

School of Education

**A Longitudinal Study of Preservice Teachers and their Efficacy
Beliefs about Teaching and Learning Science**

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**This thesis is presented for the Degree of
Doctor of Philosophy
of
Curtin University**

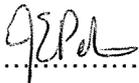
April 2018

Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number SMEC-92-11.

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Date: 23/4/18

Abstract

Many studies have explored the impact of self-efficacy beliefs of individuals on the teaching of science in primary schools, both at preservice and inservice level. These studies highlighted that teachers often have low science teaching efficacy although science methods units, resources and support have been identified as improving efficacy beliefs.

This longitudinal study investigated how, why and to what extent science teaching efficacy beliefs change over time from preservice teacher education to first year teaching and was guided by three research questions. These research questions explored how prior experiences of science shaped the preservice teachers' science teaching beliefs as they began a science methods unit. It also considered how aspects of preservice teachers' tertiary preparation, specifically science methods units and practical experiences, helped to shape these beliefs. Finally, it explored how these beliefs continued to develop as the participants began their teaching degrees. This study differs from previous studies in that it explored how individuals develop their science teaching efficacy beliefs over time— a feature that has been limited in previous studies. Similarly, the literature has concentrated principally on what factors influence these self-efficacy beliefs but has not carefully analysed how the significance of these factors may change as preservice teachers transition into their early careers which is the focus of this study.

The study used a qualitative dominant mixed methods design, that relied on the qualitative data but included both qualitative and quantitative data sources. The wider study cohort of 136 preservice teachers completed the *Science Teaching Self-Efficacy Beliefs Instrument for Preservice Teachers* (STEBI-B) at the beginning and end of the science methods unit. From the results, 10 students were selected using purposeful sampling to be part of semi-structured interviews throughout the research study. Thirty-five interviews in total were completed.

Results from the STEBI-B and in-depth interviews showed that, despite mostly negative prior experiences of science, the science methods unit they experienced positively impacted the science teaching efficacy beliefs of participants. Influences

that positively impacted the participants' efficacy beliefs in their university degrees included opportunities to develop their knowledge of curriculum and resources, improving their pedagogical knowledge, observing others successfully teaching science and teaching it successfully themselves, as well as the structure and nature of science learning activities presented in the science units. After their first year of teaching, most of the participants expressed moderate to high levels of confidence to teach science, despite experiencing varying opportunities to teach science in their different contexts. Aspects of their first year of teaching that influenced the participants' perceptions of science included support, time, resources and having science specialist teachers in their schools.

This study has highlighted that a purpose-designed science education tertiary unit can positively contribute to science efficacy beliefs, despite previous experiences of science. These beliefs can be sustained, even when there are little opportunities or negative experiences of teaching science. A greater understanding of the key influences to impact on these efficacy beliefs have been identified, which highlights the importance of partnerships between universities and education providers to more effectively cater for the needs of preservice teachers at their different stages of development.

Acknowledgements

I would like to sincerely thank my supervisors at the School of Education Curtin University, for their support and guidance during my doctoral studies. To Professor David Treagust, thank you for your continued optimism, reassurance and patience as I persisted with this thesis. I have so greatly appreciated the advice you have given me throughout my study. To Dr. Mihye Won, thank you for the critical feedback you have provided which has challenged me and ultimately improved the quality of this submission.

I am grateful for the willingness of all of the participants to be involved in this study. I would especially like to thank all of the in-depth interview participants for the insights they have shared and their commitment to the study.

I would like to thank Catholic Education Western Australia for awarding me a Doctoral Scholarship which has assisted me in completing this thesis. I am also particularly grateful for the support of my Principal, Mr Chris Cully.

My deepest love and appreciation is for my husband and the incredible support he has given me throughout this process. He has been my biggest encourager and has good-naturedly handled any of the curveballs that have occurred. To my Mum, Dad and family, thank you for the assistance and love you have provided throughout all of my postgraduate study. And finally, to my beautiful, fun-loving and energetic children, I love you so much and I hope that I have made you proud.

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Chapter 1

Introduction

1.0 Overview of the Study

Science in Australian primary schools is in a state of renewal and change. Included as part of the first stages of the *Australian Curriculum*, quality science teaching resources have been developed to meet the needs of teachers and science has been identified as a priority by the Australian Government through recent STEM (Science, Technology, Engineering and Mathematics) initiatives. Requirements have also been established at a national level for the inclusion of science units within the structure of tertiary education degrees.

Despite this progress, many studies have reported that preservice teachers experience low self-efficacy about their abilities to teach science in an effective way. Low self-efficacy beliefs have been associated with a reduced quantity of science teaching and more teacher-directed styles of instruction. Whilst previous research has highlighted that well-designed science courses at university can have a positive impact on self-efficacy beliefs (e.g. Bautista, 2011; Brand & Wilkins, 2007; Menon & Sadler, 2017; Smolleck & Voder, 2009; Varma, Volkmann & Haniscin, 2009), there is a lack of longitudinal research to show whether these beliefs change over time, primarily as these individuals transition from their tertiary degree to their first years of employment as qualified teachers.

The study is designed to longitudinally investigate the self-efficacy beliefs of a sample of preservice teachers and their perceptions of teaching and learning science as they complete their final years of tertiary study and begin their teaching careers. The research also explores those influences that the preservice teachers perceive as impacting on their science teaching efficacy beliefs at various stages of their development as a teacher.

The research employed a concurrent embedded mixed methods design, with the primary data sources being qualitative. The qualitative and quantitative data collection

began at the start of a science methods unit, which, for most participants, was during the second semester of the third year of their degree. A sample of preservice teachers were involved in semi-structured interviews at the beginning of the unit, at the end of the unit, at the end of their degree and after their first year of teaching. These interviews were designed to elicit what the in-depth interview participants perceived as significant to their self-efficacy beliefs about teaching and learning science, and what meanings they attributed to this. These qualitative data were complemented by the collection of quantitative data from the wider preservice cohort to which the participants belonged. The *Science Teaching Efficacy Belief Instrument for Preservice Teachers* (STEBI-B) was administered at the beginning and end of a science methods unit to quantitatively measure the science teaching efficacy beliefs of the wider cohort of preservice teachers, which included the in-depth interview participants.

1.1 Rationale

The researcher of the study was employed as a lecturer in primary science at a university in Australia. Every year, early childhood and primary preservice teachers began a science unit coordinated by the researcher with seemingly negative science teaching efficacy beliefs. These preservice teachers often shared that they perceived they had weak science content knowledge and some preservice teachers even expressed concern about their ability to successfully complete the unit. What became noticeable over a period of years of teaching the unit was that the science teaching efficacy beliefs of preservice teachers seemed to improve over the course of the unit. From unit and lecturer evaluations, the unit was consistently recognised as outstanding, and there were overwhelmingly positive comments about how the unit had contributed to knowledge, teaching skills and enthusiasm to teach science.

Beyond recognising that these science teaching efficacy beliefs were important for the successful running of the science unit, the longer-term impact of these beliefs was not known and was of interest to the researcher. It seemed logical to the researcher that negative science teaching efficacy beliefs could lead to lower quality teaching, which could in turn have a dramatic impact on student learning. As a lecturer who was influenced by a constructivist view of learning and teaching, the unit was designed in a way to ascertain teaching and learning beliefs and embed them within the learning

environment. The researcher's constructivist approach was influenced by previous study and teaching experience in both primary and tertiary settings. Constructivist approaches maintain that individuals bring pre-existing beliefs, knowledge and skills to learning experiences, which they negotiate as they re-construct their understandings (Garbett, 2011). Teaching and learning beliefs held by preservice teachers can be influenced by an individual's experience as a learner and their life experiences (Hornstra & Mansfield, 2015). Efficacy beliefs are one sub-structure of an individual's belief system (Pajares, 1992). As such, in this unit, individuals were encouraged to explore their beliefs and make meaning of them through peer discussion and reflection on experiences.

It therefore seemed critical to make a positive impact on the science teaching efficacy beliefs of preservice teachers in a tertiary setting, as university is a time for development and formation (Berg & Smith, 2016; Ucar, 2012). The researcher became interested in whether and how these self-efficacy beliefs changed over time, and several questions emerged. Firstly, questions emerged as to how prior experiences of science influenced science teaching efficacy beliefs of preservice teachers as they began a science methods unit. Secondly, the researcher questioned how university coursework and practical experience could influence science teaching efficacy beliefs. Finally, the researcher was curious of the influences to science teaching efficacy in the early careers of teachers. Investigating these questions formed the basis of the design of this current study.

1.2 Context of the Study

The researcher was the coordinator of a unit called Primary Science, with approximately 140 preservice teachers enrolled. This unit was a requisite unit for all preservice teachers completing an undergraduate degree. The preservice teachers enrolled in the unit consisted of Bachelor of Education (Early Childhood) students, Bachelor of Education (Primary) students, Master of Teaching (Primary) students and Graduate Diploma (Primary Conversion) students.

In developing the course structure for education degrees, universities are bound by the document *Accreditation of Initial Teacher Education Programs in Australia*

(Australian Institute for Teaching and School Leadership, AITSL, 2011a). This document stipulates that early childhood and primary preservice teachers in an undergraduate degree need to complete two science education units, while those enrolled in a graduate two-year entry program need to complete one science education unit. These units need to integrate theory and practice and universities have autonomy to develop the units to suit their own context. In the context of this university, the first science education unit that preservice teachers completed was a unit in their first year of study that focused on environmental education. The *Primary Science* unit followed this unit in the third year of study, and was designed to explore science content, curriculum and pedagogy for the compulsory primary years of school, which constitutes Pre-Primary to Year 6. Hence, the unit was important for both preservice teachers enrolled in early childhood and primary education degrees. Critical to the development of preservice teachers beyond the tertiary units they complete is the opportunity for practical experience in schools. The university in this current study embedded large amounts of practical experience within all degrees, well exceeding AITSL requirements (AITSL, 2011a).

The university in which the researcher was employed had developed a strategic goal to engage in research projects that examined how students perceived their readiness to enter the teaching profession and whether they perceived the university had adequately prepared them. It became apparent that a longitudinal study, which investigated science teaching beliefs at different stages of preservice degrees and as they began their careers, would be significant to ensure that the course structure and practical experience was adequately preparing individuals for the teaching profession in the area of science.

1.3 Background

1.3.1 Defining Key Terminology

Prior to further discussion as to why this research is significant, the concepts of belief and self-efficacy are defined. Beliefs are mental predispositions that may develop from experience, knowledge or social background, which may impact on behaviour (Markic & Eilks, 2012). They are therefore personal and may be resistant to change

(Kind, 2015). Shermer (2011) argues that individuals are often unwilling to change their beliefs due to the complex way beliefs are formed, and they will often vigorously defend and rationalise them. In relation to education, teacher beliefs include teaching philosophy and opinions about teaching and learning (Milner, Sondergeld, Demir, Johnson & Czerniak, 2012). These beliefs can be influenced by an individual's own experiences as a learner, his or her teacher education experiences, as well as professional experiences as teachers (Hornstra & Mansfield, 2015). In relation to preservice teachers, individuals enter their tertiary education with *inside knowledge* that is different to other professions, due to their own experiences in primary and secondary school, which can lead to strong beliefs about teaching and learning (Kind, 2015). Therefore, teacher education programs have a considerable role in the development of teaching beliefs which can have significant ramifications for teaching practice (Brown, Friedrichsen & Abell, 2013; Bryan, 2003; Ucar, 2012). Previous studies have found that teacher beliefs can be either a stimulus or obstacle for science education (Maier, Greenfield & Butotsky-Shearer, 2013; Skamp, 2012).

One sub-structure of beliefs is self-efficacy. Ideas about self-efficacy have developed from social cognitive theory predominantly through the work of Albert Bandura. In social cognitive theory, learning occurs in a social context and this impacts the development of social behaviours in humans (Bandura, 1986). Particular assumptions underlie this theory about learning and behaviour. One assumption is that individuals behave due to the interaction between their thoughts, behaviour and context (Bandura, 2001). Another assumption is that people have an ability to purposefully make things happen in their own lives, which can impact their own behaviour and the environment (Bandura, 2001). Bandura (1994) states

Perceived self-efficacy is defined as people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives. Self-efficacy beliefs determine how people feel, think, motivate themselves and behave. (p.1)

In relation to education, teacher efficacy beliefs have been connected to effective instructional practices and student engagement (Edwards, Higley, Zeruth & Murphy, 2007; Guo, Justice, Sawyer & Tompkins, 2011). Teaching efficacy refers to a teacher's self-belief in his or her ability to achieve learning goals regardless of the

behavioural and learning needs of their students (Tschannen-Moran & McMaster, 2009).

1.3.2 Science Teaching Efficacy Research in Preservice Teacher Education

Science teaching efficacy can be defined as a teacher's perception of his or her capability to successfully teach science to students (Mansfield & Woods-McConney, 2012). In some literature, self-efficacy is often inter-changed with the term confidence, which can be problematic in that confidence can be too general when describing what the confidence is specifically about (Palmer, Dixon & Archer, 2015). Hattie and Yates (2014) maintain that self-efficacy can also be described as task-related confidence which helps to bridge the distinction between the terms. In this study, supporting the work of Palmer et al. (2015), the term confidence is used through the interview design, as it is a term more readily understood by participants, but in the thesis, the term is only used when the type of confidence can be defined.

Science teaching efficacy beliefs of preservice teachers have been the subject of many studies (Avery & Meyer, 2012; Bleicher, 2007; Howitt, 2007; Ling & Richardson, 2009). Several studies have identified that primary preservice teachers often have low science teaching efficacy when beginning science units at university (Bleicher, 2007; Hechter, 2011; Yoon, Pedretti, Bencze, Hewitt, Perris & Van Oostveen, 2006). Previous experiences of science in primary and secondary school have been identified as contributing to these efficacy beliefs (Mansfield & Woods-McConney, 2012; Thomas & Pedersen, 2003; Thomas, Pedersen & Finson, 2001).

Science units within early childhood and primary education degrees are normally designed as either science content or science methods units. The aim of science content units is to increase science content knowledge in different disciplines. Science methods units are intended to improve preservice teachers' content knowledge and pedagogical skills, although the amount of science content is not covered. There have been mixed findings about whether science content units positively contribute to science teaching efficacy beliefs (Bayraktar, 2011; Morrell & Carroll, 2003; Palmer, Dixon & Archer, 2015). Alternatively, the literature has identified that a well-designed science methods unit can increase the self-efficacy beliefs of preservice teachers

(Bautista, 2011; Brand & Wilkins, 2007; Cone, 2009b; Varma, Volkmann & Haniscin, 2009).

Practical experiences are also vital components of education degrees. In relation to the development of science teaching efficacy beliefs, there are mixed findings about how practical experiences can impact on such beliefs. In some cases, there was a decrease in science teaching efficacy following a practical experience (Settlage, Southerland, Smith & Ceglie, 2009; Utley, Moseley & Bryant, 2005). Aspects of practical experiences that have been identified as increasing self-efficacy beliefs include actually seeing quality science being taught and having the opportunity to teach science themselves (Capa Adyin & Woolfolk Hoy, 2005; Velthuis, Fisser & Pieters, 2014). However, even in the case of negative practical experiences, Palmer (2006a) argues that the positive effects of a science methods unit on science teaching efficacy can withstand a negative practical experience, and that practical experiences can contribute to the durability of these beliefs.

1.4 Research Questions and Significance

The literature relating to the science teaching efficacy beliefs of preservice teachers has primarily focused on short-term studies that investigated the impact of science coursework or practical experiences on self-efficacy beliefs. Surprisingly, exploration of how individuals perceive their beliefs change or develop over time has been limited. Similarly, the literature has concentrated principally on what influences these self-efficacy beliefs but has not carefully analysed how the significance of these influences may change as preservice teachers transition into their early careers.

The purpose of this research was to examine how preservice teachers developed their self-efficacy beliefs about teaching and learning science at various stages of their tertiary degrees. Also the research investigated how these science teaching efficacy beliefs changed as the preservice teachers began their teaching careers. The aim was to critically examine what influences preservice teachers perceived as contributing to their self-efficacy beliefs at these different stages. On this basis, an overall research question was developed:

- How, why and to what extent do science teaching efficacy beliefs change over time from preservice teacher education to first year teaching?

From this research problem, several sub-questions were constructed:

- Research Question 1- How, why and to what extent do prior experiences of science teaching and learning influence science teaching efficacy beliefs?
- Research Question 2- How, why and to what extent does preservice teacher preparation influence science teaching efficacy beliefs?
- Research Question 3-How, why and to what extent does the first year of teaching influence science teaching efficacy beliefs?

The study used a longitudinal design to explore each individual's science teaching efficacy beliefs over the final years of a university degree and into the first year of employment, recognising that self-efficacy beliefs do not remain constant (Bandura, 1994; Palmer, 2011). Longitudinal research is generally underrepresented in education research (McKinnon, 2010). The researcher was interested in exploring the trajectory of preservice teachers' science teaching efficacy beliefs over the transition period from preservice to inservice, and what influence these beliefs at different stages of development. The limitations of previous research have been in their short-term nature, which restricts the ability to understand what influences long term development of efficacy beliefs (Clift & Brady, 2005). Many researchers have identified the importance of conducting longitudinal studies relating to teaching efficacy beliefs, due to limitations identified in each of the cross-sectional studies (Bleicher, 2004; Cantrell, Young & Moore, 2003; Cone, 2009a; Henson, 2001; Pajares, 1992; Tschannen-Moran & Woolfolk Hoy, 2001).

1.5 Research Methods

This research used a concurrent embedded mixed methods research design that incorporated both qualitative and quantitative data sources (Creswell & Plano Clark, 2010). In a concurrent embedded model, the research draws upon the worldview of the primary approach, which in this context of this research is an interpretivist or qualitative worldview investigating how individuals interpret and give meaning to

their experiences (Merriam, 2009). An interpretivist research paradigm emphasises that reality is complex and individuals “construct their understanding based on their experiences, culture and context” (Treagust, Won & Duit, 2014, p. 7). The research is underpinned by a constructivist epistemology, which maintains that individuals construct knowledge based on their experiences, which may differ from one individual to the other (Egbert & Sanden, 2013). Interpretivist research is naturalistic, in that it highlights the importance of context (Bogdan & Biklen, 2003) and the intent of the researcher is to make sense of the meanings others have about the world (Creswell, 2009).

The primary data collection method was semi-structured interviews. Interviews were used with a sample of 10 participants at four different points during their final years of university and their first year of teaching. An interview guide was developed to support the researcher in gaining an understanding of the research questions. Purposeful sampling was used to invite participants to be involved in these interviews.

Supporting the semi-structured interviews was the use of the STEBI-B questionnaire, which was administered to the wider preservice teacher cohort at the beginning and end of the science methods course. This had two distinct purposes. It initially served as one of the processes for maximum variance sampling to assist with the selection of participants. It was also used as a way of measuring changes in science teaching efficacy beliefs from the beginning to end of the *Primary Science* unit.

The major form of data analysis that was used by the research was based on a model by Onwuegbuzie and Teddlie (2003). Qualitative data analysis was conducted using systematic text condensation process, which involved coding, condensing and synthesising the data collected (Malterud, 2012). The results of the STEBI-B were descriptively and comparatively analysed. The web-based program Dedoose was used to support the data analysis process.

All ethical issues were carefully examined. The researcher gained informed consent from all participants involved in the semi-structured interviews. Privacy and confidentiality were maintained through the use of pseudonyms and access to the data only for the supervisor and researcher. In relation to the results from the questionnaire, data was presented as cohort results, which ensured individual responses remained

confidential. Consideration was a factor in order to minimise the disruption for participants, by administering questionnaires in workshop time, and allowing participants to negotiate the location and time of the interviews.

Some limitations of the current study are apparent. Firstly, the unique structuring of the science education units and practical experience at the university suggest that some of the findings may not be applicable to all preservice education programs. Due to the interpretivist paradigm from which the study was developed, generalisation of the findings is problematic. The longitudinal nature of the research is also a limitation due to participation attrition rates that can occur (McKinnon, 2010). These limitations are further discussed in the last chapter of the thesis.

1.6 Outline of the Thesis

This chapter has introduced the theoretical framework on which the current study is based and has situated its significance in relation to prior research into science teaching efficacy beliefs of preservice teachers. The research question was introduced which asked how, why and to what extent science teaching efficacy beliefs change over time from preservice teacher education to first year teaching. Three sub-questions were further developed from this question. It has provided an outline of the aims of the study and how the research will be carried out.

The remaining chapters are organised as follows. Chapter 2 contextualises the current research in relevant literature, relating to prior research into self-efficacy beliefs of preservice teachers relating to the teaching and learning of science. In Chapter 3, the methodological framework for the research design is presented in more detail, outlining the data collection, analysis and ethical issues that were considered in the current study. The results and discussion of the study relating to each of the 3 research sub-questions are presented in Chapters 4 to 6 respectively. The final chapter summarises the key findings of the study, discusses the limitations of the research and presents recommendations for future research in this area.

Chapter 2

Literature Review

2.0 Introduction

This study focuses on the development of self-efficacy beliefs of early childhood and primary preservice teachers in teaching science, as developed through their teacher education programs. This chapter reviews current and significant studies on self-efficacy and its impact on the teaching process. Contemporary views will be presented on the status and development of self-efficacy in teaching science as early childhood and primary teachers go through their pre-service and inservice teacher education programs. As the context of the study, the initial and inservice teacher education programs for early childhood and primary teachers in Australia will be considered.

2.1 Theoretical Framework

Many theorists emphasise the importance of beliefs in the teaching process. Some researchers assert that in order for educational reform to occur, it is important to examine the teachers' beliefs, because teaching beliefs can influence the quality of science education (Maier, Greenfield & Bulotsky-Shearer, 2013; Skamp, 2012). This emphasis is supported by a study conducted by Keys (2005), which concluded that teacher beliefs need to be examined in educational research, because these beliefs may actually impede the progress of curriculum implementation.

Teacher education programs are crucial in the formation and development of teacher beliefs. Some studies have concluded that tertiary preparation for teaching needs to focus on the beliefs of preservice teachers, due to the role that these beliefs have in the teaching process (Bryan, 2003; Ucar, 2012). Therefore, exploring the role of beliefs about teaching and learning in relation to preservice science education is important in order to investigate how these beliefs influence the quality of science teaching and learning. This study aims to explore the impact that self-efficacy beliefs that are held by preservice teachers have on their teaching and learning of science over time. It will also consider what contributes to the development of these beliefs at different stages of the preservice teacher's development.

2.1.1 Defining Beliefs

Prior to a discussion of self-efficacy, the concept of beliefs must firstly be defined. According to Hancock and Gallard (2004), a belief can be defined as “an understanding held by an individual that guides that individual’s intentions for action” (p. 281). Beliefs include concepts such as self-concept, self-esteem, opinions, perceptions and confidence, and they can influence action (Pajares, 1992). Some researchers have argued that beliefs are formed in a complex way and are therefore resistant to change (Haney & McArthur, 2002; Shermer, 2011). They are deeply personal and may often be traced back to memories of past experiences (Haney & McArthur, 2002). Haney and McArthur (2002) stated that holding multiple central beliefs form a belief structure and Pajares (1992) maintained that self-efficacy is one of many substructures.

In relating to education, “teacher beliefs can be described as their convictions, philosophy, tenants, or opinions about teaching and learning” (Milner, Sondergeld, Demir, Johnson & Czerniak, 2012, p. 113). Teacher beliefs may be influenced by their own experiences as learners, their teacher education experiences, their life experiences, as well as their professional experiences as teachers (Hornstra & Mansfield, 2015). A teacher’s belief system is complex and may impact the understanding of pedagogical knowledge and teaching practices (Bryan, 2003). These aspects need to be considered in the context of this present research, as the study investigates those influences that impact on science teaching efficacy beliefs during preservice teacher education and in early career.

