort in relation to both confidence and competence, the findings before the SBE are nearly like a bell-curve with participants spread out along the continuum. After time in the classroom, findings clustered around feeling somewhat confident and competent to confident and competent to teach science with no-one identifying with the rating of not at all or very low.

Part 2: Digging deeper into the impact of school-based experiences on pre-service teachers' confidence and competence to teach science

This section investigates the impacts of SBE further in relation to confidence and competence to teach primary science through the 18 participants' responses to two questions addressed as part of the four focus group interviews. They form the sub-headings used below and illustrative quotes have been drawn from the data to represent the key themes emerging in response to each question. In identifying appropriate quotes for this paper, the focus was on identifying FGI responses that (i) captured the essence of how the particular theme was being referred to across the groups, and (ii) were articulate and coherent. While there were certainly nuanced components to the participants' responses connected in relation to each theme, decisions were made to maintain a focus on insights that would best assist in answering the research question shaping this paper and to work within the parameters of this context.

*What are the aspects of the SBEs that helped you in developing confidence and competence in teaching primary science***?**

From the analysis of focus group interview transcripts, the following six themes emerged that capture the components of SBE that the participating pre-service teachers identified as most contributing to the development of their confidence and competence in primary science education.

- Working with others;
- Support from university teaching staff;
- First-hand experience as a science learner;
- Working with small groups of children;
- Being in the deep end; and
- Network of support.

Illustrative quotes are shared below in Table 2 before being unpacked in detail below.

Table 2. Pre-service teacher quotes illustrative of the aspects of SBE that developed confidence and competence in teaching primary science

Quote number	Quote from pre-service teacher	PST identifier
Working with others		
1	Having the other students in your team so you weren't alone. And if you'd gone into one of those situations where, you know, [the school students] ask you a question and you don't know the answer then your team member would be able to help you. And just to be able to bounce ideas and strategies really helped me to learn a lot.	Pre-service teacher (PST) 4, Focus group (FG 2
Support from university teaching staff		
2	For me, it was just the actual support from the teaching staff. We saw you guys walking around and felt monitored in a safe way. So, if I was doing something really wrong, someone would step in and say, "Look, hang on …". I didn't feel like I was left out in the wilderness in charge of these students. I felt like there was good enough sort of, you know, authority above me to step in if I was completely seriously missing something. I felt reassured having you three there just to keep an eye out on things.	(PST 6, FG 2)
First-hand experience as a science learner		
3	I liked having the sessions beforehand. So, if we were doing kitchen science [with the school students], we did it ourselves first. By doing all those different activities, just for ideas, it's given me more confidence because I could see how simple all the ideas were and what you could extrapolate from them, which was good and to see that you don't need expensive equipment and stuff.	(PST 12, FG 3)
Working with small groups of children		

4	It gives you ideas for ways of teaching a small group and if you can cater for a small group, you can adapt those ideas to a larger group. For example, in our first lesson, engagement, we got them to outline each other and draw all this stuff. I would probably adapt that section and put them into pairs, so a pair can draw just one and work together and talk. So instead of a teacher talking and putting ideas down, the kids can talk about what's in the body and put it down. It's still scaffolding occurring because it's two kids. I think it's more adapting the way we do things and the teaching approach to suit the kids we've got in the class.	(PST 16, FG 4)
Being in the deep end		
5	Being thrown in the deep end at beginning of course was an important experience for me. It was about being in there and it was getting involved. It was about working with the kids and having something to reflect on rather than other units where we haven't really been reflecting much at all. There's no experience there to reflect on.	(PST 11, FG 3)
Network of support		
6	It's good to have a network at the start and to build your confidence slowly from the start. I have confidence now to be able to go out and teach science next year on placement. I think with everything it's always good to have a network at the start to build up. It's like when we first go out as teachers, you will have another teacher in the school who is there to help us and guide us through our first year, just to help us understand. I also think everyone needs a good support system – in this case, peers, other teachers, students, and uni staff - to learn.	(PST 15, FG 4)

Emerging from these findings is the notion that support is a critical underpinning factor in increasing primary pre-service teachers' confidence and competence to teach science. The participants identified support being embedded with their SBE in three forms:

1. Through working directly with their peers in small groups (e.g. team teaching) to develop and implement science learning experiences with school students (see Quote 1);
2. Through the guidance provided to them from the science education teaching staff at the university (see Quote 2); and

3. Via a wider support network that included peers (not only their team teaching colleagues) and teaching staff, but also in-service teachers and the school students themselves (see Quote 6).