2.1.2 Social Cognitive Theory and Self-Efficacy

As a sub-structure of beliefs, any discussion about self-efficacy needs to be firstly situated in its theoretical framework. The first conceptual strand examining self-efficacy emerged through the work of Rotter (1966) focusing on the *Locus of Control*. This theory examined the extent to which an individual feels that he or she can control the reinforcement of their actions (Tschannen-Moran, Woolfolk Hoy & Hoy, 1998). Individuals who believed that they could impact an outcome were determined to have an internal locus of control, while individuals who believed that an achievement was

due to environmental factors acted from an external locus of control (Tschannen-Moran et al., 1998).

A second conceptual strand, social cognitive theory, was primarily developed through the work of Albert Bandura. At the core of this theory is that individuals learn through their social context, which influences their social behaviour (Bandura, 1986). This theory has been developed from two key assertions. Firstly, the interrelationship between thought, behaviour and context influences how an individual behaves (Bandura, 2001). This theory also assumes that people have agency in their own lives, in that they can be proactive, self-reflect and self-regulate, thereby influencing their own behaviour and their social environment (Bandura, 2001).

Bandura (1993; 1997; 2001) maintained that an individual's belief in their capacity to control their own behaviour and environment is the essential feature of human agency. These beliefs are referred to by Bandura as self-efficacy and may influence how individuals think, behave and motivate themselves (Bandura, 1993). Specifically, in terms of behaviour, self-efficacy has both a direct and indirect influence on how an individual behaves (Klassen & Usher, 2010). Higher self-efficacy may directly increase effort and persistence but may also indirectly support the emotional state of the individual (Klassen & Usher, 2010). However, individuals with weaker efficacy beliefs may avoid situations and activities which could in turn influence their ongoing development (Bandura, 1993). Self-efficacy is task specific and highly contextual, which separates it from other forms of self-beliefs (Phan, 2012a).

Personal efficacy beliefs are not necessarily predictors of performance in the future (Bandura, 1989). Tschannen-Moran et al. (1998) emphasised that personal efficacy is about how an individual perceives his or her own competence and does not focus on the level of competence itself. Further to this, Bandura (1997) stated "there is a marked difference between possessing sub skills and being able to integrate them into appropriate courses of action and to execute them well under difficult circumstances" (p.37). It therefore follows that people with the same skill level may perform a given task differently depending on differences in their perceived self-efficacy (Bandura, 1997).

Self-efficacy is thought to be composed of two components. Enochs and Riggs (1990) state “behaviour is enacted when people only expect specific behaviour to result in desirable outcomes (outcome expectancy), but they also believe in their own ability to perform the behaviour” (p. 2). The latter part of this quote introduces the first component, personal efficacy, which refers to the beliefs that an individual holds as to his or her own competence to complete a task successfully (Ling & Richardson, 2009). In some literature, this idea of personal efficacy has been expanded to not only focus on capability beliefs, but to also a recognition of the importance of environmental factors or context beliefs (Ford, 1992). The second is outcome expectancy, which in the case of teaching is “an individual’s belief that effective teaching will bring about student learning” (Swars & Dooley, 2011, p. 194) or a desirable outcome. Sandholtz and Ringstaff (2014) believe that there is a reciprocal relationship between personal and outcome efficacy, which can create positive or negative reinforcement. For example, if self-efficacy beliefs increase there may be a positive impact on beliefs about positive learning outcomes, which then continues to improve self-efficacy beliefs. These two components of self-efficacy have been the focus of many studies in teaching, which will be further explored in the following sections of this review.

Self-efficacy is not considered as something that remains constant throughout one’s life. A key aspect that impacts on self-efficacy is memory, in that the memories of past performance can impact on an individual’s perceptions of the current task (Hattie & Yates, 2014). Different periods of life present new challenges and require new types of competencies, therefore requiring a person to further develop their personal efficacy (Bandura, 1994; Phan 2012b). Four key terms can be used to describe these changes to efficacy beliefs. These are acquisition, generality, durability and resilience (Bandura, 1997; Palmer, 2011). Acquisition involves the initial development of self-beliefs and generality relates to how widely these beliefs may be applied (Palmer, 2011). Palmer (2006a) stated that durability refers to the stability of a belief excluding the influence of other factors. Resilience of self-efficacy refers to how a person’s sense of agency may bounce back despite difficulties (Palmer, 2011).

In education settings, self-efficacy and achievement are interrelated. A heightened sense of self-efficacy can have a positive impact on cognitive processing and other processes, which can lead to an enhancement of achievement (Phan, 2012a). Self-

efficacy beliefs are predictive of academic achievement, particularly as individuals move into higher levels of education (Yiang, Song, Lee & Bong, 2014). In turn, achievement of a task may improve self-efficacy beliefs (Phan, 2012a). However, achievement may be also influenced by numerous factors including personality, motivation, self-concept, as well as social and environmental reasons (Fong & Krause, 2012; Phan 2012a).

Personal efficacy also plays a significant role in an individual's intrinsic motivation. Intrinsic motivation relates to being driven by curiosity, interest and enjoyment of an activity itself (Niehaus, Rudasill & Adelson, 2012). A major source of motivation is cognitively generated by forethought, which involves setting goals and anticipating likely outcomes (Bandura, 1997, 1994, 1993, 1989; Zimmerman, Bandura & Martinez-Pons, 1992). This leads to an individual following certain courses of action. Bandura (1993) states that efficacy beliefs:

Determine the goals people set for themselves, how much effort they expend, how long they persevere in the face of difficulties, and their resilience to failures. When faced with obstacles and failures, people who harbor self-doubts about their capabilities slacken their efforts or give up quickly. Those who have strong belief in their capabilities exert greater effort when they fail to master the challenge. Strong perseverance usually pays off in performance accomplishments. (p. 131)

Considering this statement, failures may be considered to have a negative influence on motivation, particularly in relation to people who experience lower levels of efficacy (Bandura, 1989).

2.1.3 Sources of Self-Efficacy

Efficacy beliefs may be fostered through mastery experiences, vicarious experiences, verbal persuasion or emotive states. Bandura (1994; 1997) maintains that the most effective source of self-efficacy beliefs is mastery experiences. When an individual achieves success through a mastery experience, he or she is more likely to be confident in his or her own ability to successfully complete a future task. However, to develop healthy self-efficacy beliefs that persist over time, an individual must have experience in persisting in tasks as well as overcoming difficulties (Bandura, 1994). Bandura (1989) claimed that

...Ordinary social realities are usually strewn with difficulties. They are full of impediments, adversities, failures, setbacks, frustrations, and inequities. Therefore, it takes a resilient sense of self-efficacy to override the numerous dissuading impediments to significant accomplishments. (p. 732)

Interestingly, the nature of the success is therefore relevant. Klassen and Usher (2010) emphasise that mastery experiences are most powerful when an individual is engaged in a challenging task. By contrast, if a person has achieved success with minimal effort, he or she may be discouraged from persisting with a task when he or she encounters failure.

The second source of efficacy identified by Bandura (1984; 1997) is through vicarious experiences and modelling from other people. If a person sees another person, which he or she perceives to have similar capabilities to their own completing a task successfully, this may be a positive source of efficacy beliefs (Fong & Krause, 2012; Klassen & Usher, 2010). On the other hand, if they see failure, it could have a negative influence on these beliefs (Bandura, 1997, 1994).

Verbal persuasion is the third potential source of efficacy beliefs. Bandura (1994) believed that those who are persuaded that they are capable of successfully completing a certain task are more likely to persevere with a given task, even when experiencing bouts of self-doubt. For this situation to be significant, those who are persuading must have qualities that are deemed credible including being competent in the skill themselves and having experience comparing the skills of others (Bandura, 1997). Interestingly, it is when a person is persuaded that they cannot achieve something, that social or verbal persuasion is considered most powerful in influencing personal efficacy (Bandura, 1994). Receiving criticism from someone, for example, may lower self-efficacy beliefs and lead to self-doubt (Fong & Krause, 2012).

The fourth source of efficacy is through a person's reaction and perception of his or her physiological and emotive states. A person's mood and/or his or her perception of the physiological state can play either a positive or negative role on a person's self-efficacy (Bandura, 1997, 1994; Henson, 2001). Individuals who feel emotions such as stress, anxiety and anticipation may be influenced by the feeling when making their own judgements about their ability to complete a task (Klassen & Usher, 2010).

These sources of efficacy information are significant but of equal importance is how an individual cognitively and affectively processes the information. This process is different for every person, and each person will interpret these sources differently (Klassen & Usher, 2010). Processing involves individuals appraising these sources of information in unique ways and considering the role of other factors such as effort, task difficulty and assistance from others (Phan, 2012b). The appraisal is often determined by success or failure in past experiences (Phan, 2012b). Phan and Nyu (2014) highlighted that emotions may also contribute to affective processing of efficacy information, as well as being a source of efficacy information.

2.1.4 Self-Efficacy and its Role in the Teaching Process

Before examining the role of self-efficacy and preservice science teaching, it is firstly important to consider the relationship of self-efficacy to the teaching process in general. The role of teacher efficacy is significant, because it can directly impact on the role of teachers to facilitate student learning. Strong teacher efficacy beliefs are connected with the ability to motivate students and facilitate learning, even when circumstances are not ideal (Klassen & Usher, 2010). Tschannen-Moran et al. (1998) developed a model to summarise teacher efficacy, by analysing research into the nature of teaching efficacy. This model recognised that teaching has the same sources of efficacy information as described by Bandura, which are mastery experiences, verbal persuasion, vicarious experiences, and physiological and emotional states. Following input from these sources, cognitive processing of the teaching task itself and an individual's personal teaching competence occurs (Tschannen-Moran et al., 1998). This processing contributes to a teacher's efficacy beliefs that will then have associated consequences, including persistence in the face of difficulty and effort exerted. These consequences will then have an impact on a teacher's performance, which contributes more sources of efficacy information, and so the process continues (Praetoris, Lauermann, Klassen, Dickhäuser, Janke & Dresel, 2017); Tschannen-Moran et al., 1998).

When examining the context of a primary school, it is important to distinguish between general teaching efficacy and situation specific efficacy beliefs. Teachers may have an overall healthy general teaching efficacy, in that they are confident in their abilities

to create a positive learning environment, manage classroom behaviour, give instructions and contribute to student learning. However, these same teachers may have negative efficacy beliefs about their abilities to teach in a specific learning area, a different environment or even in relation to different aspects of teaching such as classroom management (Berg & Smith, 2016; Tschannen-Moran et al., 1998). Efficacy beliefs are therefore context and subject specific (Bursal, 2012).

Stage of career development is also important when examining teaching efficacy beliefs. It is considered difficult to impact on the personal teaching efficacy of experienced teachers, which have been solidified with time and experience (Berg & Smith, 2016; Henson, 2001). To support this, research conducted by Tschannen-Moran and McMaster (2009) showed that impacting the personal teaching efficacy of practising teachers through a professional development program is highly complex. This research identified that the only source to significantly improve teaching self-efficacy was an authentic, task-specific mastery experience, with verbal persuasion and vicarious experience having little significance. In contrast, several researchers argue that self-efficacy beliefs are most malleable during preservice teacher education, and therefore there needs to be investment in developing strong teaching efficacy beliefs during this period of development (Berg & Smith, 2016; Labone, 2004; Menon & Sadler, 2016). Teaching efficacy beliefs are therefore not stable over time and different career stages are considered less stable than others (Praetoris et al., 2017).

There have been several key findings exploring the impact of self-efficacy beliefs on the teaching process. If a person perceives that he or she has the personal capabilities to perform effective instructional practices, it is more likely that his or her students will achieve the desired learning outcomes (Edwards, Higley, Zeruth & Murphy, 2007). Research has highlighted the positive correlation between student engagement and teacher self-efficacy (Guo, Justice, Sawyer & Tompkins, 2011). Strong teaching efficacy beliefs are also associated with higher levels of teacher enthusiasm (Praetoris et al., 2017; Skaalvik & Skaalvik, 2010).

As teachers work collectively in a staff as part of a school, this can impact on an individual's sense of teaching efficacy. If the culture permeating a school is negative, focusing on the limited role of teachers in assisting or improving student learning, then

it is likely that an individual teacher in that school will be negatively influenced in terms of his or her personal efficacy (Bandura, 1994). On the other hand, a high level of collective efficacy in a school environment raises expectations about what can be achieved, and individuals demonstrate more resilience in meeting these expectations (Goddard, Hoy & Woolfolk Hoy, 2004). Collective efficacy is also considered a protective factor for teachers handling stress (Klassen, 2010). High collective teacher efficacy is identified as a significant predictor of high personal teaching efficacy for individual teachers within that school (Goddard & Goddard, 2001). Collective efficacy is fostered by professional networks, which in turn can positively influence student achievement (Moolenaar, Slegers & Daly, 2012). Bandura (1993) also has found a positive correlation between perceived collective efficacy and student achievement. When examining teaching efficacy, it is important to consider the role of collective efficacy and the differences that exist within various school environments.

2.1.5 Significance and Gaps in Teacher Efficacy Research

It is important to establish the significance of this current study in the broader framework of the key literature relating to self-efficacy. As discussed in this section of the chapter, individuals have agency in their own lives and form beliefs about their capabilities to complete given tasks, which is referred to as self-efficacy. Self-efficacy beliefs are formed through the cognitive processing of different sources of information, which include mastery experiences, verbal persuasion, vicarious experiences, and emotional and physiological states. In the context of teaching, high self-efficacy beliefs have been found to correlate with teacher enthusiasm, student achievement and student engagement. However, teaching efficacy beliefs are context and situation specific, and can vary at different stages of career development, hence the significance of exploring science teaching efficacy beliefs of preservice teachers.

Several gaps exist in the literature. Most teaching efficacy research has been conducted in North America (Berg & Smith, 2016; Klassen & Usher, 2010). In their review of teaching efficacy research, Klassen and Usher (2010) found that only 4% of all teaching efficacy studies occurred in Australia. This highlights an area of development for researchers in Australia (Berg & Smith, 2016). Also of significance

is the emphasis on quantitative research in self-efficacy research (Berg & Smith, 2016; Klassen & Usher, 2010; Labone, 2004). This constitutes an important gap in the literature, as qualitative approaches have the potential to offer complex and rich explanations for phenomena (Berg & Smith, 2016; Klassen & Usher, 2010). Longitudinal approaches to teaching efficacy research are also underrepresented in the literature (Phan, 2012; Praetoris et al., 2017), which limits the ability to understand changes in self-efficacy beliefs over time and what factors might contribute to these changing beliefs. This current study is situated in the Australian context and has been designed using a longitudinal and qualitative dominant mixed methods design.

2.2 Teaching Efficacy Beliefs of Preservice Teachers

It has been established that research into exploring efficacy beliefs is important to examine in the teaching process. Prior to specifically examining the science teaching efficacy beliefs of preservice teachers, it is important to consider the wider general teaching efficacy beliefs that preservice teachers possess. As self-efficacy is a substructure of an individual's belief system and teaching efficacy beliefs are interrelated to improved student engagement and learning, self-efficacy beliefs must form part of teacher education programs. According to Haney and McArthur (2002), "excluding teacher beliefs from any teacher training experience is tantamount to ignoring the importance of prior knowledge in student learning" (p. 800). This is particularly important as efficacy beliefs are less stable during this stage of development, and therefore initial teacher education may positively contribute to healthy teaching efficacy beliefs (Berg & Smith, 2016). Bandura (1997) believed that a difference exists between preparatory efficacy, or the development of skills, and performance efficacy, which is the use of established skills. The preservice stage of teaching could be considered as a preparatory efficacy stage of development.

This section of the chapter will examine key literature in the area of preservice teaching efficacy beliefs. It briefly discusses how personal qualities influence developing teaching efficacy beliefs and how universities need to consider these efficacy beliefs when designing courses. Research into the science teaching efficacy beliefs of preservice teachers as they enter science education units will then be presented,

narrowing the scope of the current study. Finally, contextual factors that influence these science teaching efficacy beliefs will be presented.

2.2.1 Teaching Efficacy Beliefs in Teacher Education Programs

Several studies have focused on identifying the teacher efficacy beliefs of preservice teachers. Results from these studies can be inconsistent, which can be partially explained by the vast differences in contextual factors influencing teacher education programs globally (Berg & Smith, 2016). In an Australian study examining the self-efficacy of preservice teachers, Pendergast, Garvis and Keogh (2011) argued that preservice teachers come into a teaching degree overestimating their personal teacher efficacy, possibly due to their own experiences of schooling or positive emotional arousal due to their excitement in entering a teacher education program. The first stage of their longitudinal research showed a decline in the self-efficacy of preservice teachers enrolled in one-year graduate diploma degrees in relation to instructional strategies, classroom management and student engagement from the first semester of their teaching degree to the second semester, which included a 7-week practical experience. Interestingly, those enrolled in the early childhood degree had higher levels of personal teaching efficacy at both points in the study, which the authors argue could relate to the participants' external work experiences that allowed them to gain mastery experiences, which included experience in day care centres (Pendergast, Garvis & Keogh, 2011).

In contrast to these results, in a different cross-sectional study, it was found that primary preservice teachers at various stage of their degree did not exhibit significant differences in their personal and general teaching efficacy (Woodcock, 2011). This led the researcher to question the impact of teacher education courses on the improvement of preservice teachers' teaching efficacy. However, authors of a multiple country study that examined the teaching efficacy of preservice teachers at the beginning of a unit on inclusive education, and for some countries, the beginning of their teaching degree, identified that using current levels of teaching efficacy can assist teacher educators in knowing students' understandings and beliefs. This therefore assists teacher educators in developing meaningful and appropriate teaching and learning experiences (Loreman, Sharma & Forlin, 2013).

A study by Edwards et al. (2007) identified that preservice teachers at the end of their degree experienced higher levels of confidence in their abilities to use more traditional pedagogical approaches but had lower levels of self-efficacy in relation to being a facilitator or agent of change in their classrooms. These researchers argued that tertiary educators involved in teacher preparation need to foster experiences that will assist students in developing a repertoire of strategies and ideas about more student-centred pedagogical approaches. Self-efficacy beliefs have also been identified as a significant predictor in relation to preservice teachers using cognitive and metacognitive strategies with the aim of facilitating conceptual change (Saçkes & Trundle, 2014).

The actual design of a teaching degree may have an impact on developing teacher efficacy. One study identified that successful field or practical experiences linked to coursework were considered to have the most impact on a preservice teacher's self-efficacy and confidence (Yost, 2006). Another study found that carefully designed coursework in the context of inclusive education increased the self-efficacy beliefs of preservice teachers (Sharma, 2012). Tuchmann and Isaacs' (2011) study recognised that universities prepare preservice teachers well in relation to instructional practices, which led to higher level of efficacy beliefs. Another research study investigated whether enrolling in an early childhood or elementary degree would influence preservice teacher efficacy (Ling, Hazareesingh, Taylor, Gorrell & Carlson, 2001). The results of this cross-institution study saw that completing courses in both degrees changed the perceptions of the preservice teachers from initially focusing on the traditional conceptions of teaching to more facilitative, constructivist approaches at the end of the degree. This change in perception correlated with higher levels of perceived teacher efficacy (Ling et al., 2001).

Preservice teachers enter initial teacher programs with varying levels of general and specific teaching efficacy beliefs. An individual's own personality and qualities influences their self-efficacy beliefs. The self-efficacy of preservice teachers may be influenced by personal motivation, and personality characteristics such as humour and capability (Poulou, 2007). Experiencing self-doubt may be considered advantageous in a preparatory efficacy stage of development, such as teacher education. Bandura (1997) suggested that doubt can manifest as a decrease in perceived self-efficacy, but

this should be considered a natural and desirable part of growth as teachers develop new skills. This is supported by research by Tschannen-Moran and McMaster (2009). The self-efficacy beliefs of preservice teachers as learners can influence the qualities that they require in their instructors (Komarraju, 2013).

Understanding teacher efficacy beliefs is significant when considering the program structure of teacher education degrees. In order to assist universities to plan for extra development opportunities or redevelop their coursework and practical experiences to help increase their self-efficacy, it is important to determine what information preservice teachers use that influences their personal efficacy (O'Neill & Stephenson, 2012). Labone (2004) suggested that in order to develop teachers with resilient and positive efficacy beliefs, diverse contextual conditions need to be provided within a teaching degree. This obviously highlights the role of teacher educators in determining these efficacy beliefs so that appropriate learning experiences can be provided (Pendergast, Garvis & Keogh, 2011).

2.2.2 Science Teaching Efficacy of Preservice Teachers

Preservice teachers enrolled in early childhood and primary teaching degrees are trained to be generalists during their studies as they learn the content and pedagogy of all learning areas. In the context of science teaching efficacy beliefs of preservice teachers, personal teaching efficacy influences these individuals in two differing ways. The first is that these preservice teachers are in fact still students, so their self-belief in their own learning capabilities will impact on their academic performance (Bandura, 1993). In this context, the preservice teachers' self-beliefs about their abilities to learn science will impact on their learning of science content and pedagogy necessary for teaching science in primary school. Their prior experiences in learning science in their primary and high school years will have had a significant impact on these efficacy beliefs and these beliefs would have been influenced by their perceptions of content difficulty, the learning environment, the teacher, assessment procedures and even their peers (Bandura, 1994). Secondly, these individuals are developing teachers and "teachers' beliefs in their personal efficacy to motivate and promote learning affect the types of learning environments they create and the level of academic progress their students achieve" (Bandura, 1993 p. 117). In relation to science teaching, these

preservice teachers would be conscious of their ability to implement the curriculum, use appropriate pedagogical skills, support and accurately assess student learning, develop a positive learning environment and effectively use resources. Both aspects are important considerations when examining the science teaching efficacy beliefs of preservice teachers.

Preservice teachers begin science units with pre-existing views about science education. These views relate to nature of science, what science teaching is like and what science learning should be like (Abell & Bryan, 1997; Hubbard & Abell, 2005). In exploring the metaphors that preservice teachers applied to the teaching of science, research by Cassel and Vincent (2011) reported that many preservice teachers think of science as an area that facilitates exploration and inquiry. Similarly, research by Hubbard and Abell (2005) found that many preservice teachers believe science should be hands on, fun, and about discovery. This view of science was regardless of the preservice teachers' previous science experiences, which were overwhelming characterised as negative (Hubbard & Abell, 2005).

Science teaching efficacy can be defined as “the belief that one has the ability to teach science effectively (personal science teaching efficacy) and the belief that one’s students can learn science (science teaching outcome expectancy)” (Kazempour, 2014, p. 80). There is a substantial body of research into science teaching efficacy beliefs of preservice teachers. This research has highlighted that preservice teachers enrolled in early childhood or primary degrees often have low science teaching efficacy beliefs at the start of a science education unit (Bleicher, 2007; Buss, 2010; Hechter, 2011; Yoon, Pedretti, Bencze, Hewitt, Perris & Van Oostveen, 2006). Mulholland and Wallace (2000) claimed that these low efficacy beliefs are a result of being *non-science people*, which is challenging as early childhood and primary teachers are required to teach all learning areas, with each having its own approach and focus. Moscovici and Osisoma (2008) maintained that some preservice elementary teachers experience *sciencephobia* at various levels, which the authors believed stemmed from unsuccessful science learning in the past. Research conducted by Buss (2010) found that preservice teachers had lower levels of teaching efficacy in science and mathematics compared to other learning areas. Data from another research study showed that while most preservice teachers entered a science methods course with weak science backgrounds, all

students, regardless of their ability, expressed concerns about their abilities to teach science to children (Bleicher & Lindgren, 2005). However, when preservice teachers possess strong science teaching efficacy beliefs, there has been association with a more positive attitude towards science teaching (Senler, 2016).

In analysing data from preservice teachers involved in a science methods unit, Palmer (2006b, p. 345) broadened Bandura's focus of sources of efficacy into the following categories:

1. Enactive mastery (i.e., a successful experience teaching a child);
2. Cognitive content mastery (i.e., a successful learning experience involving the understanding of science concepts);
3. Cognitive pedagogical mastery (i.e., a successful learning experience involving the understanding of science teaching techniques);
4. Unspecified cognitive mastery (i.e., a successful learning experience was indicated, but whether it was content or pedagogy could not be established);
5. Cognitive self-modelling (i.e., students imagined themselves teaching);
6. Simulated modelling (i.e., role playing a primary class);
7. Verbal persuasion (i.e., students received feedback that their teaching was successful);
8. Physiological/ affective states (i.e., coping with stress, fear and anxiety);
9. Other (i.e., students whose responses could not be categorised).

This expansion of Bandura's sources of efficacy information takes into consideration specific and distinctive aspects of science teaching in the context of completing science units at university. It is representative of the dual roles of learner and developing teacher that preservice teachers demonstrate when completing a science unit.

2.2.3 Contextual Influences and their Contribution to Science Efficacy Beliefs

Many studies discuss the contextual influences that impact on the science self-efficacy beliefs of preservice teachers. Hancock and Gallard (2004) found that previous science experiences, content of university methods courses, cultural norms for teaching practice and current practical experiences influence the self-efficacy of preservice teachers. Other influences include age, family, school, gender and post compulsory studies. Van Aalderen-Smeets, Walma van der Molen and Asma (2011) argued that

The amount of dependency on context factors that teachers perceive is a stronger prediction of the intention to teach than their general beliefs about the influence of

these factors on teaching. The perceived influence of context factors is more descriptive, but says nothing about whether teachers believe and feel that these context factors play a role in whether or not they will teach science. (p. 176)

It is, therefore, not simply the influence in itself that seems to impact on science teaching efficacy. Rather, it is the way that the person perceives these influences themselves that is considered significant.

Studies focusing on the difference between the self-efficacy of males and females in personal science teaching efficacy are varied. Research conducted by Bayraktar (2011) found no statistical difference between males and females, also supported by research by Mulholland, Dorman and Odgers (2004) and Yilmaz and Çavaş (2008). However, other studies have reported males demonstrating higher science self-efficacy than females (Bleicher, 2004; Cantrell, Young & Moore, 2003; Lumpe et al., 2012; Odgers, 2007).

Another variable that may impact on science teaching self-efficacy is age. Although a majority of preservice teachers enter undergraduate teacher education programs straight after high school or in their early twenties, others may enter as a career change or following the birth of children. Data collected by Odgers (2007) identified a correlation between age and science learning. In this study, preservice teachers who were older, that is, not directly out of high school, valued science learning more than the younger preservice teachers. Science educators may also need to consider the cultural values that preservice teachers bring into the class, as these may influence how they view the science teaching and learning process (Akerson & Donnelly, 2008).

Previous experiences of science teaching and learning are often identified as significant in relation to the science teaching efficacy beliefs of preservice teachers. Thomas and Pedersen (2003) argued that preservice teachers bring with them memories of their own experiences with science that impact on their learning of science at university. Research conducted to examine science teaching efficacy of teachers in several Western Australian schools found that positive prior experiences of science and science teachers, particularly when the participants were in school and also university, had a positive impact on the personal science teaching efficacy of these teachers (Mansfield & Woods-McConney, 2012). Research conducted on secondary

preservice teachers and their memories of their secondary science experiences showed that a science teacher's enthusiasm, and positive attitude towards science were particularly memorable, as was the ability to explain concepts and provide hands-on experiences (Hudson, Usak, Fancovicova, Erdgoan & Prokop, 2010). Gunning and Mensah (2011) noted that for preservice primary teachers who did not identify as science teachers, the main reason for this identity was their lack of experience with science, in the form of either lacking content or practical experience with this area.

The amount or quality of science previously studied is another contextual influence to examine. Goodrum, Druham and Abbs (2011) have identified that only half of the Australian Year 12 cohort studied a science subject in 2010. This has decreased from approximately 90% in the early 1990s and these researchers maintained that more needs to be done by education authorities to engage students with science during prior years of schooling (Goodrum, Druham & Abbs, 2011). This research is supported by another study that found that there was a declining participation in academically demanding science subjects between 1986 and 2012 (Hackling, Murcia, West & Anderson, 2014). Another study has identified that there are sex differences in relation to participation in science subjects in high school, with more males choosing Biology and Physics, and more females enrolled in Earth Sciences (Kennedy, Lyons & Quinn, 2014). These authors maintained that post-compulsory science is still in decline, suggesting that possible reasons for this include broadening of the curriculum in these years and a reduction in the minimal number of required subjects for students to complete for graduation from high school (Kennedy et al., 2014). It has also been recognised that students in Australia have less positive attitudes towards science than many other countries and that there is a significant decrease in attitude from primary to secondary science (Hackling et al., 2014).

In this context, it is interesting to examine how experiences of high school science influence science teaching efficacy beliefs. In an Australian study, Odgers (2007) showed a link between studying two subjects of science in high school, one of which was chemistry or physics, and higher levels of self-efficacy. This same study revealed almost one third of preservice teachers completed no high school science (Odgers, 2007). Interestingly, in a different study, preservice teachers identified their science

content knowledge as a limiting factor in the development of science teaching efficacy (Swars & Dooley, 2011).

Numerous aspects may impact on whether preservice teachers perceive their prior science experience as positive or negative, but the key aspect is whether students are engaged with the coursework and instructor. Hechter (2011) suggests that it is not poor achievement, for example, in itself that impacts on self-efficacy, but rather it is how a student perceives this poor achievement. The quality of the science course is considered important, as identified by longitudinal research conducted by Mulholland and Wallace (2002). This study involved participants who completed science subjects in high school, but whose experiences led them to feel less confident about their abilities to succeed in science. Participants attributed their challenges to finding the content difficult, lack of engagement in the area and having teachers who did not support their learning (Mulholland & Wallace, 2002).

The number of science units studied at university level and the influence on science teaching efficacy has also been explored. Odgers (2007), Utley, Moseley and Bryant (2005), and Mulholland et al., (2004) identified links between the number of science education units completed as part of a university degree and self-efficacy. In research from the Netherlands, a high level of science content knowledge was connected to higher self-efficacy (Velthuis, Fisser & Pieters, 2014). Research by Yilmaz-Tuzun (2008) discovered a correlation between the self-efficacy beliefs of preservice teachers in relation to teaching methods, classroom management and science content, and the number of science content courses taken at university. Another study found that most preservice teachers did not select any post-secondary science courses, other than those required as part of their degree while at university, which possibly impacted their personal science teaching efficacy (Hechter, 2011).

2.2.4 Significance and Gaps in Preservice Teacher Efficacy Research

Teaching efficacy beliefs are considered less resistant to change during teacher education programs than for practising teachers. Due to the connection between teaching efficacy beliefs and student engagement and learning and recognising that teaching efficacy beliefs are malleable during preservice teacher development these

beliefs need to be considered when developing approaches to teaching degrees. Teaching efficacy beliefs are influenced by personal characteristics such as motivation and capability. However, research is mixed in relation to the impact of teacher preparation program on teaching efficacy beliefs, which is often attributed to personal contextual factors.

There is a substantial body of research that highlights the preservice teachers often begin science education units with low levels of science teaching efficacy beliefs. Contextual factors have contributed to these beliefs, such as the relationship between gender and age on science teaching efficacy beliefs. However, one significant factor that enhanced these beliefs was the previous positive experiences of science during school or university. In contrast, negative prior experiences of science may hinder the development of healthy science teaching efficacy beliefs.

To support the significance of this current study, the following quote from Tschannen-Moran and Woolfolk Hoy (2007) outlined the importance of research into the self-efficacy beliefs of preservice teachers:

Teachers entering the field have typically experienced “apprenticeships” of at least 17 years as students. What are the qualities of the teachers they remember and what is the impact of these memories on preservice teachers’ developing sense of efficacy as teachers? Likewise, what is the impact of modelling by university professors and by cooperating teachers during student teaching? (p. 954)

Preservice teachers, unlike undergraduate students entering into other courses at university, have been informal apprentices during their own school experiences. They therefore enter teacher education courses with a range of beliefs and experiences which will impact their ability to learn and teach. The questions raised by Tschannen-Moran and Woolfolk Hoy in the above quote are addressed in this current study, in the context of science education.

The literature points to areas for further study. Several researchers have highlighted the importance of longitudinal research in the area of preservice science teaching efficacy beliefs (Bleicher, 2007; Bryan, 2003; Cantrell, Young & Moore, 2003; Cone, 2009a; Palmer, 2011). Andersen, Dragsted, Evans and Sørensen (2004) suggested that opportunities to follow new teachers from their teacher education institutions into their

first years of teaching may be both mutually beneficial to the teacher and the institution.

Exploring the role of contextual factors and how these factors influence teaching efficacy beliefs have also been identified as important future areas of research. Seo (2016) argues that more longitudinal studies that explore how contextual factors impact and modify efficacy beliefs of preservice teachers is an important area to pursue. Similarly, Pajares (1996) suggested that more longitudinal and cross-sectional research is required in this area to explore the role of factors such as age, family and school influences in the development of personal self-efficacy.

2.3 Preservice Science Preparation

It has been established that preservice teachers enter science education units with low levels of science teaching efficacy beliefs. The following discussion explains how science education fits into requirements of initial teacher education programs in Australia in relation to tertiary units and practical experience. Research is then presented that explores how science education units and science teacher educators impact on the science teaching efficacy beliefs of preservice teachers. The final discussion reflects on the role of practical experiences on these developing beliefs and presents key research into this area.

2.3.1 Science in Australian Initial Teacher Education Programs

Through the completion of a nationally accredited teaching program, it is expected that graduate teachers will be able to demonstrate key knowledge and skills required for teaching in Australian schools (O'Meara, 2011). The *Australian Professional Standards for Teachers* articulate what teachers should know and be able to do at various career stages, with the aim for enhancing the professionalism and status of teaching in Australia (AITSL, 2011b). Whilst written in general terms, these standards give guidance of expectations of early career teachers. One key expectation is that "graduate teachers have an understanding of their subject/s, curriculum content and teaching strategies" (AITSL, 2011b, p. 5).

Accompanying the *Australian Professional Standards for Teachers* is the document *Accreditation of Initial Teacher Education Programs in Australia*, which describes the characteristics of teacher education programs that are necessary for preservice teachers to meet the graduate standards (AITSL, 2011a). In relation to early childhood and primary education, teacher education programs need to prepare preservice teachers for all of the learning areas in the school curriculum in various contexts (AITSL, 2011a).

However, the document also establishes the requirements for the science learning area. Initial primary teacher education programs need to contain “at least one-eighth of a year of full-time equivalent study of discipline-specific curriculum and pedagogical studies in science” (AITSL, 2011a, p. 13), equivalent to two science units within an undergraduate education degree and one unit for a two-year graduate entry program. Tertiary providers are able to respond to their own context when organising course structure (AITSL, 2011a). Universities are also able to make the decision to have purely science discipline units or science pedagogy units, or they are able to integrate them (AITSL, 2011a). While this allows universities to cater for the specific needs of their context, this also leads to inconsistencies between states and universities (Treagust, Won, Petersen & Wynne, 2015).

Another necessary element of initial teacher education programs in Australia is practical experience which provide important learning opportunities for preservice teachers by allowing them to connect theory with practice (Onnismaa, Tahkokallio & Kalliala, 2015). In Australia, preservice teachers must be involved in a minimum of 80 days of practical experience for undergraduate degrees, or 60 days for postgraduate programs (AITSL, 2011a). No specific requirement is included within the AITSL document to indicate whether science needs to be taught during practical experiences (Treagust et al., 2015). A report by Rowley, Kos, Raban, Fler, Cullen & Elliot (2011) emphasised that there is significant variance between tertiary teacher education providers in terms of how practical experience is provided and the length of time of such experiences. There is also a lack of commonality in terms of teaching requirements and how preservice teachers are assessed within these practical experiences (Rowley et al., 2011).

A recent initiative in Australia is for teacher education programs offering early childhood degrees to have their courses approved by Australian Children's Education and Care Quality Authority (ACECQA). This has implications for the structure of courses, units and practical experience offered within early childhood degrees in Australia. Early childhood initial teacher programs need to include a mix of learning theories, pedagogy, professional studies, practical experiences, cultural studies and curriculum studies, including science (ACECQA, 2013). Again, the structure of early childhood degrees varies considerably across the country. There have been concerns raised about how much early childhood pedagogy and curriculum are embedded within these courses, particularly within learning area units that combine early childhood and primary preservice teachers (Rowley et al., 2011).

Like the AITSL (2011b) requirements, preservice early childhood degrees need to provide 80 days of practical experience, but ACECQA (2013) stipulates that of this experience, 10 days must be with children from birth to age two, a significant number of days allocated to working with children between the ages of two and five, and the remaining with children over age five. In research conducted by Garvis, Lemon, Pendergast and Yim (2013), Australian universities are in their infancy in terms of providing quality practical experience for children from birth to age three. In a recent study, preservice teachers expressed high levels of dissatisfaction with practical experiences with this age group (Rouse, Morrissey & Rahimi, 2012). However, benefits of high quality experiences with this age of students has benefits for preservice early childhood teachers including connecting their knowledge of how young children learn in different environments (Garvis et al., 2013).

In 2014, an Australian report was released that examined features of high quality teacher education programs (Teacher Education Ministerial Advisory Group, 2014). This report highlighted several recommendations including primary teachers specialising in mathematics, science or a language, having structured and integrated practical experiences, and the importance of rigorous induction in schools (Teacher Education Ministerial Advisory Group, 2014). Other key recommendations were the importance of using research-based approaches with preservice teachers, and the balance of teaching content knowledge and pedagogy (Teacher Education Ministerial Advisory Group, 2014).

There are renewed calls for ongoing changes for science in initial education programs. There are calls for universities to train more science specialists for Australian primary schools (Prinsley & Johnston, 2015; Treagust, Won, Petersen & Wynne, 2015). Some universities are creating specialisation pathways for primary preservice teachers in science, which is delivered through collaboration between education and science faculties (Dinham, 2014; Pesina & Carroll, 2014). There have also been calls to ensure that universities employ discipline experts to teach discipline areas and pedagogical experts to teach pedagogy to preservice teachers (Prinsley & Johnston, 2015).

The next sections of this chapter will explore in detail how aspects of teacher education programs can affect the science teaching efficacy beliefs of preservice teachers. These aspects are science education units, science teacher educators and practical experiences.

2.3.2 Science Education Units

A focus on teacher beliefs must be at the core of science education programs, running parallel to efforts to improve pedagogical content knowledge (Milner, Sondergeld, Demir, Johnson & Czerniak, 2012). Buss (2010) argued that a primary aim of a teaching degree should be assisting preservice students to develop confidence in teaching science. Tertiary science education for preservice teachers may take different forms. One way that universities may prepare preservice teachers is through the provision of science content units which primarily aim to increase science content knowledge. However, there have been mixed results in relation to the impact of science content courses on science teaching efficacy. Interestingly, the results of a study conducted by Morrell and Carroll (2003) saw no statistical increase in science teaching efficacy of preservice teachers following the completion of a science content course. A Turkish study found that preservice teachers felt confident in their knowledge of science topics, perhaps as a result of the science content courses they completed at a post-secondary level as part of their degree, which included biology, chemistry and physics (Bayraktar, 2011).

More recent studies have highlighted that tailoring science content courses to the needs of preservice teachers may positively influence science teaching efficacy beliefs. In

an Australian study, Palmer et al. (2015) found that a science content course tailored specifically to meet the needs of preservice primary teachers did enhance the science self-efficacy of participants. This increase remained stable for ten months following the course. This is supported by research from Menon and Sadler (2017), who identified that a science content course in physics, aimed specifically at early childhood and primary preservice teachers, positively influenced the science teaching efficacy beliefs of all participants. This was regardless of whether participants began the unit experiencing low, medium or high science teaching efficacy beliefs (Menon & Sadler, 2017). The researchers found that the science teaching efficacy gains were due to participants experiencing an increased confidence to teach science, a positive shift in attitude towards science, feelings of engagement when learning science in the unit, a strong science teaching role model and the development of ideas for how they would incorporate science in their classroom into the future.

In contrast to science content units, science methods units are generally included within most teaching degrees. As opposed to science content units, which aim to improve science content knowledge, science methods units are designed to focus on improving both the content knowledge and teaching skills in relation to teaching science. As a result of this approach, the same amount of content is not covered, but the purpose of science methods units is to assist preservice teachers with proven approaches and practical strategies to assist them when teaching science in a classroom, thus improving their pedagogical content knowledge (Howitt, 2007). The remaining discussion in this section will concentrate principally on science methods units, due to their relevance to the current study.

Even in the case of negative prior experiences with science, a well-designed science methods course may increase the confidence of preservice teachers when learning science and may also impact on their future teaching of science (Bleicher, 2007). This finding is supported by further research, which demonstrated that students who began a science methods unit as *fearful* or *disinterested* and with low levels of science teaching efficacy, completed it indicating much higher levels of self-efficacy beliefs (Bleicher, 2009). Interestingly, Palmer (2006a) identified no significant change in science teaching self-efficacy levels of preservice teachers from immediately after a science methods unit to nine months later. He argued that if a carefully thought out

science methods course is completed one year before the end of a degree, a higher level of science teaching efficacy can persist into the first years of teaching.

Several aspects of science methods units have been found to increase science teaching efficacy of preservice teachers. One key feature related to the overall structure of the unit. A carefully planned science methods unit has been found to increase both personal science teaching efficacy and outcome expectancy (Brand & Wilkins, 2007). Units designed to help preservice teachers learn content, increase pedagogical knowledge and be involved in simulated modelling have also enhanced science teaching efficacy beliefs (Palmer, 2006b). Bleicher and Lindgren (2005) argue that while many academics believe there should be more science methods units included in a preservice degree, instead the focus should be on the actual design of the methods course by including opportunities for experiential learning, discussion and reflection.

Other aspects can be influential to enhancing science teaching efficacy of preservice teachers. One aspect that was shown to increase science teaching efficacy was actually seeing children engaged, motivated and thinking during science methods units (Swars & Dooley, 2011). Cooper, Kenny and Fraser (2012) identified that utilising a quality teaching and learning resource during science methods units increased the science teaching efficacy of preservice teachers. This was regardless of the preservice teachers' experience of using the materials and previous negative science experiences (Cooper et al., 2012). Cone (2009b) found that incorporating service learning into a science methods course had a positive impact on preservice teachers' outcome expectancy but had no effect on their personal efficacy. Authentic assessment and providing opportunities for discussion may also increase the science teaching efficacy beliefs of preservice teachers (Gunning & Mensah, 2011).

The learning environment can also be significant in enhancing science teaching efficacy of preservice teachers. One study found that a science methods unit that allowed preservice teachers to experience an authentic science learning environment helped the participants "see the world through the eyes of a child" (Howitt & Venville, 2009, p. 227). According to these authors, science methods units should assist preservice teachers to re-connect with science by providing them with opportunities to experience wonder and curiosity (Howitt & Venville, 2009). Some studies have also

identified that science methods units that have used exemplars of science teaching can increase the science teaching self-efficacy of participants (Buss, 2010; Yoon, Pedretti, Bencze, Hewitt, Perris & Van Oostveen, 2006).

Science methods units can have many varying approaches and therefore different sources of teaching efficacy may be influential. Bautista (2011) researched the impact of a science methods course for early childhood education majors designed to focus exclusively on providing mastery and vicarious experiences. Results from this study indicated that the course positively impacted on both outcome expectancy and science teaching self-efficacy (Bautista, 2011). Brand and Wilkins (2007) found that preservice teachers reported that providing mastery experiences was instrumental in their development, although stress reduction, vicarious experiences and social persuasion were also present in their findings.

Most science methods courses focus on incorporating an inquiry approach. This is often used to introduce preservice teachers to the scientific process, with the aim that this will be incorporated by the preservice teachers themselves when teaching science. Some studies have explored whether a science methods course that incorporated an inquiry approach impacted on the science-teaching efficacy of preservice teachers. Qualitative data showed that a science methods course designed to focus on science inquiry positively impacted on preservice teachers' perceptions of teaching and learning science (Varma, Volkman & Haniscin, 2009), which is further supported by research conducted by Smolleck and Voder (2009). This outcome was despite the fact that most of the participants reported feeling frustrated when initially being immersed in the science inquiry process (Varma et al., 2009). Varma et al. (2009) suggested that this feeling related to their lack of prior positive science experiences, self-doubt about learning science and their desire for specific and explicit instruction about how to teach science.

Research on the impact of using an inquiry approach on science teaching efficacy of preservice teachers has produced varied findings. One study that involved preservice teachers in an inquiry-based science methods unit produced interesting changes in the science teaching efficacy of preservice teachers (Avery & Meyer, 2012). There were two distinct groups in terms of their science teaching efficacy at the end of the unit,

one group that seemed to have their science outlook improving and the other worsening, with the second group often beginning with higher than average levels of science teaching efficacy. This led the researchers to question whether different types of students benefit from different approaches to teaching and learning about science (Avery & Meyer, 2012). A Western Australian study showed some second-year preservice teachers actually decreased in their science teaching efficacy beliefs after completing a science methods unit on inquiry learning (Pepper, 2013). Another study saw that a science methods unit impacted on preservice teachers in that they moved from a teacher directed view of science teaching to a more student-centred view (Ucar, 2012). Ling and Richardson (2009) found that by engaging students in a science methods unit that focused on inquiry led to improvements in personal science teaching efficacy, but not in science teaching outcome expectancy as measured by the STEBI-B. The authors of this study believed that this was due to where this unit was placed within the teaching degree because it was early on in their degree program and preservice teachers had little teaching experience (Ling & Richardson, 2009).

In some universities, there has been an attempt to deliberately integrate science methods units and a practical experience. Science methods units should be integrated with practical experiences in order to support the development of preservice teachers (Leonard, Barnes-Johnson, Dantley & Kimber, 2011). Research conducted by Swars and Dooley (2011) found that meaningfully integrating science coursework and a practicum led to significant increases in science teaching self-efficacy. Another study that incorporated both a science method unit and practicum recognised that preservice teachers need opportunities and scaffolding to trial using inquiry methods at this stage of development (Smolleck & Morgan, 2011). Experiencing success with this during practical experiences was critical to how participants then applied these approaches in their early careers (Smollet & Morgan, 2011).

One way that some Australian universities have responded to concerns about the low science teaching efficacy experienced by preservice teachers is to investigate the effectiveness of school-based approaches to science teacher education (The Steps Project, 2015). The five universities involved in this project have locally developed approaches to the preservice teacher science curriculum with the aim to increase confidence and pedagogical content knowledge. While each university approaches

this differently, the common focus is to bridge the theory-practice gap, in a way that has schools and academics in partnership (The Steps Project, 2015). In each of the courses, preservice teachers plan and implement science lessons with children, supported by partner teachers and their teacher educators (The Steps Project, 2015). Several researchers have examined the benefits of exploring alternate models to promoting science teaching efficacy beliefs. In an Australian study that explored the impact of professional development offered by a science centre on the self-efficacy of preservice and inservice teachers, the researchers found that offering professional development in science education in an informal setting, such as a science centre, may have positive ramifications for developing science teaching efficacy (McKinnon & Lamberts, 2013). Jones (2008) argued that professional development planned jointly for preservice and inservice teachers could have positive implications for the science teaching efficacy beliefs of both groups of teachers.

2.3.3 The Role of Science Teacher Educators

As it has been established, science methods units can have an impact on the science teaching efficacy of preservice teachers. Therefore, the role of the science teacher educator is paramount (Howitt, 2007). The responsibilities of a teacher educator are quite broad, but several researchers believe that they have a direct impact on developing efficacy beliefs of preservice teachers. Poulou (2007) argued that the teacher educators may help preservice teachers achieve *calibration* by assisting them to find a match between their personal beliefs and their own capabilities. This may involve either helping preservice teachers reduce negative beliefs or promoting the positive or realistic aspects of their teaching performance (Poulou, 2007). Preservice teachers experience differences in terms of their efficacy beliefs, motivation and other aspects of their personality, which may require teacher educators to adjust their own characteristics to meet their needs (Komarraju, 2013). Teacher educators need to recognise the challenges preservice teachers face, check up on them periodically throughout a unit, and provide them with quality and ongoing feedback to successfully assist them with their development (Taylor & Ntoumanis, 2007).