Through these various forms of support, the pre-service teachers were empowered to not only undertake the teaching of science in a controlled environment but to actually take control of the learning experience and develop a sense of ownership for student outcomes. While not the same as complete autonomy with a whole class of students (e.g. 25 to 30 children), it was a small and supported step in a positive direction.

The criticism that the SBE approach does not emulate the reality of teaching science to a whole class of students is certainly accurate, but misses the intention of the experience. Many of the participants recognised this nuance as being a form of scaffolding. Working with small groups of students (see Quote 4) further supported them in developing their confidence and competence as it provided a low risk way of venturing into a learning area that induced anxiety and uncertainty for many. Despite this small-scale teaching experience, there was still a sense from participants that the SBE provided them with an enormous challenge. This required the pre-service teachers to access their personal resources and call on the support of other to rise to this task (see Quote 5). This notion of 'being in the deep end' encapsulated more than the act of teaching a small group of students, but the whole process that goes around the implementation of an activity (e.g. developing pedagogical skills, enhancing own content knowledge, working in an unfamiliar context, etc.).

A final factor that assisted the participants in building their confidence and competence around science education was the structure of the SBE, which required them to have a lived experience of a range of science activities as a learner before enacting them as a teacher (see Quote 3). This allowed the pre-service teachers to understand how the activity

would work and reveal the joy in the task from the perspective of a student, which made it easier to implement and convey when engaging with the activity from a teaching perspective.

What do you think is the single most important way that the SBEs impacted on you as a teacher and your perceptions of science teaching and learning?

From the analysis of focus group interview transcripts, the following nine themes emerged that capture the key impacts of SBEs on participating pre-service teachers' identity and understandings of being a future teacher of primary science.

- Excitement for teaching science;
- More student-centred;
- Removal of fear;
- Science teaching seems more achievable;
- Science is relevant;
- More confident about being a primary teacher in general;
- Importance of hands-on learning experiences;
- Better sense of what science is and how it could be taught; and
- Working collaboratively.

Illustrative quotes are shared below in Table 3 before being unpacked in detail below.

Table 3. Pre-service teacher quotes illustrative the impacts of SBEs on identity and perceptions of teaching science

Quote number	Quote from pre-service teacher	PST identifier
Excitement for teaching science		
7	Just gaining more confidence made me more excited about science. Because I've never really come across it in classroom before, [the SBE] sort of made me more anti-science to excited about science.	PST 2, FG 1
More student-centred		

8	Now I feel I give the kids more sway in what they want to learn about. I know we still have to meet curriculum needs, but I see that you can do more of it during the day without having to plan overly big activities with lots of materials and all that kind of stuff.	PST 1, FG 1
	Removal of fear	
9	[This experience] took fear away completely about teaching science. I'm still not an expert, but feel like I can do it.	PST 9, FG 3
	Science teaching seems more achievable	
10	It seems more achievable to me now to put science into practice in the classroom.	PST 10, FG 3
	Science is relevant	
11	Not everyone is going to want to be the stereotypical scientist in a lab coat but that doesn't make it any less important to know. A lot of what gets covered in primary science is going to be relevant all the students regardless.	PST 3, FG 2
	More confidence about being a primary teacher in general	
12	The confidence and competence and not only in the science. Now I feel I know a lot more about science than I did coming in but also being able to transfer that to and relate that to other teaching experiences we are going to have on placement. It has given me a lot of confidence to be able to plan lessons in other learning areas.	PST 5, FG 2
	Importance of hands-on learning experiences	
13	I've realised how important it is to have hands-on experiences to get students involved and keep them focused. In SOSE (Studies of Society and Environment), we've had far less guidance on how to teach this learning area and felt that lesson [I implemented] didn't work. I realised how the hands-on approach really worked for science and could be applied to teaching in other areas too.	PST 8, FG 2
	Better sense of what science is and how it could be taught	
14	Just the narrowing of the very broad definition of science in the curriculum has made a huge difference because it is not stated very clearly what aspects of science they want me to teach. All they say is that they want the children to be aware of things … And being able to see how you can do that with literacy has been hugely beneficial.	PST 14, PG 4
	Working collaboratively	
15	We had some problems but it all got sorted out. I found once we sat down as a group and talked about everything, it became a really good work environment where we all bounced off each other, we let each other speak and we were learning off the kids because we all got on heaps better. I think it comes down to if you've got good communication, things will always work out better in a group. It was good to do that because especially in a school you're always going to be working with other teachers and some you may not get along with, some you will get along with, so it's good to learn to work with other people.	PST 17, FG 4