Science teacher educators are responsible for planning the teaching and learning experience within the units, providing feedback to impact on performance, and

modelling effective science teaching practices. Implications of research conducted by Mansfield and Woods-McConney (2012) emphasised the role of science teacher educators as assisting students to seek out collaboration with other teachers in science, and to provide science teaching experiences, in order to maximise opportunities for mastery and vicarious experiences. Teacher educators must understand the science teaching efficacy beliefs of preservice teachers and recognise that these beliefs are most malleable during this stage of career development (Smolleck & Morgan, 2011).

Researchers have identified further qualities of science teacher educators that are considered important and relevant to the developing self-efficacy of preservice teachers. Some positive characteristics that have been previously identified in research are enthusiasm, use of humour, passion for science, and an approachable and friendly nature (Howitt, 2007). Alternatively, in an Australian study, many of the preservice teachers involved reported that their university lecturers and the science methods units that they were involved in were not engaging and idealistic (McKinnon & Lamberts, 2013). The ability of a science teacher educator to model and incorporate innovative teaching strategies also has been found to enhance preservice teachers' science teaching efficacy (Bleicher, 2007). Science teacher educators can positively influence science teaching efficacy beliefs through developing active learning experiences and modelling good teaching strategies (Menon & Sadler, 2017).

Relationships between science teacher educators and preservice teachers have been identified as important to enhancing science teaching efficacy beliefs. Developing a positive relationship with preservice teachers and using effective classroom management strategies have been recognised as contributing to science teaching efficacy beliefs (Hubbard & Abell, 2005; Kettler, 2013; Poulou, 2007). Hubbard and Abell (2005) have suggested that in developing such a relationship with preservice teachers, science teacher educators may actually contribute to preservice teachers only paying lip service to inquiry and constructivist approaches to science education. They argued that preservice teachers may be attempting to appease the science teacher educators by discussing the benefits of using these approaches, but this does not have the revolutionary impact on their actual teaching of science that science educators hope for (Hubbard & Abell, 2005).

2.3.4 The Role of Practical Experiences

The tertiary institution in this present study incorporates a significant amount of practical experience within its four-year education degree. For preservice teachers enrolled in the Bachelor of Education (Primary) degree, this constitutes 32 weeks of experience in Year 1 to 7 classrooms. For those currently enrolled in the Bachelor of Education (Early Childhood and Care) degree, this constitutes 22 weeks in Kindergarten to Year 3 classrooms, plus 10 weeks in a day care centre. The amount of practical experience offered within the degree is considered very attractive to potential preservice teachers and marketed as one reason that the university is superior in relation to the teaching degrees that they offer.

It is perhaps interesting to consider that even with this amount of practical experience for preservice students, it is probable that some students will not view a lot of science being taught. This may be due to the fact that the classroom teacher does not enjoy teaching science or struggles with the demands of an overcrowded curriculum. Another reason could be that many schools in Western Australia now make use of a science specialist teacher, which provides the classroom teacher and preservice teacher time for preparation or marking. However, practical experiences assist with calibrating self-efficacy beliefs and may also contribute to these beliefs becoming durable and resilient (Palmer, 2006a; Poulou, 2007; Labone, 2004).

Additional practical experience does not always correlate with increased science teaching efficacy beliefs. Mulholland and Wallace (2003) identified that for some of the preservice teachers in their study there were seldom opportunities for viewing or teaching science during practical experiences. Results of studies into the benefits of practical experiences on science teaching efficacy are varied. One study found that practical experience had negligible influence on science teaching efficacy (Yilmaz and Çavaş, 2008). Results from other research showed that more practical experience led to science teaching efficacy beliefs of preservice teachers decreasing (Capa Adyin & Woolfolk Hoy, 2005). In contrast, Cantrell et al. (2003) saw a significant increase in personal science teaching efficacy when preservice teachers actually taught science for more than three hours on a three-week practical experience. Similarly, Velthuis, Fisser and Pieters (2014) identified a positive correlation between the frequency of

science teaching during a practical experience and personal science teaching efficacy. However, in this study, the positive impact was more dramatic during the first experiences of teaching science, with a less impressive impact in further teaching experiences (Velthuis et al., 2014).

Exploring the connection between science methods units and practical experiences contributes to the discussion on the development of science teaching efficacy beliefs of preservice teachers. Some studies have found that for many preservice teachers, any benefits in improved science teaching efficacy developed as a result of a science methods unit could actually decrease after a practicum experience (Settlage, Southerland, Smith & Ceglie, 2009; Utley, Moseley & Bryant, 2005). In contrast, a Western Australian study found that school placement was a major source of gaining confidence to teach science, but in the absence of this, science methods units played an important role (Howitt, 2007). In examining the durability of science teaching efficacy from immediately after a science methods unit to 9-months after, Palmer (2006a) identified that of the small number of preservice teachers whose self-efficacy did decrease, many did not actually have the opportunity to teach science during their practical experience. Preservice teachers may be hindered in their ability to apply what they learn in science methods units in a practical experience, but this does not always negate their desire to use these methods when they begin teaching (Fazio, Melville & Bartley, 2010).

Several elements have been identified as crucial to positive practical experiences. Andersen et al. (2004) identified other significant factors that contribute to a positive practical experience including mentoring, available resources, materials and timetabling. In research conducted by Kenny (2012), participants identified communication as critical to success with a teaching practicum, and also emphasised the importance of preservice teachers being prepared and organised for their teaching experiences. Research conducted by Hudson (2005) found that preservice teachers need to be provided with opportunities to talk about how they teach science. He argued that this needs to be provided in an environment where the cooperating teacher is attentive and encourages the preservice teacher to reflect on practice.

The role of the cooperating teacher during practical experiences has been examined in the literature. A cooperating teacher is the inservice teacher with whom a preservice teacher is placed for a practical experience. Research has identified that the cooperating teacher can be critical to the success of a practical experience and influential on developing teaching efficacy beliefs (O'Neill & Stephenson, 2012). Other studies have identified the positive influence on science teaching efficacy beliefs as a result of a strong relationship developing between the cooperating teacher and preservice teacher (Capa Adyin & Woolfolk Hoy, 2005; Hamman, Oliveraz, Lesley, Button, Chan, Griffith & Elliot, 2006). However, other studies have identified that many preservice teachers did not feel supported by their cooperating teacher during their practical experience, which has a negative impact on their self-efficacy beliefs (Bhattacharyya, Volk & Lumpe, 2009; Haney & McArthur, 2002).

Qualities of cooperating teachers that facilitate the improvement of science teaching efficacy beliefs have also been examined in research. Mulholland and Wallace (2001) maintained that a major constraint that impacted on participants in their research was a lack of positive role models demonstrating effective science teaching. One study identified that support received from cooperating teachers was the most influential quality to impact on science teaching efficacy beliefs during practical experiences (Hamman et al., 2006). The role of immediate feedback on a practical experience has been highlighted by McDonnough and Matkins (2010) and Soprano and Yang (2013) whose research suggests that this can be significant in increasing teaching efficacy beliefs in science. One study identified limited correlation between the vicarious experience provided by the cooperating teacher and the preservice teacher's personal efficacy (Capa Adyin & Woolfolk Hoy, 2005). Capa Adyin and Woolfolk Hoy (2005) argued that vicarious experience may only be significant to the development of the personal efficacy if the individual views the cooperating teacher as having similar capabilities to the preservice teacher themselves, echoing Bandura's (1997) claims about the power of vicarious experiences.

The benefits of a strong partnership between preservice teachers and cooperating teachers during practical experience can positively influence both stakeholders (Jones, 2008). In one study, cooperating teachers engaged in more reflective practice about their science teaching and their own science teaching efficacy beliefs were enhanced

through the partnership with a preservice teacher (Jones, 2008). In another study examining the mutual benefits of a practical experience, the science teaching efficacy beliefs of cooperating teachers increased, and these participants maintained that the quality of their mentoring was also enhanced through the experience (Hudson & McRobbie, 2003). For the preservice teachers involved in this same study, participants reported an improved understanding of how to teach science as a result of the partnership (Hudson & McRobbie, 2003).

In most practical experiences, primary student teachers are placed within a generalist classroom. However, in Varma and Hanuscin's (2008) research, preservice teachers were placed in a specialist science teacher's classroom. Most of the preservice teachers reported that the experience was consistent with what they had previously learnt in their science methods unit and the authors noted that these experiences provided a guaranteed opportunity for preservice teachers to see science being taught. However, questions remained as to whether preservice teachers recognise how they can apply such experiences to a generalist primary classroom (Varma & Hanuscin, 2008). Other studies have identified improvement of self-efficacy of preservice teachers completing practicums in informal science environments, for example museums, aquariums and science centres (Anderson, Lawson & Mayer-Smith, 2006; Riedinger, Marbach-Ad, McGinnis, Hestness & Pease, 2010).

2.3.5 Significance and Gaps in Research Exploring the Impact of Teacher Education Programs on Science Teaching Efficacy Beliefs

Australian initial teacher education programs undergo accreditation processes overseen by AITSL. AITSL stipulates what must be covered within a degree in relation to unit and practical experience requirements, while simultaneously recognising the importance of universities responding to their contextual situations. Early childhood teaching degrees must similarly be guided by ACECQA requirements. Undergraduate preservice early childhood and primary teachers need to complete two science education units within their degrees, while those enrolled in postgraduate degrees are required to complete 1 unit.

Science education units can be classified as either science content or science methods units. While research exploring the impact of science content courses on science teaching efficacy has been varied, science methods units, when carefully designed, can contribute to an enhancement of efficacy beliefs. Critical to the design and implementation of these units is the science teacher educator. Research has shown that when a science teacher educator possesses certain qualities such as a passion for science and when they work to build positive relationships with preservice teachers, that this contributes to improvements in science teaching efficacy.

Findings from research that explore how a practical experience impacts on science teaching efficacy is varied. In some circumstances, it is likely that some preservice teachers may not see science being taught or have the opportunity to teach science themselves. This can be explained in the Australian context, as there are no formal guidelines about the requirements to teach science specifically during a practical experience. In some instances when there have been positive science teaching and learning experiences, findings from studies have shown benefits for both preservice and cooperating teachers. There have been some studies that have examined how the deliberate integration of science methods units and practical experiences have enhanced science teaching efficacy of preservice teachers.

There are identifiable gaps in the existing literature. Most research exploring the impact of science initial teacher education programs has involved a quantitative design, utilising the STEBI-B instrument designed and validated by Enochs and Riggs (1995). Cantrell (2003) and Hechter (2011) argue that conducting a traditional pre-test of the STEBI-B at the beginning of a science methods unit may mean students actually inflate their personal science teaching efficacy because they do not yet understand the complexity of science teaching. Carefully designed mixed methods approaches may be useful in countering such issues with the STEBI-B and are underrepresented in teaching efficacy research (Klassen & Usher, 2010). Incorporating qualitative methods may assist researchers in more deeply exploring the factors that influence self-efficacy beliefs and the meanings preservice teachers prescribe to these beliefs (Klassen & Usher, 2010). Capa Adyin and Woolfolk Hoy (2005) believe that more research is needed that focuses on the use of in-depth interviews to ensure this occurs.

Cross-sectional approaches dominate research into preservice science teaching efficacy and the impact of science methods units or practical experience. These approaches tend to emphasise the current science teaching efficacy beliefs, rather than the changes that preservice teachers' may experience (Kazempour, 2014). Longitudinal research that explores how and why self-efficacy beliefs change over time, and what factors influence this is underrepresented in current literature. Palmer (2006b) argued the importance of ascertaining whether gains in science teaching efficacy developed from a science methods unit will persist with the passage of time. This is supported by recommendations from research conducted by Brand and Wilkins (2007), and Davis and Smithey (2009).

Several researchers have identified the importance of future studies that explore the malleability, resilience and durability of science teaching efficacy beliefs of preservice teachers (Buss, 2009; Mulholland et al., 2004). Others have highlighted the importance of in-depth exploration of contextual factors and mechanisms that influence these beliefs at different times (Fazio et al., 2010; Klassen & Usher, 2010; Menon & Sadler, 2017; Phan, 2012). Another study has suggested that a gap exists in current literature in relation to how science education units support preservice teachers who have varying science teaching efficacy beliefs at the beginning of the unit (Menon & Sadler, 2016). In a recent study, Menon and Sadler (2017) identified that while a science unit positively contributed to the science teaching efficacy beliefs of preservice teachers, they recognised that persistent challenges were present at the end of their research study. These included continued self-doubts about content knowledge, whether the science unit would have a long-term impact on their science teaching efficacy beliefs and how these preservice teachers would handle the complexities of general classroom teaching and how this would influence their science teaching (Menon & Sadler, 2017). These challenges all constitute important gaps in the current research literature.

2.4 Science Teaching Efficacy

Research exploring science teaching efficacy beliefs has not been limited to preservice education. There has been significant research exploring the self-efficacy beliefs of inservice teachers. This remaining section of this chapter will examine this in more

detail. Studies discussing science teaching efficacy beliefs of inservice teachers are presented. An exploration of studies of the transition period from preservice to inservice teaching are then discussed. Finally, the current state of science in Australian early childhood settings and primary schools are explained.

2.4.1 Inservice Science Teaching Efficacy Beliefs

There is a substantial body of research exploring the science teaching efficacy beliefs of inservice teachers. Research in this area emerged significantly since the 1990's. Enoch and Riggs (1990) developed an instrument to quantitatively measure efficacy when teaching science called the Science Teaching Efficacy Belief Instrument (STEBI). In this initial research, the authors identified that teachers with low level of science teaching efficacy taught the subject less than those teachers with higher levels of self-efficacy. Since this time, this instrument has also been further developed into a specific instrument aimed at determining the science-teaching efficacy of preservice teachers (STEBI-B). Tschannen-Moran et al. (1998) identified that teachers of science with low science teaching outcome expectancy (STOE) scores were less effective in teaching science and used more teacher directed styles.

High levels of science teaching efficacy beliefs have been associated with improved student achievement (Lumpe, Czerniak, Haney & Beltyukova, 2012). Science teaching efficacy beliefs are also predictive of a teacher's intention to teach science in their own classrooms (Van Aalderen-Smeets & Walma van der Molen, 2013). However, Lardy (2011) argued that the science teaching efficacy beliefs of inservice teachers do not always correlate with actual science teaching practices, signalling a complex and dynamic range of factors that might influence this. This position is supported by other research suggesting that while science teaching efficacy beliefs are important, other factors such as resources, support and time are also critical to the effective teaching of science (Milner et al., 2012).

The sources of information that impact science efficacy beliefs are also important to be considered. Mansfield and Woods-McConney (2012) adapted the model created by Tschannen-Moran et al. (1998) after researching the efficacy sources of teachers teaching science in primary Western Australian schools. Their data supported the

importance of mastery experience, vicarious experience and physiological and affective states as sources of personal science teaching efficacy. However, they found no data to support the distinct role of verbal persuasion but claimed that it may have occurred implicitly through vicarious and mastery experiences (Mansfield & Woods-McConney, 2012). Palmer (2011) also examined the sources of efficacy information to impact on developing science teaching efficacy beliefs. In this study, although all sources of efficacy information were considered to be significant, cognitive mastery, that is, the “perceived success in understanding a pedagogical concept” (Palmer, 2011, p. 593) and verbal persuasion were found to be the most significant in contributing to the development of stronger efficacy beliefs.

The context in which teachers operate has been identified as a significant influence on science teaching efficacy beliefs (Rudman & Webb, 2009). In developing their model of science teaching efficacy beliefs, Mansfield and Woods-McConney (2012) recognised the science specific nature of the teaching context, including influential factors such as time, resources, student learning needs, science content knowledge, knowledge about how to teach science and general teaching skills. The modified model also acknowledged the importance of collaboration and participation in whole school science events, as well as professional development in contributing to personal science teaching efficacy, which was supported by their research findings (Mansfield & Woods-McConney, 2012). These aspects are supported by research by Skamp (2012), who outlined that teachers show more confidence in teaching science when they believe they have a strong curriculum resource to support them. He argued that access to these curriculum resources supported teachers with their content knowledge and contributed to them enjoying teaching science. Conversely, research has also identified that school environments that have poor resources and facilities and high levels of disadvantage negatively influence science teaching efficacy beliefs (Rudman & Webb, 2009).

Professional development is one key way that science teaching efficacy beliefs of inservice teachers are facilitated. Teachers feel that they need ongoing professional development in order to improve their teaching performance in science (Keys, 2005). One study that explored the impact of a professional learning program on implementing inquiry models in science found that both participants’ personal science

teaching efficacy and outcome expectancy increased (Eschach, 2003). An Australian study noted that teachers' confidence when teaching science improved significantly after their involvement in the *Primary Connections* professional development program (Hackling, 2006). These teachers also reported that after a term of implementation of the approach, their performance in relation to science teaching had improved, because they were using a more hands-on approach, had a better sense of structure when teaching science and were actually teaching science significantly more often than they had in the past (Hackling, 2006).

In a study conducted by Morgan (2012), teachers of middle to upper primary involved in a professional learning community focusing on collaborative learning and reflective practice, increased their satisfaction when teaching science. Participants in this study identified that they could see the potential for improving student learning using the skills they had gained (Morgan, 2012). Similarly, research by Palmer (2011) identified that a science teaching intervention focusing on workshops, observation opportunities and actual teaching aimed at inservice teachers increased their overall personal science teaching efficacy, even though the intervention was designed to target only one specialised sub skill. A study exploring the impact of elementary teachers who participated in long-term science professional development program, identified that the teachers experienced significant gains in their science teaching self-efficacy (Lumpe, Czerniak, Haney & Beltyukova, 2012).

The way in which professional development in science is offered to inservice teachers is also important to contemplate. Prinsley and Johnston (2015) argued that universities should coordinate and facilitate evidence-based professional development in order to more effectively support teachers in schools. One study examined the role of universities in providing science and mathematics content knowledge courses to inservice teachers in an attempt to upgrade their skills as required for promotion (Swackhamer, Koellner, Basile & Kimbrough, 2009). These teachers increased their perceptions about the abilities to improve student learning outcomes in science and mathematics (Swackhamer et al., 2009). Professional development offered through science centres has also contributed to improvements in science teaching efficacy beliefs of inservice teachers (McKinnon & Lamberts, 2013).

2.4.2 Transition from Preservice to Inservice Teaching

In order to explore the changes in science teaching efficacy beliefs as preservice teachers become inservice teachers, it is important to contemplate some of the wider factors that may impact on these beliefs. In the context of early childhood settings and primary schools, science is only one of the learning areas that early career teachers need to consider. However, the transition into the first years of employment for any teacher may be challenging for numerous reasons including workload, meeting expectations and time management. Challenging behaviour was reported as the biggest concern for early career teachers in research conducted by Hudson (2012), in addition to the difficulty of creating a work-life balance. Of significant concern, international research indicates that approximately 25-45% of teachers resign or burn out within their first 5 years of teaching (Burke, Schuck, Aubusson, Buchanan, Louviere & Prescott, 2013). However, research in the Australian context is limited and no one study conclusively points to the actual attrition rates of primary teachers in Australia (AITSL, 2016).

When exploring the challenges of early career teachers when teaching science, it is important to understand the wider picture of simply entering the teaching profession (Mulholland & Wallace, 2000). As they are generalist teachers in early childhood and primary settings, they often have conflicting issues such as timetabling all of the learning areas, school expectations or commitments, as well as the demand to meet the learner diversity in their class. Managing student behaviour and implementing collaborative learning when teaching science, which is often promoted in science methods units at university, can also be difficult for early career teachers to demonstrate, leading them to use more teacher directed styles in the science classroom (Mulholland & Wallace, 2001; Onafowora, 2004). Dreon and McDonald (2012) investigated whether two novice science secondary teachers with high levels of science content knowledge utilised inquiry approaches to teaching science. Their findings demonstrated that these students experienced anxiety when teaching with an inquiry approach, which led them to change their teaching approach to a more traditional approach.

Certain characteristics are considered vital to prevent early career teachers reaching the critical point of resignation or burn out. Keogh, Garvis, Pendergast and Diamond (2012) maintain “the intensity of initial teaching experiences may be moderated by using agency, efficacy and resilience (AER), providing the novice with protective layers” (p. 47). Resilience can be defined as how an individual responds to challenging situations and relates to the interaction between individuals and their environment over time (Mansfield, Beltman, Price & McConney, 2012). Resilience in novice teachers has been identified as a factor that fosters teacher retention and, due to its nature being a process of time, it is something that needs to be a focus of teacher education courses (Doney, 2013). According to Mansfield et al. (2012) resilience has four dimensions: the emotional dimension, which refers to how an individual cares for his or her own wellbeing, bounces back and copes with the demands of their job; the motivational dimension, which refers to an individual’s ability to persist, remain optimistic and maintain his or her confidence and self- belief; the social dimension, which refers to an individual’s ability to seek help, take advice and solve problems; and the profession-related dimension, which is the ability to be flexible, reflective, organised and possessing effective teaching skills (Mansfield et al., 2012). Research by Mansfield, Beltman and Price (2014) highlighted the importance of the school context, specifically school organisation, relationships, student diversity and behaviour management, on the developing resilience of early career teachers. Self-efficacy is considered to be a protective factor for resiliency in early career teachers (Day, 2008). However, self-efficacy may also be enhanced by a teacher demonstrating resilience and overcoming challenges that they face (Beltman, Mansfield & Price, 2011).

There have been mixed results from studies exploring the personal teaching efficacy of new teachers. One study contrasted the teaching self-efficacy of novice and experienced teachers, and perhaps as expected, novice teachers in general had a lower mean self-efficacy (Tschannen-Moran & Woolfolk Hoy, 2007). Early career teachers with lower teaching efficacy beliefs tend to superficially engage in inquiry practice and exhibit negative professional attitudes and lower levels of resiliency than the novice teachers who had higher levels of teaching efficacy (Fry, 2009). Another research study identified that verbal persuasion was considered quite important by early career teachers, noticeable in the form of support by colleagues and parents, although mastery experiences still tended to be more significant (Tschannen-Moran &

Woolfolk Hoy, 2007). Yost (2006) argued that for novice teachers, higher levels of teaching efficacy, developed due to successful student teaching experiences and the ability to reflect and problem solve, outweighed the role of a supportive school environment in teaching success. Early career teachers who exhibited sufficiently high general personal teaching efficacy, personally reported that they were using skills learnt within their teacher training, particularly in relation to classroom management and instructional strategies (Ozder, 2011).

Providing support for early career teachers has been identified as significant in several studies. Capa Adyin and Woolfolk Hoy (2005) maintained that it is important to continually support teachers in their first year of teaching, as research suggests that personal efficacy beliefs drop in the first year of employment. Indeed, research by Smith and Jang (2011) highlighted that support must also be provided for early career teachers who have stronger teaching efficacy beliefs as well as those with lower levels of teaching efficacy in order to further their development.

One key way that support can be provided to early career teachers is through mentoring programs. Early career teachers in science have expressed their need for mentoring to help them bridge the gap between their preservice preparation and their responsibilities as inservice teachers (Australian Science Teachers' Association & Office of the Chief Scientist, 2014). The research of Bullough, Young and Draper (2004) highlighted that a purposeful mentoring system can enhance beginning teacher development and assist these teachers in developing resilience, which is supported by Bradbury (2010). Further, beginning teachers need experienced staff members to provide support and guidance, and who are willing to collaborate with them (Hudson, 2012).

However, mentor teachers must be carefully selected in order for the novice teacher to develop skills in best practice in relation to science. Unfortunately, for early childhood educators who graduate and work in childcare centres, there are often a limited number of qualified teachers who can provide collegial support (Onnismaa, Tahkokallio, & Kalliala, 2015). In one study, the support of more experienced teachers actually led novice teachers to adopt more traditional approaches to science teaching, primarily due to the borrowing of resources and ideas from more experienced teachers (Park, Hewson, Lemberger & Marion, 2010).

Research has been conducted to analyse other ways of supporting early career teachers. In their review of current educational research in relation to the challenges that new teachers face, Davis, Petish and Smithey (2006) emphasised the positive impact of supportive induction and the opportunity for undergoing professional development to assist novice teachers with strategies and content for science teaching. Research as part of the Australian Research Council Grant *Renewing the teaching profession in regional areas through community partnerships*, identified that systematic induction into a school had numerous benefits including new teachers feeling a sense of relief and being welcomed into the school community, and teachers quickly recognising and demonstrating their responsibilities as a teacher (Carter, 2012). Informal science experiences, such as co-teaching afterschool science sessions have also been found to increase confidence of novice teachers (Katz, McGinnis, Riedinger, Marbach-Ad & Dai, 2013). One study examined the positive impact that using a group email site had on teaching efficacy by providing an opportunity to share concerns, problem solve and offer support (Keogh et al., 2012).

Partnerships between universities and schools continue to be important beyond the graduation of preservice teachers. Smith and Jang (2011) argued that it is important for early career teachers, mentor teachers and university personnel to work together to discuss assumptions and expectations about the roles and responsibilities of all partners, in order to improve student progress. In one study, developing structured professional learning communities within a school supported by universities designed for teachers to investigate and restructure science ideas, led to direct mastery and vicarious experiences for early career teachers, leading to higher levels of science teaching efficacy beliefs (Mintzes, Marcum, Messerschmidt-Yates & Mark, 2013). Support may also occur through the use of curriculum resources. The use of *Primary Connections* curriculum resources has positively impacted on teacher pedagogical knowledge and confidence in teaching science in Australian primary schools (Skamp, 2012). However, teachers require continual support in using curriculum materials to maximise student learning in order to prevent these resources being used in the wrong way (Bismack, Arias, Davis & Palincsar, 2014).

2.4.3 Science in Australian Early Childhood Settings and Primary Schools

Currently, the status and experience of science in Australian early childhood settings and primary schools can be viewed as both encouraging and challenging. It is important to consider both settings in the context of this current study, particularly as preservice teachers enrolled in early childhood education degrees may be employed in either setting upon graduation.

One significant shift in how science was valued in primary schools was the inclusion of science in the *Australian Curriculum* in 2010 for students from Pre-Primary to Year 10. The science learning area has been structured in such a way to emphasise science understanding and skills, as well as allowing students opportunities to see how science relates to everyday life (Australian Academy of Science, 2011). An Australian Government (2014) review of the national curriculum and its implementation found that the science learning area was rigorous and structured well. However, concerns were raised about the emphasis on constructivism and inquiry in the science curriculum design, which may devalue the role of knowledge (Australian Government, 2014). A major finding was that the national curriculum in its entirety was overcrowded, caused by an overall design flaw. This overcrowding may cause teachers to focus more on breadth of learning rather than depth, in contrast to the curriculum from countries such as Singapore and Finland (Australian Government, 2014).

Early childhood education has had renewed focus in Australia in recent years, which has been attributed to the publication of the early childhood framework entitled *Belonging, Being and Becoming: The Early Years Learning Framework* (Australian Government Department of Education, and Workplace Relations for the Council of Australian Governments, 2009). This framework has been instrumental to recent changes to early childhood policy and practice and advocates the importance of play-based approaches and intentional teaching. In the area of science, the document emphasises the teaching of scientific language, understandings and skills (Nolan, 2012). Contrary to this approach to science in early childhood, Professor Kenneth Wilshire, in his role of reviewing the national curriculum, maintains that up until Year 3, the curriculum emphasis should be primarily on the teaching of literacy and

numeracy skills, with play, socialisation and movement skills also a focus (Australian Government, 2014). Professor Wilshire argues that other learning areas such as science and humanities and social sciences should not be an explicit focus in the early years (Australian Government, 2014).

In Australia, early childhood education may be provided in childcare centres, preschools, kindergartens or schools, and this period generally refers to birth to eight years old. Previously, early childhood education was categorised by a diverse variety of providers for early childhood, with varying regulations and requirements across states (Elliot, 2006). There were also divergent expectations in relation to the staff qualifications (Elliot, 2006). In 2012, the Australian government, in agreement with all states and territories in Australia, introduced the *National Quality Framework* (NQF), which created national standards, regulations, assessment and rating inspections, and learning frameworks for all early education providers (Organisation for Economic Cooperation and Development [OECD], 2016). ACECQA, a regulatory body, was also established to facilitate the audit and support of early childhood programs (OECD, 2016). An increase in staff qualifications also occurred, with qualified teachers employed to work in childcare centres (OECD, 2016). This has had implications in terms of the accreditation of initial teacher education programs and the quality of curriculum offered in early childhood settings. Questions can still be raised about whether this has led to a more prominent role of science within the early childhood curriculum.

In recent years, Science, Technology, Engineering and Mathematics (STEM) subjects have increased in prominence in Australian educational dialogue. In 2014, the Office of the Chief Scientist released a discussion paper highlighting the importance of STEM for Australia's future, emphasising benefits for innovation, creativity and Australia's competitiveness with the rest of the world. Specifically, in relation to education, recommendations included providing inspiring and inquiry-based STEM experiences for all children and increasing the number of STEM qualified teachers in classrooms (Office of the Chief Scientist, 2014). The Australian Government responded to this paper through several initiatives, including the *Students First* policy and connecting schools with STEM professionals (Australian Government, 2015). A recent issues paper has highlighted that focusing on STEM skills early in education can enhance

critical thinking, communication and digital skills, and may also increase the likelihood of students engaging in STEM disciplines in later education (Department for Education and Training, 2017).

The provision of quality curriculum resources has also occurred in Australia for teachers of primary school science. This has impacted on the way that science is perceived in primary schools across Australia. *Primary Connections* was an initiative of the Australian Academy of Science that was supported by all sectors (government, independent and Catholic schools), and all states and territories (Hackling, 2006). *Primary Connections* has been developed from the 5E's inquiry approach (Bybee, 1997) and is for all primary school years (students aged from five to twelve). It is primarily a science professional learning program, which is supported by curriculum resources. This approach and the curriculum resources developed in line with this is used across Australia, with over 55% of schools using the resource (Skamp, 2012). *Primary Connections* is highly regarded by teachers in primary schools, particularly for teachers who lack confidence when teaching science (Australian Science Teachers' Association & Office of the Chief Scientist, 2014).

However, the actual time that science is taught in primary schools is a significant issue. Previous research has identified that science is one of the least taught learning areas in primary schools in Australia, with an average of 45 minutes or 3% of the total weekly teaching time dedicated to it (Angus, Olney & Ainley, 2007). This is despite advice that science should be taught for approximately 2 hours each week in Western Australia (Schools Curriculum and Standards Authority, 2016). In a more recent survey in which participants were identified as having a strong interest in science, this total weekly science time was between one and two hours in primary school, with more time dedicated to the learning area as students became older (Australian Science Teachers' Association & Office of the Chief Scientist, 2014).

Some research has highlighted that many primary school teachers in Australia lack confidence with teaching science (Hackling & Prain, 2005; Skamp, 2012). Skamp (2012) maintained that primary teachers report experiencing difficulties with their science teaching performance as a result of challenges in locating resources, understanding how students learn science and time management issues. Having access

to high quality professional development and mentoring has also been identified as a challenge (Australian Science Teachers' Association & Office of the Chief Scientist, 2014).

An increasing trend in Australian primary schools is the use of science specialist teachers. There has been evidence to suggest a growing number of science specialists that have been employed in Australian primary schools in recent years (Australian Science Teachers' Association & Office of the Chief Scientist, 2014). In Victoria, a specific professional development program has trained predominantly generalist primary teachers to become specialist science teachers, in order to more effectively teach science and provide support to colleagues (Campbell & Chittleborough, 2014). Some benefits of having specialist teachers in science are evident, such as assisting the classroom teacher in delivering an overcrowded curriculum and assisting teachers who lack confidence with science (Arzewska, McMaugh & Coutts, 2010). Dinham (2014) argued that specialist teaching in science may create opportunities for team-teaching in science, which may have increase teachers' content knowledge and pedagogical knowledge. Similarly, Prinsley and Johnston (2015) propose that science specialist teachers can co-teach, mentor and provide professional development for generalist classroom teachers. However, having science specialist teachers may also have the opposite effect and lead to confidence issues for primary teachers. This is particularly concerning for a preservice teacher on his or her practical experience who may not see science being taught as they may not be required to observe lessons run by specialist teachers.

Another significant concern is Australian student performance in science. The findings of the 2011 *Trends in International Mathematics and Science Study* (TIMSS) indicate that student science results in Year 4 and 8 have not significantly changed over the last 20 years (Thomson, Hillman, Wernert, Schmid, Buckley & Munene, 2012). In contrast, results of countries such as Korea, Singapore and Finland have substantially improved during this period (Thomson et al., 2012). In the 2012 PISA results, while performing above the international average, Australia still ranks lower than Asian counterparts such as Singapore and Shanghai (Thomson, De Bortoli & Buckley, 2013). Science achievement in Australia has been found to be impacted by socioeconomic, gender and indigenous status (Hackling et al., 2014). These factors

contribute to science being considered a *national concern* in Australia (Treagust et al., 2015). This is despite STEM skills having been identified as crucial to Australia's future development (Australian Government, 2015; Department for Education and Training, 2017).

2.4.4 Significance and Gaps in the Transition from Preservice to Inservice Science Teaching

Research has examined science teaching efficacy beliefs of inservice teachers. These efficacy beliefs have been connected to improved student learning outcomes and an increased desire to teach science. Different approaches to professional development have been found to enhance these science teaching efficacy beliefs.

However, the transition for a teacher from preservice to inservice science teaching is not straightforward. In early childhood and primary school settings, teachers are required to be generalists and experience difficulties dealing with challenging student behaviour and creating a work-life balance. Self-efficacy beliefs, resilience and motivation can be protective factors for individuals, but mentoring and induction processes in schools can also support early career teachers.

It is also important to consider the current Australian context for science education in early childhood and primary school settings as these factors are the reality of the current study. There have been positive developments for science education in recent years including a heightened awareness of STEM learning areas, improve teaching and learning resources and a consistent curriculum. However, student achievement in science is still of concern as well as the amount of time science is taught within the curriculum. Interesting questions about how recent changes to the early childhood system and specialist teachers in primary school influence science teaching are also worthy of consideration.

There currently exists a lack of studies exploring the transition from preservice to inservice teaching in the area of science teaching efficacy beliefs. Following preservice teachers into their early careers will allow researchers to explore how their self-efficacy beliefs and view develop over this time (Fazio et al, 2010). Another

significant gap is that minimal teaching efficacy research has occurred in the Australian context (Klassen & Usher, 2010). This is an important avenue for further research, particularly when considered how contextual factors can influence these beliefs (Berg & Smith, 2016; Klassen & Usher, 2010).

2.5 Summary

This literature review has discussed and analysed current and significant research in relation to the importance of ascertaining science teaching efficacy beliefs that are held by preservice teachers. This has situated the present study and the associated research questions within the field of science teacher education. The theoretical framework of the study in relation to social cognitive theory and self-efficacy were discussed, and the link between self-efficacy and teaching was identified. Research into the science-teaching efficacy of preservice teachers was explored, as well as some of the contextual factors that impact on an individual's beliefs about science teaching and learning as they begin science education units. The discussion also examined the influence of tertiary institution programs, science methods units, the science teacher educator and practical experiences on the science teaching efficacy beliefs of preservice teachers. Research that explored the science teaching beliefs of inservice teachers, as well as the broader transition from preservice to inservice teaching was also examined. Finally, the current science educational climate in Australian early childhood and primary schools were briefly explored. Throughout this chapter, the gaps in the literature were presented in order to establish the significance of the current study.

Chapter 3

Methodology

3.0 Introduction

Chapter 2 reviewed the theoretical framework and key literature that informs the design of this study. In this chapter, the methodological framework of the study is outlined, including the data collection and analysis techniques used. This current study used a longitudinal, concurrent embedded mixed methods research design to address the research questions and to gain meaning of the experiences of the participants.

As previously discussed, this study investigated how preservice teachers developed their self-efficacy beliefs of teaching and learning about science through their preservice teacher preparation and into their first year of teaching. It also explored the factors that influenced these beliefs at different stages of development. The research problem was:

- How, why and to what extent do science teaching efficacy beliefs change over time from preservice teacher education to first year teaching?

Articulation of this research problem led to the development of three research sub-questions:

- Research Question 1- How, why and to what extent do prior experiences of science teaching and learning influence science teaching efficacy beliefs?
- Research Question 2- How, why and to what extent does preservice teacher preparation influence science teaching efficacy beliefs?
- Research Question 3- How, why and to what extent does the first year of teaching influence science teaching efficacy beliefs?

In section 3.1 of this chapter, the research design framework is described and elaborated on. Section 3.2 describes the demographics and sampling process of the current study. In section 3.3 the data collection and research instruments used in this current study are explored in more detail. In section 3.4, the data analysis processes are outlined and section 3.6 explains how the pilot study contributed to the overall research design. Section 3.7 describes how ethical issues were considered in this

study.

3.1 Research Design Framework and Approach

Traditionally, teacher efficacy research has been situated in quantitative methodologies because self-efficacy is set within the conceptual and methodological approaches of psychology (Labone, 2004). However, educational research is highly complex and dynamic, due to the myriad of factors influencing education. Some examples of these factors include varying student needs, socioeconomic status, government and system requirements, parental expectations, teacher beliefs and school culture. Educational research therefore needs to use data collection and analysis strategies that do justice to this complexity (Freebody, 2003).

In this present study, a concurrent embedded mixed methods and longitudinal approach to the research design was used. This approach was deemed the most appropriate method for comprehensively answering the research questions, because the researcher believed that that an exclusively qualitative or quantitative approach would not adequately answer the research questions relating to the science teaching efficacy beliefs of preservice teachers. A purely quantitative approach would be able to measure how science teaching efficacy beliefs of the wider preservice cohort changed. However, it would not be able to explore in detail the meanings that participants ascribed to changes in their beliefs, which can be achieved from a qualitative approach. Therefore, this study uses both qualitative and quantitative data to ensure that the researcher could truly ascertain the breadth and depth of understanding relating to the preservice teachers' self-efficacy beliefs. The breadth of the study refers to the ability to quantitatively capture the science teaching efficacy beliefs of a large preservice teacher cohort. The depth of the study is the qualitative and longitudinal in-depth interviews of a smaller group of participants representative of this cohort.

3.1.1 Mixed Methods

The mixed methods approach can be described as using “multiple methods, different worldviews, and different assumptions” (Creswell, 2009, p. 11) to help define and

understand a research problem. Mixed methods research therefore may employ both quantitative and qualitative research methods to collect and analyse data. Employing an exclusively qualitative approach to research can often be criticised due to perceptions of subjectivity (Cowling & Lawson, 2016), and concerns over reliability and transferability (Merriam, 2009). On the other hand, a strictly quantitative approach can focus too intently on objectivity and provide too little focus on insights and meanings perceived by individuals (Cowling & Lawson, 2016). Therefore, using a combination of both quantitative and qualitative methods can help to avoid issues inherent in each individual approach (Andrews & Halcomb, 2006; Markic & Eilks, 2007).

After a significant review of mixed method theorists, Johnson, Onwuegbuzie and Turner (2007) define mixed methods research

... as the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration. (p. 123)

This research can be described as *qualitative dominant* mixed methods research, which can be defined as relying on qualitative data, but recognising how quantitative data may be beneficial in a study (Johnson et al., 2007). In line with the qualitative dominant mixed methods approach, this research study uses a concurrent embedded design, as it is “appropriate when the researcher has different questions that require different types of data in order to enhance the application of a quantitative or qualitative design to address the primary purpose of the study” (Creswell & Plano Clark, 2010, p. 91). As such, and different to other mixed method design approaches, the embedded design draws on the worldview of the primary approach (Creswell & Plano Clark, 2010), which in this study is an interpretivist paradigm. Therefore, in this research, the primary data collection is qualitative data and the secondary quantitative data is nested or embedded within this primary method (Creswell, 2009).

Using a qualitative dominant approach to research has numerous advantages. Qualitative research is designed to help uncover how individuals make meaning and interpret their experiences (Merriam, 2009). It allows for rich description (Merriam,

2009) and is highly contextual, emphasising the importance of how individuals are influenced by and construct their worldview (Bogdan & Biklen, 2003; Cowling & Lawson, 2016 Creswell, 2009). Qualitative researchers recognise that individuals make varying understandings of the world, and therefore make meaning of it in different ways (Cowling, 2016).

There are several reasons why using quantitative data can support qualitative data in mixed methods research. Quantitative data can support the internal generalisability of qualitative findings and can be useful in providing a wider perspective in terms of differences in actions of beliefs of a wider group, therefore providing a check on bias (Maxwell, 2010). Quantitative data can also help identify patterns that may not be evident in qualitative data and can provide evidence to support a researcher's claims (Creswell & Plano Clark, 2010; Maxwell, 2010).

In the current study, the use of a concurrent embedded mixed methods design allowed for triangulation, completeness, sampling, explanation and enhancement. These terms can be defined as: triangulation as seeking convergent results; completeness is the aim to build a more comprehensive understanding of the inquiry; sampling is when one approach is used to facilitate the sampling of participants; explanation is when one approach helps to explain the results of the other; and enhancement refers to building on the results of one approach with the other (Bryman, 2006).

3.1.2 Longitudinal Studies

This study uses a longitudinal design for several reasons. A longitudinal design allows the researcher to explore how and why the beliefs of participants change over time. This type of research allows for more accurate and descriptive insights into changes in an individual's beliefs, which supports the view held by White and Arzi (2005). This is particularly important from a developmental perspective when considering the transition from university to the first year of employment for these preservice teachers. The study also benefits from a longitudinal design as this allows for the exploration of causal factors that can influence these beliefs and how they interplay over time.

Longitudinal research can be defined as

A longitudinal study is one in which two or more measures or observations of a comparable form are made of the same individuals or entities over a period of at least one year. (White & Arzi, 2005, p. 138)

It is research conducted over a longer period of time and involving repeated measures of the phenomenon (Coolican, 2013). White and Arzi (2005) suggest that the repeated measures should be approximately a year apart due to the significant changes that can occur in an educational setting over this period of time.

In the case of interpretivist research, Holland, Thomson and Henderson (2006) maintain that longitudinal research allows the researcher to look beyond merely snapshots of behaviour, thoughts and beliefs, and see how this changes over time, as well as causal factors that may impact on this. There are numerous benefits of longitudinal studies. Longitudinal research is useful for tracking development and it provides a comprehensive exploration of variables (Cohen, Manion & Morrison, 2011). It allows for an in-depth exploration of what changes happen over time, but also explores how and why these changes happen in a particular context (Carduff, Murray & Kendall, 2015). In relation to this study, a longitudinal design allows the participants involved in the in-depth interviews to reflect on the changes to their beliefs since the previous interviews and allows for an investigation of what factors contribute to these changing beliefs over time (Farrall, 2006; Hemanowicz, 2013).

However, several challenges exist when conducting longitudinal research. Longitudinal research is time consuming and it can be difficult to ensure that participation rates remain high over a longer period of time (Cohen et al., 2011; White & Arzi, 2005). Due to the fact that it does require extended participation, it can be difficult to secure participation (Cohen et al., 2011). Another challenge can be ensuring that there is consistency between each measure to ensure validity of results (White & Arzi, 2005). How these challenges were addressed in this study are explored in more detail later in this chapter.

3.2 Context

3.2.1 Background Details of the Study

In designing this study, there were two groups of participants. The first group was the wider cohort of preservice teachers enrolled in the *Primary Science* unit. The second group was a small group of 10 individuals from this cohort, who were involved in longitudinal in-depth interviews. The following discussion provides contextual information about the preservice teacher cohort enrolled in the unit.

There were approximately 140 preservice teachers enrolled in the unit *Primary Science*, consisting of Bachelor of Education (Early Childhood) students, Bachelor of Education (Primary Students), Master of Teaching (Primary) students and Graduate Diploma (Primary Conversion) students. The researcher of this study was the unit coordinator of *Primary Science* which was designed as a science methods unit. The focus of the unit was on balancing the enhancement of science content knowledge with an explicit emphasis on how to teach science. A summary of the purpose, structure and assessment of the unit is described in Table 3.1 and a more detailed description of the unit outline and assessment is included as Appendix 1.

For the preservice teachers enrolled in the Bachelor of Education, this unit was in the second semester of their third year, following a 10-week practical experience. Preservice teachers enrolled in the Master of Teaching degree, which is a two-year degree for students with another undergraduate degree, completed the unit in the second semester of their first year, also following a 10-week practical experience. The Graduate Diploma was a one-year degree and the science methods unit was an optional unit that they could take in the second semester of the year. Preservice teachers may have been in various stages of completion of their degree for reasons such as mid-year enrolments or failing units. A summary of the degrees involved in the *Primary Science* unit are described in Table 3.2

Table 3.1

Primary Science: The Purpose, Structure and Assessment of the Science Methods Unit.

Aspects of Unit	Description
Purpose	<p>At the completion of this unit a student will be able to demonstrate and explain:</p> <ul style="list-style-type: none"> • Why Science is important • Content associated with each of the concept strands in Science • Various interactive teaching techniques • How to plan lessons for science • Various resources available in the area of Science- particularly Primary Connections • The value of excursions/incursions in Western Australia • Assessment and evaluation techniques suitable for Science • The health and safety issues associated with Science • The ethics and values that are inherent in Science
Structure	<p>Students attend a two-hour weekly workshop for 13 weeks. Each workshop includes a range of different activities including presentations, experiments, incursions, hands on activities, lectures and collaborative work.</p>
Assessment	<p>The following assessment was completed as part of the course:</p> <ul style="list-style-type: none"> • Lesson Presentation - 15%. Students chose a science topic or concept and designed an interactive lesson to teach the essential elements of that topic. • Forward Planning Document - 45%. Students developed a program of work based around the science topic taught in the lesson. This included a rationale, a program that included 5 lessons and assessment strategies. • Exam - 40%. The exam included multiple-choice questions on science content covered in the unit and written answers relating to science pedagogical issues focused on.

Table 3.2

A Summary of the Different Degrees Enrolled in the Unit Primary Science.

	Bachelor of Education (Early Childhood)	Bachelor of Education (Primary)	Master of Teaching (Primary)	Graduate Diploma (Primary Conversion)
Summary of degree	A degree that allows students to become skilled and qualified to teach children from 0- 8 years	A degree that allows students to become skilled and qualified to teach children in the Primary years (Years 1-6 in Western Australia)	An intensive degree that qualifies students as teachers. These students have already successfully completed a previous undergraduate degree	A degree that allows students to be qualified to also teach Primary students (Years 1-6 in Western Australia)
Duration of degree	Four years	Four years	Two years	One year
Prerequisite to admission	ATAR Score of approximately 70 or university bridging course and successful interview with School of Education staff member	ATAR Score of approximately 70 or university bridging course and successful interview with School of Education staff member	Previous undergraduate degree and successful interview with School of Education staff member	Previous Secondary Education degree and successful interview with School of Education staff member
Practical Experience included with the degree	32 weeks- first year two weeks, second year 10 weeks, third year 10 weeks, fourth year 10-week internship	32 weeks- first year two weeks, second year 10 weeks, third year 10 weeks, fourth year 10-week internship	20 weeks- first year 10 weeks, second year 10 weeks	n/a
Placement of science methods unit within degree	Third year- second semester Following second 10-week practical experience	Third year- second semester Following second 10-week practical experience	Third year- second semester Following first 10-week practical experience	Optional unit Second semester of the year

The following discussion summarises the demographical information of the wider preservice cohort for the unit *Primary Science*. This information was collected with the initial completion of the STEBI-B questionnaire at the beginning of the unit. The number of preservice teachers who completed the questionnaire at the beginning of the unit was 136, of whom 115 were female and 21 were male. A breakdown of the number of preservice teachers enrolled in the different degrees are as follows: 41 preservice teachers were completing a Bachelor of Education (Early Childhood and Care 0-8 years); 67 were completing a Bachelor of Education (Primary); 16 were completing a Master of Teaching (Primary); and 12 were enrolled in another degree, most of which were enrolled in the Graduate Diploma.