These findings suggest that the participants engagement with and participation in SBEs had a wide-ranging impact on their sense of self as a teacher as well as what it means to be a teacher more generally. These impacts varied from the being about personal growth to focusing on student learning as well as shifted between science teaching specifically and what it means to be teacher more generally.

For some, the impact of the SBE was having a greater understanding of the conditions that contribute to quality learning in science education. For example, the incorporation of student-centred approaches into science teaching practices (see Quote 8), the relevance of science education to all learners (see Quote 11), and the importance of hands-on learning experiences to consolidate science understandings. For others, it was the overcoming of hurdles that alienated them from science and/or the teaching of science. The SBE either generated an excitement in them from experiencing science learning and teaching in a positive light (see Quote 7) or reduced the sense of fear they experienced from the thought of teaching science (see Quote 9).

The SBEs influenced how some of the participating pre-service teachers viewed themselves as future teachers of science namely through a sense of that act being viewed as more achievable (see Quote 10), but also through an enhanced understanding of science content and pedagogy (see Quote 14). Likewise, the SBE provided a more in-depth understanding and lived experience of the work of a teacher. This occurred through the development of a greater sense of confidence in ability to teach (see Quote 12) and by better understanding how to productively work with other teachers (or pre-service teachers in this instance) for improved student outcomes.

Discussion

In making sense of the findings, this section provides insights that are framed around the research question shaping this study: How do school-based experiences (SBEs) contribute to

the development of primary pre-service teachers' confidence and competence as future teachers of science?

Overall contribution

It is worth noting, firstly, that the snapshot provided by the quantitative data revealed the trend that the SBEs did make positive in-roads into shifting primary pre-service teachers' perceptions of their own levels of confidence and competence to teach science. This shift was more obvious for the Bachelor cohort than the Graduate Diploma cohort, which could be attributable to a variety of factors, such as background, education and attitudes. In particular, the range (or lack) of personal and professional experiences connected with science, in this instance, prior to entering an ITE program may have been an influential factor characterising the two groups (Naylor, Campbell-Evans, & Maloney, 2015). In drilling down further, the findings show that the Bachelor pre-service teachers experienced a larger change in their perceived competence to teach science, whereas it was in perceived confidence levels for the Graduate Diploma students. While on the surface this difference could be connected with differing motivations, other research (e.g. Hogan, Reid, & Furbish, 2017) has shown that despite these different entry points motivations driving decisions to become a teacher were generally remarkably similar. Better understanding the nuances underpinning these cohort differences warrants further research.

The qualitative data from this study does, however, reveal some key insights into *how* SBEs influence primary pre-service teachers' sense of their own capabilities regarding the learning and teaching of science, which goes some way to addressing the research question. Broadly, the impact of the SBE in this context was two-fold: (i) it broke down barriers to enable pre-service teachers to identify as a science learner and teacher, and (ii) provided targeted and supported lived experiences, which created a new point of reference for the pre-

service teachers as future teachers of science. Each of these impacts are further teased out below.

Breaking down barriers to science learner/teacher identity

Confidence and competence were identified as key threads to be examined in detail through this research. These threads are important as they are also significant factors contributing to the ways in which teacher identity is shaped and enacted (Mayer, 1999; Jones, 2008). The SBEs, in this context, played an important role in shifting the pre-service teachers from a place of fear and uncertainty about teaching science, which is how a lack of confidence and competence is enacted in practice, to acknowledging feelings of excitement, relevance and achievability about being a future teacher of science. While the SBE placed them in the 'deep end', first-hand experiences of science as both a learner and a teacher (an area examined in more depth in the following section) enabled a re-examination of the barriers that many had constructed in relation to science education. While this study focused on improving confidence and competence by way of influencing identity development, recent research from Chen and Menshah (2018) discovered that supporting primary preservice teachers' development of a science teacher identity was a proactive way to address the challenges posed by low self-efficacy, self-confidence, and pedagogical content knowledge in science. Despite coming at the same concern from different angles, both studies identified meaningful science SBE as being critical to addressing these concerns. These opportunities provide a supportive and structured environment, which at its core enabled pre-service teachers' existing notions of what science learning and teaching may or may involve to be challenged and changed. By having a scaffolded way to interact with and enact primary science learning and teaching in a meaningful and authentic way, the SBE provided participants with a safe space and a low-stakes way (e.g. not being assessed) to experience success and failure in the classroom. It is worth noting that the impact of the SBE was not only about the development

of a science learner/teacher identity, but teacher identity more generally. It seems that an important component of a SBE is the opportunity for pre-service teachers to move from a more hypothetical and theoretical position of what it means to be a teacher (of science or otherwise) to a practical and informed understanding.

Lived experience of science learning/teaching

Many of the key learnings stemming from the SBE were not only directly related to practice, but are difficult to deeply understand without first-hand experience (Kenny, 2009). Most, if not all, of the emergent themes connected with the impact of lived experience (e.g. predominately those emerging in response to the second research question) are challenging to understanding from a purely theoretical or conceptual viewpoint. For example, the notion of student-centred learning and the value of this approach in science education can be understood on paper, but it is only in the reality of experiencing for yourself both in and out of the classroom (in this instance of this SBE) that how this approach is enacted in practice and the impact it has on student learning can be deeply understood. This finding can be equally applied to the participants' lived experiences of working collaboratively, whether that be with school students or their peers, as well the positive impact of having a network of support through the SBE on learning to teach science (both themes arising in response to the first research question). Again, in principle, pre-service teachers may know that these aspects play an important role in supporting their development as a teacher, but experiencing them brings into focus how and why they matter. This provision through SBEs of personal lived experience of both science learning and teaching can be further understood through the framework of opportunities to learn (OTL) as described by Jita (2018). This framework defines whether, in this case, pre-service teachers have had the opportunity to learn the theory underpinning the teaching a particular learning area (e.g. science) as well the opportunity to demonstrate proficiency in teaching this learning area in practice. The greater intent driving

the OTL framework is to effectively prepare highly competent and confident pre-service teachers for the teaching profession. The findings suggest that the SBE is achieving similar outcome to Jita's (2018) research findings through the provision of hands-on science learning and teaching experiences with participants gaining a richer sense of what science is and how it could be taught in primary school settings.

Limiting factors

In response to the research question, this paper largely documents the positive and productive impacts of SBEs for pre-service teachers in this specific context. SBEs are not, however, without their limiting factors; an area that the author has explored, grappled with, and documented over a two-year period (see Author, 2018c). Of particular relevance to this study are the equity and inclusion issues raised for off campus enrolments in ITE programs with recent numbers suggesting that around 25% of pre-service teachers (approximately 22,000) are enrolled in this mode of study (AITSL, 2018). This raises questions about how SBEs can be meaningful emulated for online learners, if at all. Ussher (2016) experienced success in supporting online students in a New Zealand ITE program to enact SBEs to build strong partnerships with their local school community. While this approach was workable in this context (e.g. small cohort, not geographically isolated), it may not be such a successful approach for some ITE programs in Australia who have large numbers of pre-service teachers studying online with many located not only in rural and remote areas of the country, but internationally also. While SBEs are a significant step towards better preparing primary pre-service teachers to be confident and competent teachers of science, more innovative approaches are needed if this is to be a workable, and ultimately equitable, opportunity across contexts and cohorts.