For the preservice teachers enrolled in the Bachelor of Education (Primary) degree, the preservice teachers were required to specialise in English, Mathematics, Science, Society and Environment, Special Needs, Theatre Arts, and Service Learning and Social Justice. Of the 67 Bachelor of Education (Primary) respondents, the majority specialised in Mathematics (26) and Special Needs (20), with only six preservice teachers specialising in Science.

The preservice teachers were also asked about their previous backgrounds in the area of science. Seventy-one preservice teachers in the cohort had completed a unit called *Environmental Science and Technology* at university, which was a requisite unit in the Bachelor of Education (Primary) degree. However, very few preservice teachers had completed any other tertiary level science units. Five students had completed a human biology unit and one student had completed a biology unit. Two preservice teachers had completed chemistry or physics units at tertiary level.

The cohort was also asked about the science units completed in Year 12 of high school. Of the cohort, 45 preservice teachers had completed human biology in Year 12, 11 preservice teachers had completed biology, four had studied chemistry and one had studied physics.

3.2.2 Selection of the In-Depth Interview Participants

In this research, purposeful sampling was used to select participants for the qualitative longitudinal in-depth interviews. In this research, it was important to ensure that the selected participants involved were individuals who experienced the phenomenon and could provide information-rich descriptions of their experiences (Creswell, 2009; Merriam, 2009; Patton, 2002; Suri, 2011). Specifically, in this study, the researcher employed the use of *Maximum Variation Sampling*, which involves identifying variations in cases that have experienced the phenomenon to document their unique perspectives and then looking for shared patterns (Merriam, 2009). The following criteria were established to assist the sampling process:

- Enrolled in the unit *Primary Science*,
- Variance in Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE) as evident in the *Science Teaching Self-Efficacy Beliefs Instrument for Preservice Teachers* (STEBI-B) questionnaire administered in the first workshop of the *Primary Science* unit,
- Variance in age, gender, science background and degree that was similar to the wider student cohort.

In order to identify variations, the researcher examined the STEBI-B results for students with low, medium and high science teaching efficacy beliefs, in comparison to the cohort mean. The researcher also examined aspects such as degree enrolled in, gender and previous science experience to assist in identifying variations. Ten students were asked to then be involved with the longitudinal interview process, all of whom accepted. The researcher aimed for *data sufficiency* to ensure that these cases would be sufficient in addressing the purpose of the research (Suri, 2011).

3.2.3 Demographics of the In-Depth Interview Participants

Brief background details of the participants involved in the in-depth interviews are outlined in Table 3.3. The demographic information shown includes the sex, age range, university degree the students were enrolled in, and additional contextual information relevant to the study. Pseudonyms are used to identify participants throughout the results and discussion chapter.

Table 3.3

Demographics of the study participants involved in the in-depth interviews.

Participant	Sex	Age Range	Degree	Additional contextualising information (where relevant to the results)
Kerrie	Female	20-25	Bachelor of Education (Early Childhood and Care 0-8 years)	No other science units completed during degree. Expressed a lot of worry towards science at the beginning of the unit
Jamie	Female	20-25	Bachelor of Education (Early Childhood)	Successfully completed unit- <i>Environmental Science and Technology</i>
Mark	Male	20-25	Bachelor of Education (Primary)	Successfully completed unit- <i>Environmental Science and Technology</i>
John	Male	20-25	Bachelor of Education (Primary)	Began another degree in sports science before changing to this degree and had successfully completed unit- <i>Environmental Science and Technology</i>
Toni	Female	20-25	Bachelor of Education (Primary)	Successfully completed unit- <i>Environmental Science and Technology</i>
Lucy	Female	25-30	Bachelor of Education (Primary)	Completed two years of a nursing degree, 1.5 years of biomedicine transferred to Education. Specialising in science
Sarah	Female	20-25	Bachelor of Education (Primary)	Successfully completed unit- <i>Environmental Science and Technology</i>
Kate	Female	20-25	Bachelor of Education (Primary)	Specialising in science and had successfully completed unit- <i>Environmental Science and Technology</i>
Alan	Male	25-30	Master of Teaching (Primary)	Had successfully completed a prior degree in Geophysics
Maria	Female	30-35	Graduate Diploma	Already has a neuroscience and secondary education degree

The in-depth interview participants vary in age, degree and science background. These participants were: Kerrie and Jamie, who were enrolled in the Bachelor of Education (Early Childhood) degree; Mark, John, Lucy, Toni, Sarah and Kate, who were enrolled in the Bachelor of Education (Primary) degree; Alan, who was enrolled in the Master of Teaching (Primary) degree; and Maria, who was enrolled in the Graduate Diploma (Primary Conversion). The majority of the participants were in the 20-25 year old age range, with Alan, Maria and Lucy older. Of the in-depth participant group, Alan, John, Maria and Lucy had worked towards or completed a previous tertiary degree in a science field. Lucy and Kate were specialising in science as part of the requirements of their Bachelor of Education (Primary) degree, while the others had very little science coursework experience at university.

3.3 Data Collection

Two types of research instruments were used to collect data in this study: semi-structured interviews and the STEBI-B questionnaire. An overview of the relationship between the research questions and data collection tools is shown in Table 3.4.

3.3.1 The Research Instruments: Semi-Structured Interviews

The primary instrument was a semi-structured interview, which was used at four different points during the longitudinal research to gather qualitative data. Kvale and Brinkmann (2009) state, “the research interview is an interpersonal situation, a conversation between two partners about a theme of mutual interest” (p. 123). The interviews used were semi-structured and therefore used as a guide with an outline of topics that were covered as well as suggested questions for each stage of the interview process (Kvale & Brinkmann, 2009). Semi-structured interviews are open-ended, and

This type of interview involves developing a general set of questions and format that you follow and use on all participants. While the general structure is the same for all individuals being interviewed, the interviewer can vary questions as the situation demands. (Lichtman, 2006, p. 118)

Table 3.4
Relationship between the Research Questions and Data Collection Tools.

Research Question	Instrument	Form of Data	When Completed
Research Question 1 How, why and to what extent do prior experiences of science teaching and learning influence science teaching efficacy beliefs?	Semi-structured interviews	Open ended	August 2013
	STEBI-B	Likert coded	August 2013
Research Question 2 How, why and to what extent does preservice teacher preparation influence science teaching efficacy beliefs?	Semi-structured interviews	Open ended	August 2013 November 2013 October 2014
	STEBI-B	Likert coded	November 2013
Research Question 3 How, why and to what extent does the first year of teaching influence science teaching efficacy beliefs?	Semi-structured interviews	Open ended	January 2016

The researcher therefore used different strategies to further elicit information from the participants where required. These included, but were not limited to, the following: pausing; nodding; using probing questions, such as ‘can you tell me more about that?’ or ‘can you give me more detailed description of what happened?’; and seeking clarification about what the participants meant in their specific response (Kvale & Brinkmann, 2009). Palmer (2006a) identified the importance of conducting interviews alongside questionnaires to help develop a more in-depth understanding of the data.

Following the acceptance of the 10 participants to be involved in qualitative data collection, semi-structured interviews were conducted in August of 2013, within the first few weeks of the *Primary Science* unit. Participants were then interviewed a second time in November of 2013 at the conclusion of the unit.

In October 2014, following the final practical experience for preservice teachers enrolled in the Bachelor of Education (Early Childhood and Primary), and Master of Teaching (Primary), the 10 in-depth interview participants were asked to participate in the third interviews. All but one of the participants were involved. This participant

had completed the Graduate Diploma degree and so therefore this interview was not relevant. Finally, in February 2016, the 10 participants were invited to participate in the final interview, which was approximately 15 months after the previous interview, meeting White and Arzi's (2005) criteria for longitudinal research design. Of these 10 participants, six agreed to be interviewed.

The interview protocol was developed to comprise questions to assist with gaining an understanding of the main research questions. The interview questions assisted the researcher to make connections between the experience, background and context of each individual preservice teacher (McKinnon, 2010). Each interview was audio recorded and then transcribed. A summary of the purposes of each interview and how they relate to the research questions are described in Table 3.5. The interview protocol can be found in Appendix 2 and an example transcript is included as Appendix 3. Generally the interviews lasted 30 minutes, although there was a range in duration from 25 to 55 minutes.

3.3.2 The Research Instruments: Science Teaching Self-Efficacy Beliefs Instrument for Preservice Teachers (STEBI-B)

Many quantitative instruments have been developed to measure the efficacy beliefs of teachers, including the Teacher Efficacy Scale (TES) and the Science Teaching Self-Efficacy Belief Instrument (STEBI) (Enochs & Riggs, 1990; Henson, Kogan & Vachahase, 2001). These instruments have been developed from Bandura's self-efficacy theory (1977; 1997).

Table 3.5

Relationship between the Purpose of Each Interview, Timing and the Research Questions

Interview	Timing	Purpose of Interview	Relationship to Research Questions
1	August 2013 At the start of the science methods unit	Efficacy beliefs about science teaching and learning Prior experiences of science Previous practical experiences relating to science teaching	1 and 2
2	November 2013 At the end of the science methods unit	Experiences of the science methods unit Current efficacy beliefs about the teaching and learning of science	2
3	October 2014 In the preservice teachers' final year, after the final practical experience	Experiences of science teaching and learning during the final teaching practical experience Current efficacy beliefs about the teaching and learning of science	2
4	February 2016	Experiences of science teaching and learning during their first year of employment Current efficacy beliefs about the teaching and learning of science	3

The STEBI has two versions: STEBI-A, which is designed for inservice teachers; and the STEBI-B, which is designed for preservice teachers. Both have two scales: the Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE), relating to the two components of self-efficacy, which are personal efficacy and outcome expectancy (Swars & Dooley, 2011; Ling & Richardson, 2009; Bleicher, 2004, Ford, 1992; Enoch & Riggs, 1990).

The STEBI-B uses a five scale likert measurement and it has has 23 statements. Thirteen statements are associated with the PSTE scale and 10 are associated with the STOE scale. Nine of the statements are negatively worded. Statements are presented and participants are invited to respond by identifying whether they strongly agree, agree, are uncertain, disagree or strongly disagree. The STEBI-B was validated by its developers, as well as in the work of other researchers (Bleicher, 2004; Enochs & Rigg,

1990). In their initial validation, Enochs and Riggs (1990) found that the personal science teaching efficacy scale had a Cronbach reliability coefficient of 0.92, while the science teaching outcome expectancy had a Cronbach reliability coefficient of 0.76. While both scales are considered reliable, the STOE is lower, which may be because preservice teachers may consider some factors outside of their control (Enoch & Riggs, 1990). The Cronbach alpha reliability for the current study is included in section 3.4.3. A copy of the STEBI-B is included as Appendix 4 and a STEBI-B Licence Agreement is found as Appendix 5.

Whilst the STEBI-B is considered reliable, there have been some criticisms of its use and development. Van Alderen-Smeets et al. (2011) have questioned the 5-point Likert scale that ranges from strongly agree to strongly disagree. These researchers believe that the middle response, which is uncertain, could have numerous meanings to the participant, such as not understanding the question or having no opinion of it. One way to rectify this is through the use of mixed methods research, as qualitative data can be used to help clarify this when required (Van Alderen-Smeets et al., 2011). Palmer (2006a) found a discrepancy between STEBI-B data and qualitative data produced through interviews and maintained that more research needs to include both approaches for accuracy. In this current research study, this aspect has been considered in the research design. Cantrell (2003) questioned the validity of using pre/post tests of self-efficacy, as some participants may overrate their confidence in the pre-test, which may lead to less statistical difference in the post test. However, the use of a mixed-methods approach in this current study helps to alleviate this issue, as the semi-structured interviews provide insight into the quantitative data.

3.3.3 Limitations of the Research Design

Some limitations were identified in the research design. Primarily, the challenge of attrition during the longitudinal research was a small issue. Due to the amount of time between the third and fourth interviews, and the fact that the preservice teachers often had full-time jobs rather than being at university, it was more challenging to attain participation in the fourth interview. However, the researcher did have a pre-existing relationship with the students as a prior employee of the university that they attended, which helped reduce the attrition rate any further.

Another limitation was that information was only sought through the perceptions of the preservice teachers themselves. It is plausible that the motivation and perceptions of these teachers may have been different to their cooperating teachers on their practical experience, Principals and university lecturers. Administering the STEBI-B prior to graduation and after the first year of employment would have also provided other information to support these perceptions. However, the logistical issues involved with this were beyond the scope of this current study.

A final limitation was that a decision was made by the researcher in the research design to only conduct the STEBI-B at the beginning and end of the science methods unit. This was due to significant logistical issues with administering the questionnaire at the end of the degree and after the first year of teaching. However, the inclusion of this data would have further enhanced the results of this study.

3.4 Data Analysis

3.4.1 Data Analysis in Mixed Methods Research

In this current study, as in other mixed methods research, a challenge facing the researcher was how to integrate the qualitative and quantitative data collected (Onwuegbuzie & Leech, 2006). The data analysis was assisted using the web-based software *Dedoose*, which is designed to support data analysis in mixed methods research.

In deciding the most appropriate form of data analysis for this research, the researcher explored Onwuegbuzie and Teddlie's (2003) seven-stage process for analysing mixed methods data. Most researchers engaged in mixed methods research will use some of these data analysing tools during their research (Onwuegbuzie & Leech, 2006). The first stage involves *data reduction*, which involves doing initial analysis of the qualitative and quantitative data respectfully, by using methods specific to the data sources. The second stage is *data display*, which involves representing the data from both the qualitative and quantitative data pictorially. The third stage is *data transformation*, where, a researcher may quantify the qualitative data or qualify the quantitative data (Creswell, 2009). *Data correlation* is the fourth step, which is where

quantitative data and qualitative data are correlated. The fifth step is *data consolidation*, where the data is combined to make new data sets. Following this is the stage of *data comparison*, where qualitative and quantitative data are compared. The final stage is *data integration*, where the data is combined into a coherent whole data set.

In the case of this current research, data reduction, data display, data transformation, data consolidation and data integration were part of the data analysis process. Table 3.6 summarises how this data analysis occurred.

Table 3.6
A Summary of the Data Analysis Process

Data Analysis Stage	Processes Involved
Data Reduction	<ul style="list-style-type: none"> • Qualitative data - meaning coded • Quantitative data - descriptive and comparative statistical analysis
Data Display	<ul style="list-style-type: none"> • Qualitative data - meaning condensation • Quantitative data - tables
Data Transformation	<ul style="list-style-type: none"> • Quantitative data converted into qualitative data using Dedoose web-based software
Data Consolidation	<ul style="list-style-type: none"> • Converted quantitative data and qualitative data consolidated to form a new data set in Dedoose
Data Integration	<ul style="list-style-type: none"> • Quantitative and qualitative data integrated in Dedoose to form a coherent whole.

3.4.2 Qualitative Data Analysis

In this current study the major form of qualitative data analysis that was used was *systematic text condensation* in order to support the descriptive and interpretive approach. This corresponded to the theoretical and methodological framework of this study. This approach is advocated by Malterud (2012) who argues that it is feasible and transparent. The aim of such an approach is to systematically organise and make connections with different aspects of the data in order for the research participants to

interpret and make sense of the data (Bogdan & Bilken, 2003; Stringer, 2004). The five parts of systematic text condensation are: reading over the qualitative data and identify themes; using the themes to identify codes; using the process of condensation to move from codes to meaning; synthesising the condensation to descriptions and concepts; and finally reviewing the sequences of analysis and the researcher making adjustments where required. These steps are described in more detail below and related to this current research.

In the first step of systematic text condensation, the primary focus is on reading through the qualitative data collected, which is supported by Creswell (2009). Creswell (2009) argues that this is important to get a *sense of the whole*. In the current study, the researcher read through the entire interview transcripts, recording key ideas that arose (Creswell, 2009). Through this process the researcher was able to list preliminary themes that emerged (Malterud, 2012).

The second step involved reviewing each transcript to identify meaning units, which is basically any text from the transcript that related in some capacity to the research questions (Malterud, 2012). From here, the process of coding occurred, which connected to Onwuegbuzie and Teddlie's (2003) concept of data reduction. Coding can be defined as the process of taking qualitative data and "segmenting sentences (or paragraphs) or images into categories, and labelling those categories with a term, often a term based in the actual language of the participant" (Creswell, 2009, p. 186). For this step, the researcher had to decontextualise the text from its original context and the coding elaborated on some of the key themes identified in the first step. Sometimes, codes can be developed in advance by consulting existing literature (Creswell, 2009; Kvale & Brinkmann, 2009), which was relevant to this current study. Developing a list of coding categories is therefore a crucial step for a researcher (Bogdan & Biklen, 2003).

The third step involves the condensation of the codes to assist in order to make meaning, which relates to the data display phase of analysis (Malterud, 2012). This involved the researcher sorting the code groups into sub-groups, reviewing every meaning unit in this subgroup, and then reducing the content into a *condensate*

(Malterud, 2012). In short, the condensation process involves compressing longer statements into brief statements that express the main essence of the longer statement (Kvale & Brinkmann, 2009). The researcher aimed to ensure that these meaning condensations retained the original language of the participants, which Malterud (2012) believes is important in systematic text condensation.

The fourth step involves putting back the pieces of the data, reconceptualising it, and relating it to the codes and condensates created (Malterud, 2012). This relates to Onwuegbuzie and Teddlie's (2003) concepts of data consolidation and data integration and involved the qualified quantitative data. In this current study, the researcher took on the role of *re-narrator* and developed thick descriptions, which also involved revisiting the original data sources. In the final step, the whole analytical process was reviewed, recognising that themes, codes, condensates and descriptions are all flexible and may be adjusted if new patterns emerge (Malterud, 2012).

3.4.3 Quantitative Data Analysis

The Statistical Analysis Package (SPSS) version 21 was used to analyse the quantitative data produced from the STEBI-B. The results of the final administration of the STEBI-B were analysed for reliability using Cronbach's alpha. This is shown in Table 3.7 and is comparable to the alpha values identified by Enochs and Riggs (1990), who achieved 0.90 PSTE and 0.76 STOE.

Table 3.7
STEBI-B Reliabilities

Scale	No. of items	Reliability	
		August 2103 (N = 136)	November 2013 (N = 135)
Personal Science Teaching Efficacy Belief Scale	13	0.89	0.85
Science Teaching Outcome Expectancy Scale	10	0.62	0.70

Initially, descriptive and comparative statistics were completed based on the sets of results from both STEBI-B administrations. Means, standard deviations, t-tests and one-way ANOVA with post tests were carried out. The scores for each individual

were calculated after the first administration, which assisted the researcher to identify participants with differing efficacy beliefs. This, combined with other information including gender, prior science experience and degree was useful in providing additional information about the science teaching and learning beliefs of participants (Bleicher, 2004).

Following this and using the Dedoose program, this quantitative data was converted to qualitative data in the data transformation stage, leading to further analysis. Results for individual items of the STEBI-B were examined to identify areas of concern for the wider preservice cohort. An area of concern was identified by the researcher when the mean score for an item fell between the Likert scale scores of Uncertain (score=3) and Strongly Disagree (score=1). Items that had a mean score slightly higher than three were also considered. As part of the scoring process, the researcher had previously accounted for reverse scored items as discussed previously in this chapter. Similarly, the researcher then looked for areas of strength within the qualified STEBI-B results. An area of strength was identified when the mean score for an item fell within the Likert scale of between Strongly Agree (score=5) or Agree (score=4), depending on how the item was phrased.

3.5 Pilot Study

A pilot study was completed in the second half of 2012, to explore whether the design and data collection processes were appropriate. Participants were primarily third year preservice teachers in the Bachelor of Education (Early Childhood/ Primary) at a tertiary institution in Western Australia. The STEBI-B was administered in a first semester lecture for a different unit, prior to a 10-week practicum. This practicum was then followed by the *Primary Science* unit in second semester. From the results of this instrument, five participants were selected to trial interview questions at the beginning and end of the unit.

Several issues were identified during the pilot study. Firstly, conducting the STEBI-B during a lecture was problematic, as lecture attendance can be significantly lower than in other university teaching formats, including tutorials and workshops. Conducting the STEBI-B prior to the practicum also limited the ability of the

researcher to judge the effectiveness of the *Primary Science* unit. It was also recognised that the researcher needed to determine a way to ascertain key demographic information about the cohort. These issues were rectified in the current study. Interview questions were found to be appropriate to assist the researcher in making meaning of the research questions. One significant issue that was identified due to the ethical issue that presented, was that another researcher should interview the participants at the end of the science unit, due to the fact that the researcher was the unit coordinator for the unit.

3.6 Ethical Issues

One of the major ethical issues involved in this current research was that the researcher was the unit coordinator and presenter for the *Primary Science* unit. Preservice teachers could have felt compelled into participating in the research, leading to an asymmetrical power relationship (Brinkmann & Kvale, 2005). It was therefore essential that all participation was voluntary, and that students could change their mind at any point in the research process. All preservice teachers were provided with an information sheet detailing the purpose and nature of the research, what methods and instruments would be used, as well as the potential benefits and risks of being involved. A separate information sheet was developed for the administration of the STEBI-B to the whole preservice teacher cohort (Appendix 6) and for the in-depth interview participants (Appendix 7). On the information sheet and in person, participants were informed that they were able to make a voluntary choice as to whether they wished to be involved and that they could withdraw at any stage with prejudice. Students were informed that withdrawing or not participating would not impact their grade in the *Primary Science* unit. A consent form for the STEBI-B participants (Appendix 8) and in-depth interview participants (Appendix 9) also accompanied the information sheets, because written consent was required. To also address this issue, an alternate interviewer was involved in the second interview, which involved a reflection on the *Primary Science* unit, to ensure that the participants could provide honest reflections about the unit.

Privacy, confidentiality and consideration were also ethical issues that needed to be considered. In the information sheet, participants were guaranteed privacy and confidentiality in relation to the data that was collected. Participants had the right to remain anonymous and pseudonyms were used. Participants were informed that only the researcher and supervisor had access to the data collected during the research. In relation to the responses from the STEBI-B questionnaire, data were presented as cohort results, which ensured that individual responses remained confidential. Data were collected in such a way to minimise disruption. In the case of administering the STEBI-B questionnaire, this was scheduled for the planned unit workshops. In relation to the interviews, flexibility was required, and participants were able to negotiate the location and time of the interview.

Research that is ethical needs to be credible, therefore demonstrating reliability and validity. The researcher of this current study used the following methods to demonstrate this. Firstly, the researcher used prolonged engagement, which involved a long, intense contact with the research focus, as well as an in-depth focus on essential elements (Creswell & Miller, 2000; Lincoln & Guba, 2007). The research used several reliability procedures such as checking transcripts and quantitative data for errors, and rechecking codes and condensates developed through the analysis process (Creswell, 2009). It also involved pre-testing interview questions, which was completed in the pilot study, and training the additional interviewer for the interview following the *Primary Science* unit (Silverman, 2001).

To ensure validity and reliability, the following processes were employed. Data was triangulated using multiple sources of evidence to justify themes (Creswell, 2009; Creswell & Miller, 2000; Silverman, 2001; Yin, 2009). Another strategy that was used was member checking, whereby participants are involved in checking the data and interpretations as it was developed (Creswell, 2009; Creswell & Miller, 2000; Lincoln & Guba, 2007). Thick, rich descriptions were also used in this research study, which assists the reader in relating to the experience that is presented (Creswell, 2009; Creswell & Miller, 2000; Lincoln & Guba, 2007). The researcher actively looked for information that contrasted the themes identified. The researcher established a relationship with a peer to allow for peer debriefing, which assisted the accuracy of

the study (Creswell, 2009; Lincoln & Guba, 2007; Merriam, 2009). Finally, an audit trail was established and through the doctoral supervision process this allowed for constant review of the research process (Creswell, 2009; Lincoln & Guba, 2007; Merriam, 2009).