Conclusion and Implications

In light of the limitations, this research has interesting implications for teachers and teacher educators alike. While this work highlights that science-focused SBEs are beneficial for the personal and professional growth of pre-service teachers, capitalising on this finding requires significant input. For teachers, SBEs would require the opening up of their classrooms (virtually or in reality) to pre-service teachers more regularly. In taking greater responsibility, teachers would potentially have to expose their own vulnerabilities in relation to science education and be willing to work through these barriers alongside a pre-service teacher. For teacher educators, there is a need to reimagine and potentially reinvent what SBEs look like to ensure their ongoing feasibility and sustainability. This would require a significant amount of innovation and partnership development to ensure the value of the SBEs to pre-service teacher learning is recognised.

This study reinforces what we already know: pre-service teachers need lived experiences in the classroom to not only increase their confidence and competence to teach, but to more deeply reinforce their identity as a teacher. These lived experiences provided by a SBE can be characterised as an opportunity to actually work in the ways, though on small scale, that teachers do to enact beneficial science learning experiences for their students. This knowledge is taken to the next level, however, when we consider that the unique feature of this work was to re-envisage what this experience might look and how it might be enacted in ways that are meaningful, authentic and, importantly, provide a way to bridge the theory-practice gap. A SBE provides a way to shift from the abstract notions shared in university workshops of what you could do in practice to the more concrete experience of this is how these ideas feel and play out in reality of the classroom. These outcomes start to matter even more so when understood within the context of science education in primary school where anxiety and uncertainty about the learning and teaching of science still exist. At its core, this study was about engaging with a different approach to find a creative solution to a long-term

issue in science education for primary pre-service teachers with steps taken in the right direction to making a positive difference to future teachers of science.

References

AITSL. (2018). *The rise of online initial teacher education: What do we know?* Retrieved from: https://www.aitsl.edu.au/docs/default-source/research-evidence/spotlight/spotlight_ite_online__.pdf?sfvrsn=22a8f73c_2

Alake-Tuenter, E. (2014). *Inquiry-based science teaching competence of pre-service primary teachers* [Unpublished thesis]. Retrieved from: http://edepot.wur.nl/315471

Anderson, D., Bartholomew, R., & Moeed, A. (2009). Confidence, knowledge and teaching strategies: A study of pre-service science teachers in a New Zealand university. Paper presented at British Educational Research Association Annual Conference, 2-5 September 2009, University of Manchester.

Appleton, K. (1992). Discipline knowledge and confidence to teach science: Self-perceptions of primary teacher education students. *Research in Science Education, 22*(1), 11-19.

Appleton, K. (1995). Student teachers' confidence to teach science: Is more science knowledge necessary to improve confidence? *International Journal of Science Education, 17*(3), 357-369.

Australian Academy of Science (2019). *Curriculum resources: Primary Connections – Linking science with literacy*. Retrieved: https://primaryconnections.org.au/curriculum-resources

Author, 2012

Author, 2018a

Author, 2018b

Author, 2018c

Bahr, N., & Mellor, S. (2016). *Building quality in teaching and teacher education*: *Australian Education Review No. 61.* Melbourne, Vic: Australian Council for Educational Research.

Bannister-Tyrrell, M. L., Mavropoulou, S., Jones, M., Bailey, J., O'Donnell-Ostini, A., & Dorji, R. (2018). Initial Teacher Preparation for Teaching Students with Exceptionalities: Pre-service Teachers' Knowledge and Perceived Competence. *Australian Journal of Teacher Education, 43*(6). DOI: http://dx.doi.org/10.14221/ajte.2018v43n6.2

Bybee, R.W., Taylor, J.A., Gardner, A., Van Scotter, P., Carlson Powell, J., Westbrook, A., & Landes, N. (2006). *The BSCS 5E instructional model: Origins, effectiveness, and applications.* Colorado Springs, CO: BSCS.

Cartwright, T.J., & Atwood, J. (2014). Elementary pre-service teachers' response-shift bias: Self-efficacy and attitudes towards science. *International Journal of Science Education, 36*(14), 2421-2437.

Casey, M.A., & Kueger, R.A. (2000). *Focus groups: A practical guide for applied research.* (3rd ed.). Thousand Oaks, CA: Sage.

Chen, J., & Menshah, F.M. (2018). Teaching contexts that influence elementary pre-service teachers' teacher and science identity development. *Journal of Science Teacher Education, 29*(5), 420-439.

Cohen, L., Manion, L., & Morrison, K. (2007). Research methods in education (6th ed.). New York, NY, US: Routledge/Taylor & Francis Group.

Craven, G., Beswick, K., Fleming, J., Fletcher, T., Green, M., Jensen, B., Leinonen, E., Rickards, F. (2014). *Action now: classroom ready teachers*. Canberra, Australia: Teacher Education Ministerial Advisory Group.

Creswell, J.W., & Plano Clark, V.L. (2017). *Designing and conducting mixed methods research (3rd ed.).* SAGE publications.

Darling-Hammond, L. (2006). Constructing 21st-century teacher education. *Journal of Teacher Education, 57*(3), 300-314.

Davis, G.C., Baral, R., Strayer, T., & Serrano, E.L. (2018). Using pre- and post-survey instruments in interventions; Determining the random response benchmark and its implications for measuring effectiveness. *Public Health Nutrition, 21*(6), 1043-1047.

Dilshad, R.M., & Latif, M.I. (2013). Focus group interviews as a tool for qualitative research: An analysis. *Pakistan Journal of Social Sciences, 33*(1), 191-198.

Education International. (2017). *Quality Teaching.* Retrieved from: https://www.ei-ie.org/en/detail_page/4657/quality-teaching

Gauthier, C., & Dembélé, M. (2004). *Quality of teaching and quality of education: A review of research findings.* Paris, France: UNESCO.

Hanuscin, D.L., & Musikul, K. (2007). School's IN for Summer: An alternative field experience for elementary science methods students. *Journal of Elementary Science Education, 19*(1), 57-68.

Harlen, W., & Holroyd, C. (1997). Primary teachers' understandings of concepts of science: Impact on confidence and teaching. *International Journal of Science Education, 19*(1), 93-105.

Hill, A. (2008). Learning in the workplace: new forms of learning for preservice teachers. In P. Kell, W. Vialle, D. Konza and G. Vogl (eds.). *Learning and the learner: exploring learning for new times* (pp. 236-250). Wollogong, NSW: University of Wollongong Press.

Hogan, V., Reid, L., & Furbish, D. (2017). A Comparison of the Motivations of Pre-degree and Degree Education Students for Becoming Teachers in Aotearoa New Zealand. *Australian Journal of Teacher Education*, 42(11). DOI: http://dx.doi.org/10.14221/ajte.2017v42n11.6

Holroyd, C., & Harlen, W. (1996). Primary teachers' confidence about teaching science and technology. *Research papers in Education, 11*(3), 323-335.

Hudson, P. (2010). School-based experiences: Developing primary science preservce teachers' practices. *Journal of Science and Mathematics in Southeast Asia, 33*(2), 149-167.

Hudson, P. (2014). Understanding pre-service teachers' development of pedagogical knowledge practice when co-teaching primary science to peers. *Journal of Science and Mathematics in Southeast Asia, 37*(1), 44-66.

Jita, T. (2018). Exploring pre-service teachers' opportunities to learn to teach science with ICTs during teaching practice. *Journal of Education, 71*, DOI: http://dx.doi.org/10.17159/2520-9868/i71a05

Jones, M.M. (2008). Collaborative partnerships: A model for science teacher education and professional development. *Australian Journal of Teacher Education. 33*(3), 61-76.

Kenny, J. (2009). A partnership based approach to professional learning: Pre-service and in-service teachers working together to teach primary science. *Australian Journal of Teacher Education, 34*(6), 1-22.