A frequent aim of educational research is the ability to generalise results. In research that is primarily qualitative, *naturalistic generalisations* are based on personal experience and can be connected through context (Lincoln & Guba, 2000). Merriam (2009) refers to this as transferability. Generalisations are “arrived at by recognising the similarities of objects and issues in and out of context and by sensing the natural covariations of happenings” (Stake, 2000, p. 22). Schofield (2000) maintains that qualitative researchers interested in studying educational processes should attempt to generalise in three domains: to *what is*, which means to study the typical, common or ordinary; to *what may be*, which means to consider current social and educational trends and design research to highlight these issues; and to *what could be*, which means locating situations that are exceptional to see what is occurring there. The researcher has attempted to meet all of these criteria through the selection of the context, the purposeful selection of participants and through relating the findings to current theory (Merriam, 2009).

3.7 Summary

As described above, the current research used a mixed methods research design to answer the overall research question and three research sub-questions identified. This mixed methods research was primarily qualitative, with data collected longitudinally through interviews. These interview data were supported by quantitative data collected through the STEBI-B questionnaire. Data were analysed and ethical issues were considered to support the theoretical and methodological framework of the study.

Chapter 4

Prior Experiences of Science Teaching and Learning and the Influence on Science Teaching Efficacy Beliefs

4.0 Introduction

This study aimed to explore the overall research problem: How, why and to what extent do science teaching efficacy beliefs change over time? The intention of the study was to explore whether science teaching efficacy beliefs change over time and what may influence these beliefs at different stages of development as preservice teachers complete their teacher education training and move into their first year of teaching. Although previous studies have explored the impact of science education units and practical experiences on science teaching efficacy beliefs of preservice years, as previously discussed, these studies have primarily involved quantitative, cross-sectional approaches. The current study has been designed longitudinally and involves a qualitative dominant mixed methods design, in order to ascertain what meaning participants prescribe to their beliefs at different points in their development and what they believe has influenced these beliefs. This chapter also helps to address existing gaps in the literature, by exploring how contextual factors impact and modify science teaching efficacy beliefs (Seo, 2016).

This is the first data chapter, which presents the results and discussion of the first research question: How, why and to what extent do prior experiences of science teaching and learning influence science teaching efficacy beliefs? In order to comprehensively answer this research question, quantitative data of the wider preservice teacher cohort are presented, capturing science teaching efficacy beliefs from a pre-test administered at the beginning of the research period. These data complement the qualitative data from the participants who were involved in in-depth interviews also at the beginning of the research period. Data that explores what in-depth participants perceive as influencing their science teaching efficacy beliefs are also addressed. This chapter also discusses the results relevant to this question in relation to the current literature.

4.1 Science Teaching Efficacy Beliefs at the Beginning of the *Primary Science* Unit: STEBI-B Results

This research study involved two groups of participants. The science teaching efficacy beliefs of the wider preservice cohort enrolled in the unit *Primary Science* were captured using the quantitative STEBI-B questionnaire. At the beginning of the unit, 136 preservice teachers completed this questionnaire as a pre-test. The other group of participants were 10 individuals who were involved in longitudinal, in-depth interviews. Data from the in-depth interview participants' science teaching efficacy beliefs at the beginning of the unit were both quantitative, in relation to their results from the STEBI-B questionnaire and qualitative, from the transcripts of their first interview with the researcher. The results are discussed in the following section.

4.1.1 STEBI-B Results from August 2013

To determine the wider preservice cohort's current self-efficacy beliefs, the STEBI-B was administered at the beginning of the *Primary Science* unit. While 140 preservice teachers were enrolled in the unit, 136 completed the STEBI-B at this point. As outlined in Chapter 3, section 3.2.1 of this thesis, the preservice teachers enrolled in the unit included 41 Bachelor of Education (Early Childhood and Care 0-8 years) preservice teachers, 67 Bachelor of Education (Primary) preservice teachers, 16 Master of Teaching (Primary) preservice teachers and 12 preservice teachers were enrolled in another degree, which included the Graduate Diploma (Primary Conversion). Of the total cohort, 115 preservice teachers were female and 21 preservice teachers were male.

The results of the August 2013 administration of the STEBI-B showed the wider preservice teacher cohort had a mean Personal Science Teaching Efficacy (PSTE) of 46.35 and mean Science Teaching Outcome Expectancy (STOE) of 34.54. Table 4.1 shows the PSTE and STOE means for males and females from the August administration of the STEBI-B. These results show negligible variance between these means.

Table 4.1

Total Mean STEBI-B PSTE and STOE scores broken down by gender- August 2013

	Male	Female	Df	t	Sig.
Total Mean PSTE	46.05	46.41	134	1.98	0.84
Total Mean STOE	34.62	34.53	134	1.98	0.92

Table 4.2 shows the mean of both scales when analysed by university degree.

Table 4.2

Total Mean STEBI-B PSTE and STOE scores broken down by university degree- August 2013

Degree	Total Mean PSTE	Total Mean STOE
Bachelor of Education (Early Childhood and Care 0-8 years)	42.95	34
Bachelor of Education (Primary)	47.18	34.81
Master of Teaching (Primary)	48.31	36.25
Other	50.45	33.10

When analysed through university degree of enrolment, the mean PSTE of preservice teachers enrolled in the Bachelor of Education (Early Childhood and Care 0-8 years) was lower than the mean Bachelor of Education (Primary), Master of Teaching (Primary) and the Other category. A one-way ANOVA was conducted to compare the differences in PSTE scores for preservice teachers enrolled in different degrees. There was a significant difference between the degrees [$F(3, 130) = 4.72, p = 0.004$]. Post hoc comparisons using the Scheffe test indicated that the mean score for those enrolled in a Bachelor of Education (Early Childhood and Care 0-8 years) ($M = 42.95, SD = 7.78$) was significantly different than those enrolled in the Bachelor of Education (Primary) ($M = 47.18, SD = 6.99$) and those enrolled in the Other Category ($M = 50.45, SD = 8.70$). However, the other comparisons were not significant.

In contrast, those preservice teachers enrolled in the Other category had a mean STOE score, lower than the mean Bachelor of Education (Early Childhood and Care 0-8 years), Bachelor of Education (Primary) and Master of Teaching (Primary). Again, a one-way ANOVA was conducted to compare the differences in STOE scores for preservice teachers enrolled in different degrees. There was no significant variance between the degrees in this test [$F(3, 130) = 41.89, p = 0.13$] or in the resulting post hoc Scheffe test.

As part of the data analysis, results for individual items were examined to identify areas of concern or strength for the wider preservice cohort. This process is explained in Chapter 3, refer to section 3.4.3. The individual mean scores for the PSTE scale are shown in Table 4.3 and the individual mean scores for the STOE scale are shown in Table 4.4.

Table 4.3
Individual Mean Scores from the STEBI-B PSTE Scale - August 2013

STEBI-B Item (PSTE Scale)	Preservice Cohort Mean Aug. 2013
Item 2 - I will continually find better ways to teach science.	4.20
Item 3 - Even if I try very hard, I will not teach science as well as I will most subjects (Reverse score).	3.71
Item 5 - I know the steps necessary to teach science concepts effectively.	2.90
Item 6 - I will not be very effective in monitoring science experiments (Reverse score).	3.84
Item 8 - I will generally teach science ineffectively (Reverse score).	4.06
Item 12 - I understand science concepts well enough to be effective in teaching elementary science.	3.19
Item 17 - I will find it difficult to explain to students why science experiments work (Reverse score).	3.51
Item 18 - I will typically be able to answer students' science questions.	3.36
Item 19 - I wonder if I will have the necessary skills to teach science (Reverse score).	2.90
Item 20 - Given a choice, I will not invite the principal to evaluate my science teaching (Reverse score).	3.46
Item 21 - When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand it better (Reverse score).	3.58
Item 22 - When teaching science, I will usually welcome student questions.	4.23
Item 23 - I do not know what to do to turn students on to science (Reverse score).	3.57

Table 4.4
Individual Mean Scores from the STEBI-B STOE Scale - August 2013

STEBI-B Item (STOE Scale)	Preservice Cohort Mean Aug. 2013
Item 1 - When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	3.94
Item 4 - When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	4.01
Item 7 - If students are underachieving in science, it is most likely due to ineffective science teaching.	3.23
Item 9 - The inadequacy of a student's science background can be overcome by good teaching.	3.90
Item 10 - The low science achievement of some students cannot be blamed on their teachers (Reverse score).	2.74
Item 11- When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	3.46
Item 13 - Increased effort in science teaching produces little change in some students' science achievement.	3.51
Item 14 - The teacher is generally responsible for the achievement of students in science.	3.56
Item 15 - Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	3.49
Item 16 - If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	3.39

Items 5 and 19 from the PSTE scale, as well as Item 10 from the STOE scale were identified as areas of concern. The low means of Items 12 and 18 from the PSTE scale and Item 7 from the STOE scale were also flagged as possible areas of concern. These items were connected to how the preservice teacher cohort rated their science content knowledge and skills or concerns about their ability to influence student achievement in science. In contrast, Items 2 and 8 from the PSTE scale and Item 4 from the STOE scale were identified as areas of strength. These items were focused on a teacher's pedagogical skills.

As part of the process of selecting the sample for the in-depth interview participants, the STEBI-B results were used to identify preservice teachers who showed a range in comparison with the means. Along with other criteria as described in Chapter Three, section 3.2.2, 10 participants were invited and accepted to be part of the longitudinal

semi-structured interviews. A summary of the demographical information of this group is included in more detail in Table 3.3 in Chapter Three.

The mean PSTE for the in-depth interview group was 48.3, higher than the wider cohort mean of 46.35. However, the mean STOE for the group was 32.3, lower than the wider cohort mean of 34.54. Figures 4.1 and 4.2 shows the in-depth participants' PSTE and STOE scores, respectively, in comparison to the pre-test mean of the wider preservice teacher cohort.

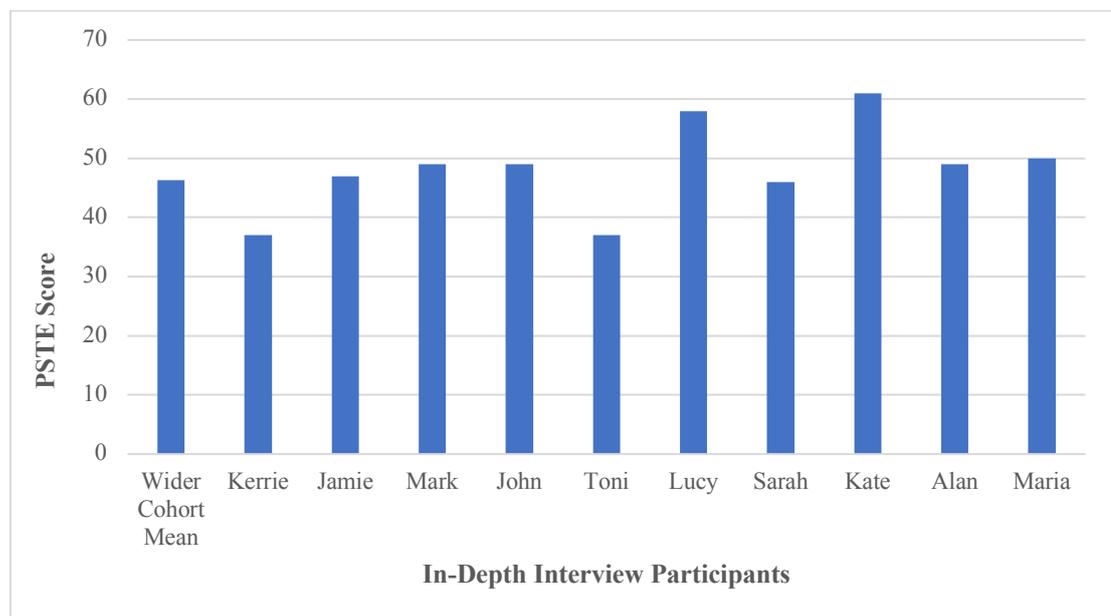


Figure 4.1 The PSTE scores of the in-depth interview participants compared to the wider cohort mean.

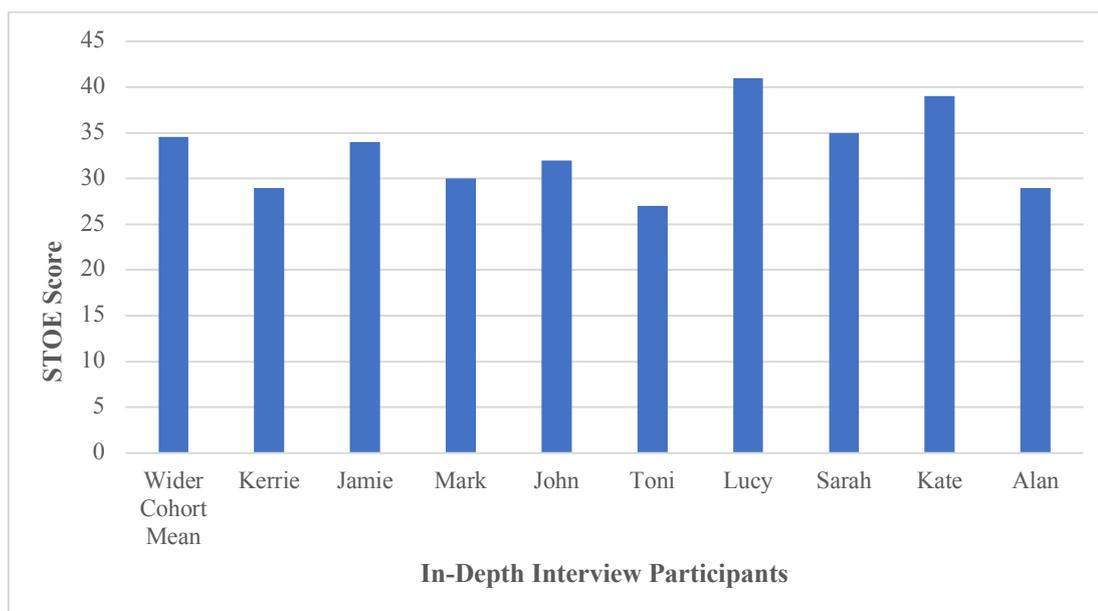


Figure 4.2 The STOE scores of in-depth interview participants compared to the wider cohort mean.

Of the in-depth interview participants, Lucy and Kate both had higher PSTE and STOE scores than the wider cohort preservice teacher means. Both of these preservice teachers were enrolled in the Bachelor of Education (Primary) degree and were specialising in science. In contrast, Kerrie who was enrolled in the Bachelor of Education (Early Childhood and Care 0-8 years) degree and Toni, enrolled in the Bachelor of Education (Primary) degree, both had lower PSTE and STOE scores than the wider cohort preservice mean and the means of their degrees they were enrolled in.

Jamie and Sarah had PSTE and STOE scores similar to the wider preservice cohort mean in both scales. Both of these preservice teachers were enrolled in an undergraduate Bachelor of Education degree, with Sarah completing the primary degree and Jamie enrolled in an early childhood degree. While Sarah's PSTE and STOE scores were similar to the mean of all students enrolled in a Bachelor of Education (Primary) degree, Jamie's PSTE score was higher than the mean for others enrolled in the Bachelor of Education (Early Childhood and Care 0-8 years).

Maria and Alan, who were both completing postgraduate degrees, and Mark and John who were enrolled in the Bachelor of Education (Primary) degree, had higher than the

mean PSTE scores and lower than the mean STOE scores in comparison with the wider preservice teacher cohort. This was more pronounced for Maria, who was enrolled in the Graduate Diploma of Education and who had already completed a secondary education degree. While her PSTE score was similar to the mean of individuals enrolled in the Other category (including the Graduate Diploma), her STOE score was lower than the mean for this category, as well as the wider preservice cohort. For Mark, John and Alan, their STOE scores were also lower than the mean for males enrolled in the unit.

4.1.2 Discussion of STEBI-B Findings: August 2013

The results from the initial STEBI-B conducted at the beginning of the science methods unit with the whole preservice cohort showed an average PSTE score of 46.35 and an average STOE of 34.54. This is comparable to several other Australian studies, including McKinnon (2010) where the results showed a 46.38 PSTE pre-test mean and a 36.06 STOE pre-test mean, and Palmer (2006a) where the results were a pre-test mean of 43 PSTE and 34 STOE. However, a limitation of administering the STEBI-B using the traditional pre and post-test method, as utilised in this current study, is that preservice teachers may overinflate their science teaching efficacy beliefs (Cantrell, 2003; Hechter, 2011). This overinflating cannot be effectively ruled out in the context of this present study.

As is evident from the results, gender had a negligible impact on the science teaching efficacy beliefs from the pre-test findings. At the beginning of *Primary Science* unit with the wider cohort, females had an average PSTE score of 46.41 and STOE score of 34.53, while the male average PSTE score was 46.05 and STOE of 34.62. This is in line with findings from Bayraktar (2011), Mulholland et al. (2004) and Yilmaz and Çavaş (2008), which showed negligible gender differences in science teaching efficacy scores from the administration of the pre-test STEBI-B questionnaire. However, the current findings are in contrast with studies by Odgers (2007), Lumpe et al. (2012), Bleicher (2004) and Cantrell, Young and Moore (2003), which found that males had higher science teaching efficacy scores than females. A possible explanation for this discrepancy could be the lower numbers of males enrolled in the *Primary Science* unit. Of the 136 preservice teachers who completed the STEBI-B questionnaire, only 21

were male, equating to 15% of total preservice teacher wider cohort. However, males are underrepresented in Australian early childhood and primary settings in general (Weldon, 2015) and other studies involving the STEBI-B have had similar percentages of males involved (e.g. Bleicher, 2004).

The findings of the STEBI-B pre-test suggest variance in relation to the degree in which preservice teachers were enrolled. It can generally be stated that the age of preservice teachers enrolled in undergraduate Bachelor of Education degrees are younger than those enrolled in postgraduate degrees. From the wider preservice cohort, the preservice teachers studying in the Other category (including Graduate Diploma of Education) and the Master of Teaching (Primary) had high mean PSTE scores of 50.45 and 48.31, respectively. Preservice teachers in these degrees have completed previous undergraduate study in another field or in education and were, on average, older than those who are studying an undergraduate degree. This supports the findings of Odgers (2007) who identified a correlation between older preservice teachers and a higher appreciation of science as a learning area. However, those in the Other category had a mean STOE score of 33.10, lower than those studying the other degrees. This may be explained by their concerns about their capabilities to gain positive science learning outcomes with younger students, as many of these preservice teachers have previous degrees in secondary education.

From this analysis of the STEBI-B items, the key areas of concern primarily related to the individual's content knowledge and concerns about teaching performance and pedagogical skills. However, the mean scores fell closer to Uncertain, rather than Strongly Disagree, which suggested that the preservice teacher participants were more unsure rather than set in their beliefs about their abilities to learn and teach science. This may be indicative of the malleability of beliefs that is often present with preservice teachers when completing preservice degrees (Berg & Smith, 2016; Labone, 2004; Menon & Sadler, 2016). Considering these are the STEBI-B results at the beginning of the *Primary Science* unit, the high means of items two, four and 22 highlight an optimism about the preservice teacher cohort's beliefs about teaching and learning science. The results may highlight that the cohort recognised that high levels of effort and enthusiasm were important for effective science teaching and felt that they wanted to continually improve their skills in teaching science. These items that

were identified as areas of strength or concern will be used as a basis of comparison to post-test findings, as discussed in the following chapter.

4.2 Science Teaching Efficacy Beliefs at the Beginning of the Primary Science Unit: In-Depth Interview Findings

4.2.1 In-Depth Interview Findings: August 2013

The qualitative data collected through the in-depth interview participants provides illumination of the STEBI-B results. In order to follow the trajectory of each of the in-depth participants throughout the research study, findings for each participant are presented, as well as contextualising information that was shared during the August 2013 semi-structured interviews.

There were two participants who were enrolled in the Bachelor of Education (Early Childhood and Care 0-8 years) degree. Kerrie was a mid-year intake into the degree, which meant that her unit and practical experience schedule was different to those enrolled from the start of the year. She lived in a low socioeconomic area and had been involved in a bridging course in order to gain entry to the Bachelor of Education. At the beginning of the *Primary Science* unit she had only completed one practical experience, while the other preservice teachers in her degree had completed two practical experiences at this point in time. Kerrie had not completed any other science education units; a new unit dedicated to science in early childhood was not scheduled to begin for a few years. As previously discussed, her PSTE and STOE scores from the STEBI-B pre-test were low compared to the wider cohort mean. In her August 2013 interview, Kerrie shared that she enjoyed watching experiments and finding out new things in science. Her responses indicated that while she had taught limited science on her practical experience, she was unsure about her ability to succeed in the unit:

I was able to teach science on my practical experience, which was about weather to Pre-Primary students... I am unsure about how well I will do in this unit, I mean, I don't know a lot of science information or how to teach it that well.
(Kerrie, interview Aug. 13)

Jamie was the other preservice teacher specialising in early childhood. She was enrolled in the Bachelor of Education (Early Childhood and Care 0-8 years), which was being reconfigured in order to more specifically meet the requirements of ACECQA and the *National Quality Framework*. Interestingly, this meant that for preservice teachers such as Jamie, there was a transition within the degree and she expressed that she felt this led to them feeling like guinea pigs, particularly in relation to being the first group to complete a practical experience in a childcare centre. For Jamie, this led to frustration and a negative practical experience, because she felt the university did not prepare or support them adequately for this experience. At the beginning of the *Primary Science* unit, Jamie had completed the unit *Environmental Science and Technology* in her first year, which is a requisite unit in the Bachelor of Education (Primary) degree and was a previous requirement of the early childhood degree. She expressed a positive attitude towards science, particularly biology and environmental science, and was excited to begin the unit, despite the stress of assignments. Jamie shared:

I quite enjoy science. I mean, I am confident with biology. I am not so confident with chemistry and physics, and maybe not so sure about how to teach it to older students, but I think I would be okay teaching science to young kids. (Jamie, interview Aug. 13)

Of the in-depth interview participants, six preservice teachers were enrolled in the Bachelor of Education (Primary) degree. Mark was enrolled in this degree and entered the degree straight from high school. He had completed the prior requisite unit *Environmental Science and Technology* and was feeling okay about beginning coursework again in the second semester of his third year, following a 10-week practical experience. As evident from the STEBI-B pre-test, Mark's PSTE score was higher than the wider cohort mean, but his STOE score was lower than the mean. The August 2013 interview provide some explanation for these scores. Mark stated about his previous experience with science in high school:

I didn't understand [science] in the first place and I was overwhelmed by it when I began doing it. I chose not to pursue it and didn't really work at trying to understand it because it wasn't a necessity. (Mark, interview Aug. 13)

John transferred to the Bachelor of Education (Primary) degree, after initially beginning a degree in sports science. He too had completed the requisite *Environmental Science and Technology* unit that was part of the degree. John indicated that while he enjoyed the university lifestyle, he was not feeling enthusiastic about being back at university following such a long practical experience. Similar to Mark, John's PSTE score from the pre-test of the STEBI-B was higher than the wider preservice cohort mean, while his STOE score was slightly lower than the cohort mean. However, in the August 2013 interview, John felt that his lack of interest in science as a learning area contributed to some of the challenges he faced during high school:

I think if you're good at that and actually interested in that then it becomes a lot easier. So for someone like me, I was not interested in that and therefore I didn't like science. (John, interview Aug. 13)