Kenny, J.D., Hobbs, L., Herbert, S., Jones, M., Chittleborough, G., Campbell, C., Gilbert, A., & Redman, C. (2014). Science teacher education partnerships with schools (STEPS): Partnerships in science teacher education. *Australian Journal of Teacher Education, 39*(12), 43-65.

Khatri, J. (2015). *Self-report.* Retrieved from: https://getrevising.co.uk/grids/self_report

Larson, L.C., & Miller, T.N. (2011). 21st century skills: Prepare students for the future. *Kappa Delta Pi Record, 47*(3), 121-123.

Lavrakas, P.J. (2008). *Encyclopedia of Survey Research Methods.* SAGE Publishers. DOI: http://dx.doi.org/10.4135/9781412963947.n105

Mayer, D. (1999). *Building teaching identities: Implications for pre-service teacher education.* Paper presented at Australian Association for Research in Education Annual Conference, 29 November to 2 December 1999, Melbourne, Australia.

McGrath, K.F., & Van Bergen, P. (2017). Male teachers are an endangered species in Australia: New research. *The Conversation.* Retrieved from: https://theconversation.com/male-teachers-are-an-endangered-species-in-australia-new-research-83464

Moseley, C., Ramsey, S.J., & Ruff, K. (2004). Science Buddies: An authentic context for developing teachers' understandings of learning, teaching, and scientific inquiry. *Jounral of Elementary Science Education, 16*(2), 1-18.

Naylor, D. (2015*). Learning to teach: What pre-service teachers report* (Unpublished thesis). Retrieved from: https://ro.ecu.edu.au/theses/1626

Naylor, D. A., Campbell-Evans, G., & Maloney, C. (2015). Learning to Teach: What Do Pre-service Teachers Report. *Australian Journal of Teacher Education*, *40*(11). DOI: http://dx.doi.org/10.14221/ajte.2015v40n11.7

Rickards, F. (2016). What are the main challenges facing teacher education in Australia? *The Conversation.* Retrieved from: https://theconversation.com/what-are-the-main-challenges-facing-teacher-education-in-australia-63658

Rowley, G., Weldon, P.R., Kleinhenz, E., & Ingvarson, L. (2013). *School-university partnerships in initial teacher preparation: An evaluation of the School Centre for Teaching Excellent initiative in Victoria.* Camberwell, Vic.: Australian Council for Educational Research.

Skamp, K. (1991). Primary science and technology: How confident are teachers? *Research in Science Education, 21*(1), 290-299.

Shorten, A, & Smith, J. (2017). Mixed methods research: Expanding the evidence base. *Evidence-based nursing, 20*(3), 74-75.

Tariq, S., & Woodman, J. (2013). Using mixed methods in health research. *Journal of the Royal Society of Medicine, 4*(6), DOI: 10.1177/2042533313479197

Tosun, T. (2000). The beliefs of pre-service elementary teachers towards science and science teaching. *School Science and Mathematics, 100*(7), 374-379.

Ussher, B. (2016). Student teachers' placement experiences in a familiar school setting: Local community partnerships with a distance ITE program. *Australian and International Journal of Rural Education, 26*(1), 3-16.

Watson, L., Hay., I., Hellyer, L., Stuckey, D., & Woolnough, J. (November 2008). *Beyond the practicum: Integrating content, pedagogy and practice in teacher education.* Paper presented at the Australian Association for Research in Education (AARE) national conference in Brisbane, Australia.

Yates, S., & Goodrum, D. (1990). How confident are primary school teachers in teaching science? *Research in Science Education, 20*(1), 300-305.

Zeichner, K., (2010). Rethinking the connections between campus courses and field experiences in college- and university-based teacher education. *Journal of Teacher Education, 61*(1-2), 89-99.

Appendix 1: Demographic and contextual features of participating pre-service teachers

Demographic features	Bachelor of Education cohort (n=50)	Graduate Diploma of Education cohort (n=96)	Totals for whole cohort (with percentages) (N=146)
Gender	Females: 40 Males: 10	Females: 74 Males: 22	Females: 114 (78%) Males: 32 (22%)
Age range	18 to 39 years	20 to 54 years	18 to 54 years
Age breakdown	18 to 20 years: 39 20 to 24 years: 5 25 to 29 years: 2	18 to 20 years: 0 20 to 24 years: 34 25 to 29 years: 31	18 to 20 years: 39 (27%)

	30 to 34 years: 1 35 to 39 years: 2 40 to 44 years: 0 45 to 49 years: 0 40 to 54 years: 0 Unknown: 1	30 to 34 years: 7 35 to 39 years: 11 40 to 44 years: 8 45 to 49 years: 3 40 to 54 years: 1 Unknown: 1	20 to 24 years: 39 (27%) 25 to 29 years: 33 (23%) 30 to 34 years: 8 (5%) 35 to 39 years: 13 (9%) 40 to 44 years: 8 (5%) 45 to 49 years: 3 (2.5%) 40 to 54 years: 1 (0.5%) Unknown: 2 (1%)
Last formal science education experience	Year 8: 1 Year 9: 2 Year 10: 15 Year 11: 7 Year 12: 19 Tertiary: 6[1]	Year 8: 1 Year 9: 3 Year 10: 25 Year 11: 7 Year 12: 27 Tertiary: 33	Year 8: 2 (1%) Year 9: 5 (3%) Year 10: 40 (28%) Year 11: 14 (10%) Year 12: 46 (31%) Tertiary: 39 (27%)
Interest in science	Interested: 17 Not interested: 32 No response: 1	Interested: 57 Not interested: 38 No response: 1	Interested: 74 (51%) Not interested: 70 (48%) No response: 2 (1%)

The gender breakdown, with a much higher number of female participants (78%), reflects the reality of primary education in Australia (McGrath & Van Bergen, 2017). With the spread of participant ages falling largely between the ages of 18 to 29 years (77%), this is indicative of the number of school leavers who enrol in initial teacher education programs and of people seeking career direction post-tertiary study or a career change following time in the workforce. It is not surprising that the participants' last formal science education experiences cluster around Year 10 (27%), as this is the final year of compulsory education in Australia, and Year 12 (32%), as the culmination of the post-compulsory secondary years of schooling. The additional cluster in the tertiary category (27%) may be directly attributed to the previous tertiary study completed by many of the participants. Specific to the Graduate Diploma cohort was their previous study with more than half having completed a Bachelor of Arts

[1] For the Bachelor of Education cohort, this science-related tertiary study was taking place concurrently to their initial teacher education studies as part of a double degree program (E.g. Bachelor of Science/Bachelor of Education (Primary)).

(42%) or Bachelor of Science (10%) and the rest undertaking qualifications in a range of areas including business, health science, music, information systems, journalism and graphic design. Finally, the participants' declared interest or disinterest in science was nearly a fifty-fifty split overall (51%-48%), but the dichotomy was not as balanced within each cohort. The higher level of interest in the Graduate Diploma cohort (60%) may be due to increased connections with science in their personal and professional lives, while the increased levels of disinterest in the Bachelor cohort (64%) could possibly be attributed to experiences of school science.

Appendix 2: Focus group interview questions

- What were your feelings about and attitudes towards science and science teaching and learning before you participated in the school-based experiences (SBE)?
- Before you undertook the SBE, how would you have ranked your (a) confidence (in teaching science) and (b) competence (ability to teach science concepts and processes) in the area of science education? 1 = not at all confident/competent to 10 = very confident/competent Explain why you gave the rankings you did for each area.
- How are you feeling towards and thinking about science and science teaching and learning now that you have had the opportunity to teach science in a classroom?
- Now that you have undertaken the SBE, how would you now rank your (a) confidence (in teaching science) and (b) competence (ability to teach science concepts and processes) in the area of science education? 1 = not at all confident/competent to 10 = very confident/competent Explain why you gave the rankings you did for each area.
- What are three aspects of the SBE that helped you in developing confidence and competence in teaching primary science?

- What are three aspects of the SBE that hindered you in developing confidence and competence in teaching primary science?
- In terms of the SBE, what could be improved to make this experience more beneficial for pre-service teachers?
- What do you think is the single most important way that the SBE impacted on you as a teacher and your perceptions of science teaching and learning?