Toni was also enrolled in the Bachelor of Education (Primary) degree, entering the teaching degree straight out of high school. She had completed the unit *Environmental Science and Technology* and had also recently completed her second 10-week practical experience, which was embedded within the degree. Toni expressed that it was challenging coming back to university after such intense practical experiences and shared that she was finding it difficult to manage her study with the need to also have a part-time job. In the pre-test of the STEBI-B, both Toni's PSTE and STOE scores were lower than the wider cohort mean. Toni came into the *Primary Science* unit with a sense of reluctance and a lack of enthusiasm:

I'm quite nervous really, because I don't know a lot about it so it's nerve-racking and not too excited about it to be honest. (Tony, interview Aug. 13)

Lucy was enrolled in the Bachelor of Education (Primary) degree and was specialising in science as part of the degree requirements. She began tertiary studies by enrolling in a nursing degree for two years, before moving into biomedicine, which she studied for approximately 18 months. She then transferred to education, and the previous units she had completed were considered advance standing towards a specialisation in science. Due to this transfer, she was enrolled in both the requisite unit *Environmental Science and Technology* and *Primary Science* simultaneously at the time of the August 2013 interview. Lucy was content being back at university following the practical

experience, although this too had been positive for her. The results from the STEBI-B pre-test showed that her PSTE and STOE scores were higher than the wider cohort mean. While there may have been periods of her life when their confidence with science waned, a renewed sense of confidence had emerged, as evident in the comment below:

I think for a while there I did have a lack of confidence.... But then at university I really embraced the whole science part and I loved it, so I regained confidence and actually wanted to learn more about science. (Lucy, interview Aug. 13)

Sarah was enrolled in the Bachelor of Education (Primary) and had completed the requisite unit *Environmental Science and Technology*. Similar to Mark and Toni, she had entered the degree straight from high school and was beginning the *Primary Science* unit in the second semester of her third year, following her second 10-week practical experience in a primary school. This practical experience was highly successful and Sarah expressed reservations about coming back to university. The results from the STEBI-B pre-test showed that Sarah's PSTE and STOE scores were similar to the wider cohort mean. However, the August 2013 interview provided some further insight into her perceptions of science. For Sarah, there existed strong feelings of self-doubt in her abilities to teach science, due to the deficiencies of her own learning:

Once I started doing uni, I kind of felt a bit behind because I hadn't had the same experience. When I went out on prac, I didn't think I was equipped because I didn't have the same kind of effective learning that I'd wanted and didn't know if I could pass it on. (Sarah, interview Aug. 13)

Kate was also specialising in science as part of her Bachelor of Education (Primary) degree. Kate had previously completed the requisite unit *Environmental Science and Technology*, as well as several other science content units that were offered through a different school at the university. These units were not specifically aimed at preservice teachers. Kate had entered the degree after high school and was completing the unit at a similar time to Mark, Toni and Sarah. While she enjoyed her practical experience, she shared that she was excited to be back at university, as she could begin to see the *light at the end of the tunnel* in terms of the completion of the degree and because she

loved learning new things. Kate's PSTE and STOE scores in the STEBI-B were higher than the wider preservice teacher cohort. This was reflected in comments she made during the August 2013 interview, stating that she had a passion for science:

I just love it; I love it to death. I'm specialising in science, but whether people want to admit it or not, science is a part of the future. And the more people who understand it, or pursue an interest in it, the better. I just think that it's such an amazing subject, whether it's understanding the mechanics of how something works from how fast a car goes when it decelerates to the way the human body works. It's just, endless possibilities of finding out things that you probably use every day. (Kate, interview Aug. 13)

The remaining in-depth interview participants were enrolled in postgraduate degrees. Alan was completing a Master of Teaching (Primary) degree, which is a two-year postgraduate course. He had previously completed an undergraduate degree in Geophysics. The *Primary Science* unit was the only science education unit included as part of the degree, which is completed in the second semester of the first year, following a 10-week practical experience. Perhaps as expected, Alan's PSTE score in the pre-test STEBI-B was higher than the wider cohort mean, but his STOE score was lower. He explained that he was completing the degree at the same time as he was experiencing a transformation in his personal belief. This was an emerging interest in the deep ecology movement, which he described as a philosophy about finding a deeper sense of self through the embracement of stewardship of the earth. In the August 2013 interview, he shared an uncertainty about how these beliefs related to his teaching preparation, as he felt there was a conflict between how he ideally viewed an educator and how the university was preparing them as teachers. This conflict in Alan's journey contributed to mixed feelings of confidence about science:

Straightaway, there's this bubbling of excitement. I think mostly because of the stance I'm in right now, where it feels like this knife edge of learning a new way of experiencing and teaching it. Yeah, so excited. I do feel somewhat confronted, not just in science but in other subjects in terms of how we teach it and bring it to the students of the world, so that's challenging, so I feel challenged by it. (Alan, interview Aug. 13)

Maria was enrolled in the Graduate Diploma of Education (Primary), having previously completed a secondary education degree. Maria studied secondary education after previously beginning a degree in neuroscience. She decided to pursue education as she felt that neuroscience did not allow her to engage adequately with other people and was too laboratory-orientated. The Graduate Diploma was a 1-year degree, and *Primary Science* was an elective for her, which is in contrast to the other in-depth interview participants. The Graduate Diploma does not have practical experience embedded within the degree. Whilst completing this degree, Maria was working part-time in a secondary male single-sex school, teaching art. In the STEBI-B pre-test, her PSTE score was higher than the wider preservice cohort mean, and similar to the mean of others enrolled in postgraduate degrees. However, her STOE score was lower than the wider cohort mean. In the August 2013 interview, Maria shared a positive attitude towards science and was enthusiastic about being involved in the *Primary Science* unit, as illustrated by the following comment:

I love it, I love science. I'm very passionate about it. So I integrate with my teaching in the arts, I integrate a lot of science understanding, especially teaching boys as well. They love facts and knowledge and information. So I try to integrate it wherever possible, so I have a very positive view of science.
(Maria, interview Aug. 13)

The in-depth interview participants' understanding of the nature of science also illuminates the STEBI-B results. Key themes that emerged from participants' responses were having a real-world purpose, being hands-on and investigative, and allowing for the development of scientific skills and questioning through inquiry. This was a common finding from all participants, despite their previous experience or own feelings towards science. One way that this was illustrated was from Kate, who believed that science involves:

Investigating in a scientific related topic. Performing experiments, being able to come up with a hypothesis or at least test a theory or see what they think. If it succeeds, great, if not, maybe explain why. (Kate, interview Aug. 13)

There was a recognition in the responses of the participants of the importance of science contributing to deeper levels of understanding, rather than just surface knowledge. This learning involved focusing on how students can apply their

knowledge, rather than focusing on just learning facts. This was expressed in the following way by Lucy:

[Science is] *being able to apply those concepts to different situations so that it shows you have an understanding of those concepts.* (Lucy, interview Aug. 13)

When participants were reflecting on what high quality science teaching and learning looks like, a strong theme emerged relating to the emphasis needing to be on student curiosity and questioning. Sarah expressed that science must be experiential, hands-on, and allow students to be curious and problem solve:

They have to be able to ask questions and explore it for themselves and not just be spoon fed the answers and just go along with the flow. (Sarah, interview Aug. 13)

Similarly, Mark believed that science contributes to the development of questioning skills, which sets it apart from other learning areas. He thinks science has lifelong applications:

It makes students ask why...it gives them a life skill...so they can ask questions like "why?" They can ask questions like, "how?" And even later in life they will want to ask "why and how?" with other things that maybe perhaps aren't even related to science. (Mark, interview Aug. 13)

4.2.2 Discussion of In-Depth Interview Findings: August 2013

As evident through the semi-structured interviews, half of the in-depth interview participants in this current study expressed some concerns with the area of science at the beginning of the *Primary Science* unit due to their prior experiences or lack of interest in science, two participants expressed some limitations of their ability to teach science, with only three participants expressing an optimistic view of teaching science. This is supported by in-depth qualitative research of 12 preservice teachers by Yoon et al., (2006), which identified that half of the participants expressed a lack of confidence due to their lack of content knowledge at the beginning of a science methods unit.

In the study by Yoon et al. there was only one participant who recorded a positive response due to previous positive science experiences and high levels of science content knowledge. In this present study, three of the participants expressed high levels of self-belief about science in the qualitative data collected in August 2013. All three participants had previous positive experiences and interest in science, with two participants having studied an unrelated science degree before commencing an education degree, and the other specialising in science as part of their education degree. At this point in the study, all of the current study's in-depth interview participants expressed that science should be exploratory, hands on and fun, supporting previous research by Hubbard and Abell (2005) and Cassel and Vincent (2011). Lucy, Maria and Kate, as illustrated through the semi-structured interviews, expressed higher levels of enthusiasm and passion towards science than the other in-depth participants. This was supported by their PSTE and STOE scores in the STEBI-B pre-test. This seems to be consistent with the findings of Senler (2016), who highlighted the correlation between higher levels of science teaching efficacy beliefs and a more positive attitude towards science. This is also reflected by John's beliefs, as he seemed to connect attitude towards science with learning success and enjoyment, which correlates with findings by Niehaus et al. (2012).

For the in-depth interview participants who expressed concerns or limitations in the August 2013 semi-structured interviews, these seemed to relate to either their ability to learn science or teach science effectively. For Kerrie, Mark, Toni and Sarah, they described significant concerns about their own content knowledge in science, which connected with worries about how they would teach it. These findings are consistent with Moscovici and Osisoma (2008), in that unsuccessful science learning in the past was associated with participants feeling scared to teach science. Jamie, while sharing mostly positive self-belief about teaching science, articulated some limitations about her capabilities. Her science background in high school was in the area of biology and she expressed concerns about her knowledge of physics and chemistry. Jamie's experiences seem to support the findings of Hackling et al. (2014) who noted that high school students' involvement in the more academic science subjects of physics and chemistry has dramatically declined in Australia in the past decade. In this current study, the wider preservice teacher cohort were asked about the high school science subjects they completed in Year 12. Of the 136 preservice teachers, only four

preservice teachers had studied chemistry and only one preservice teacher studied physics, further supporting the findings of Hacking et al. (2014).

The personal beliefs shared by Maria and Alan are interesting to consider. While Maria conveyed a positive attitude and confidence towards science through the semi-structured interviews, which was reflected in her high PSTE score, her STOE score was lower than the wider cohort mean. A possible explanation of this relates to her previous experience teaching secondary students which may have led to her experiencing self-doubt about her ability to have strong science learning outcomes with younger students. This seems to be consistent with the previous findings of Bleicher and Lindgren (2005) who found that even preservice teachers who had higher levels of science teaching efficacy beliefs often experience some doubt about their ability to successfully teach science to children. As a practising teacher, Maria may be an illustration of how efficacy beliefs are context and subject specific (Bursal, 2012).

Alan was similar to Maria in relation to his PSTE score being higher than the mean of the wider preservice teacher cohort and his STOE score lower than the mean. He had a strong science background but had no previous teaching experience. From the August 2013 interview, Alan was experiencing a discrepancy between his own emerging beliefs about deep ecology and his experiences in his postgraduate education degree. This seems to support the view of Hornstra and Mansfield (2015), who maintain that teaching beliefs are developed through the interplay of experiences as a learner, an individual's life experiences, the experiences in teacher education and other professional experiences as teachers. However, at this point of the study, it remained unclear as to whether this would have a tangible impact on his science teaching efficacy beliefs in the long term.

4.3 The Influence of Prior Science Experiences

As evident through the August 2013 semi-structured interviews, all of the participants experienced various levels of quality and opportunity in previous science learning experiences. When understanding the science teaching efficacy of preservice teachers, it is important to recognise that preservice teachers are both learners and teachers of

science. The data analysis process identified connections participants made between memories of prior science experiences and their own personal learning of science. The responses from the in-depth interview participants are discussed in relation to memories of the nature of primary school and high school science, memories of learning success in science, the perceptions of the quality of science teachers, previous tertiary science experiences and other factors.

4.3.1 Memories of the Nature of Primary and High School Science

Several of the participants did not recall science experiences in primary school. Maria, Kate, Alan and Jamie had no memory of science in primary school at all, other than irregular experiments. This is illuminated by the following comment by Alan, who remembered very little in relation to his experience of science in primary school other than an overall feeling:

I remember a disconnection with the things around me, with nature, with this joy of learning and the joy of seeing in everything a little story. (Alan, interview Aug. 13)

What was remembered by other participants tended to be the experiences that were hands-on, authentic and investigative in nature, which was a strong theme of how all of the participants believed science should be like. John had memories of being engaged through hands-on activities when he was in upper primary. He recollected being involved in exciting experiments that he found fun. Mark recalled his enjoyment of investigations with one particular teacher who taught him for Years 4 to 6 and shared his memories of some of these engaging tasks which included water rockets and solar ovens. Similarly, Kerrie recalled completing hands-on science tasks with one particular teacher in upper primary. Both Sarah and Toni shared their memories of particular topics such as learning about outer space and volcanoes, which they both recall enjoying. For both Sarah and Tony, reasons for their enjoyment were explained as having their science learning integrated with other learning areas, such as art and English.

Lucy had positive memories of primary school and recalled a high level of engagement in science, including getting involved in science opportunities outside of school. She

felt that this love of science persisted into her early high school years, where she felt a strong sense of involvement. These positive early experiences of science were significant enough for her to persist with science experiences as she encountered challenges later in high school. The following comment shares some of her memories of primary school science:

I was one of the geeky ones in the Double Helix Club and used to do science after school and really loved doing experiments and exploring the whole process. (Lucy, interview Aug. 13)

Experiences of the nature of high school science were largely viewed as negative by the in-depth interview participants. However, all of the participants excluding Toni and John, highlighted that there had been some engagement in science learning during high school, but this was overwhelmingly in lower secondary school, from Years 8 to 10. This enjoyment of science was again due to hands-on, investigative and authentic learning experiences. Such experiences, as shared by participants, included dissections, using Bunsen burners, excursions, camps and the use of real-life examples. An illustrating comment by Jamie, whose most memorable science experience in high school was a biology camp, captures the hands-on, investigative and authentic aspects of the experience:

During the night we'd go on a night walk and look at all the different animals and during the day we were doing species samples...but you kind of felt you had a purpose because it was for a reserve and we were giving them our results. (Jamie, interview Aug. 13)

For three participants, engaging science experiences also led to heightened feelings of wonder, curiosity and joy. Kate, Alan and Maria all shared experiences from high school that they considered relatively awe-inspiring. One such experience is described by Kate:

We had pet axolotls, do you know those Mexican walking fish? And I remember we were in biology at the time, the female was just about to release all her eggs into the environment. And so everyone, just raced over to the tank. And being able to see how millions of these eggs attached themselves to the plants and the tank was just amazing. (Kate, interview Aug. 13)

While there were some positive recollections of the nature of high school science, all of the in-depth interview participants expressed some level of dissatisfaction with the nature of science learning experiences in secondary school. The discontent predominantly revolved around a perceived emphasis on rote learning and theory, particularly in upper secondary years. All of the participants highlighted that their significant memories were a narrow view of science, with teaching and learning experiences revolving around the prescribed text book. This is effectively summed up by Lucy, who shared that she became *lost* in science in upper secondary school, after experiencing such positive experiences in primary school and early high school:

Year 11 was more about open up the book and understand this. Whereas, I found it really hard to comprehend and understand the concepts, without actually exploring them and how they actually worked. (Lucy, interview Aug. 13)

This perception was also captured by Kate, who shared how her perspective shifted as she moved into tertiary preparation science in Year 11. She shared:

I didn't have a whole lot of time to enjoy the subject, because a lot of it was "okay, that's great, do I need to know this for the test". (Kate, interview Aug. 13)

4.3.2 The Role and Quality of Science Teachers

The quality of the teachers throughout their primary and high school education was identified as the most significant contributor to the in-depth interview participants' experiences of science learning. The predominant experience of participants was low quality science teaching and they used words such as *bland*, *lethargic* and *dry* to describe teachers who lacked enthusiasm when teaching science. All participants except for Maria acknowledged that the quality of their teachers was the most influential factor to impact on their own learning and experiences with science. Kate, who was a high achieving science student in high school, shared her perception that teachers helping students achieve learning success contributed to how students engaged in science:

[The teachers] had a lot of impact on how well we did, which ultimately influenced whether or not we enjoyed the subject or not. (Kate, interview Aug. 13)

For seven of the in-depth interview participants, excluding Maria, Kate and Jamie, the key quality of teachers that influenced their personal science learning was the enthusiasm and passion the teacher exhibited for science. An illustrating comment is provided here by Kerrie, who did not complete any post-compulsory science study in Years 11 and 12, due to what she perceived as challenges with her learning in science. However, while her experiences of science were generally negative, she had a favourite science teacher earlier in high school, who had a positive impact on her:

Even if it was just a written lesson, he made it interesting. He joked and he was very passionate about science, and you could tell he wanted to be there and he wanted us to learn in his class. (Kerrie, interview Aug. 13)

Another quality of science teachers that was perceived as critical to learning in science was the ability of the teacher to relate to their students. Mark, John and Toni highlighted that when teachers struggled to build relationships with the students in their classes, this had a negative impact on their science learning. In the following comment, Mark shared how he felt this lack of relationship building impacted on the quality of science teaching:

The bad teachers in science I suppose didn't really have relationships with the kids and I suppose that showed in the way they taught. (Mark, interview Aug. 13)

Teachers' pedagogical skills was emphasised by two participants as being the most significant factor that influenced their learning and engagement in science. Jamie and Kate both felt that the way teachers presented or taught the content was critical to their own personal experiences. Both of these participants were high achieving students in science throughout high school but recognised that the way the teacher taught the area did not always create an optimum learning experience. Kate recalled an example of one teacher who, while positively contributing to her science grade, did not promote engagement in the subject:

I had a teacher that was stand and deliver. I didn't find that very useful, I mean it was good because you did well in tests because you knew the content you had to study. But it didn't really prompt your interest in the subject. (Kate, interview Aug. 13)

Mark, John, Lucy, Sarah and Maria also recognised that the teacher's skill in presenting content had impacted their own science learning and engagement in some capacity. Lucy had loved science in primary and early high school, and her achievement in the area had been high up until she began chemistry in Year 11, which she connected to the quality of her teacher:

I probably only did a couple of weeks of [chemistry], because the teacher moved through things very quickly, and if you asked for clarification, he pretty much said it in the exact same way. I felt like I just couldn't get anywhere with it and there was no extra guidance or help to get you back up to speed. I just felt like I was getting lost in it. (Lucy, interview Aug. 13)

4.3.3 Learning Success in Science

The learning success experienced by in-depth interview participants was also identified as influencing their science teaching efficacy beliefs as they began the *Primary Science* unit. Participants varied on whether they experienced success when learning science in high school and what the nature of the success was. For John and Toni, they could not recall a time during high school where they were able learn science effectively. However, for Mark, Kerrie, Lucy and Sarah, their learning success could be categorised as mixed. Where they failed or struggled to learn, these participants associated this with the actual nature of the experiences or the teacher. This is illustrated by Mark when he shared his perceptions of his lack of confidence in physics, despite previously being in advanced science classes:

I wasn't confident in it and I didn't feel like I had learnt the appropriate skills to pursue physics. Being able to apply it to different situations was where I fell down, rather than knowledge. I could do it in one example, but then the goal posts were moved a little bit and I struggled. (Mark, interview Aug. 13)

Science grades are one way to judge learning success in science. Jamie, Kate, Maria and Alan all received consistently high science grades in high school. Interestingly, getting good grades was not always associated as learning success by participants. Jamie shared that her high grades did not always translate to higher self-confidence in science, which she recognised as ineffective learning:

I did physics and I got really good marks, like A's for physics, but I had no understanding of it...it was all just this is the formula, put the numbers in, use your calculator and I was really good at doing those sort of things, but I never understood any of it. (Jamie, interview Aug. 13)

4.3.4 Memories of Previous Tertiary Level Science Classes and Practical Experiences

The experience of previous university science courses was varied among the participants. Alan, Maria, Lucy and John had either begun or completed a previous degree in a science-related degree, while Kate had completed multiple science discipline units as part of her specialisation in science for her primary teaching degree. No other participants had completed any additional science study at university. For Alan and John, there was a perceived discrepancy between what they had hoped they would experience and the actual experience of their science degrees. John came into university to begin a sports science degree, primarily due to his love of sport and despite his high school science experiences. He hoped that the emphasis would be on the analysis of sport, but the emphasis on physiology during his first semester led him to transfer to primary education. Alan completed a previous degree in geophysics before coming into education for postgraduate studies, and shared how his experiences of geophysics seemed incompatible with his own personal beliefs:

My experience of science going into geophysics eventually and my inspiration was I wanted to understand how the world worked. I just was so intrigued by why, how, and I was met with a very dry approach, I felt, and although I wasn't conscious of it, later on it would become known to me that I was actually yearning for a more meaningful approach to science. One that was integrated with the human body, with the human mind and so on. (Alan, interview Aug. 13)

Maria and Lucy enjoyed their tertiary science studies but questioned their long-term career paths. Lucy enjoyed her science learning in nursing and biomedicine, but she felt they did not translate into a desired vocation for her personally. For Maria, a disconnect emerged between her tertiary studies in neuroscience and her feelings about what she wanted to do in her career:

I really like engaging people, I love working with kids and it was an epiphany in a chemistry lab and [the lecturer] was doing titration and I just thought, I don't want to do this for the rest of my life. I actually want to be with people, I want to be with kids and doing rather than the paper academic side. (Maria, interview Aug. 13)

Kate's descriptions of her experiences of science during her tertiary study were positive. For her, her university science study reawakened a holistic view of science, which had narrowed for her during her studies in Year 11 and 12, due to the overemphasis on examination preparation and grades. In coming to university, she realised that she had more opportunities to show what she knew and she could broaden her perspective. In the following comment, Kate describes a moment in one of her units, where she felt connection to the learning due to her interest in the subject matter:

I did [a science unit], which was the human anatomy one, I think something clicked there for me. I just thought, I love learning about the muscles and the bones and stuff. (Kate, interview Aug. 13)

At the beginning of the *Primary Science* unit, six participants had completed another science methods unit as part of their degrees called *Environmental Science and Technology*. *Environmental Science and Technology* was normally completed in Semester Two of the first year of the degree for those completing the Bachelor of Education (Primary). The unit was structured with a one-hour lecture and a two-hour tutorial each week for 13 weeks. While focusing on environmental content, it provided an introduction to some aspects of the science curriculum and was designed to assist preservice teachers with the development of a repertoire of science teaching strategies. At the time of the August 2013 interviews, this unit was being phased out for those enrolled in early childhood degrees in order for a replacement early childhood science methods unit to meet ACECQA requirements. This meant that for those enrolled in the Bachelor of Education (Early Childhood and Care: 0-8 years), Jamie had completed the unit, but Kerrie had not, as she was a mid-year enrolment. Additionally, Lucy was completing the unit concurrently with the *Primary Science* unit.

The in-depth interview participants' perceptions of this unit were overly positive. Only Toni and Sarah expressed ambivalence with the unit. Toni shared that she felt a lack of integration between the lectures and tutorials but enjoyed the resources that were shared through the course reader. However, when it came time for her to have a go at using the resources when on her practical experiences, there was limited opportunity. For Sarah, while some aspects of the unit were perceived as beneficial, she still felt hesitant, which she felt was connected to the unit's timing in relation to her degree. She explained:

It was all right. The content was good and it was useful, and [the science teacher educator] was very passionate about what she was talking about. I think being in the first year and my first real contact with science since I left school, left me a bit unsure of it. (Sarah, interview Aug. 13)

Mark, John, Jamie and Kate detailed positive experiences with the unit. For Mark, he felt that the real strength of the unit, similar to Toni, was the course reader. In contrast to Toni though, Mark felt that he was able to use the resources presented in the course reader as the basis for providing direction to some lessons during his practical experiences. *Environmental Science and Technology* appealed to John for different reasons. In his previous experiences of science in high school and university, he felt that his immaturity was partially responsible for his lack of engagement. John felt that the hands-on nature of the tutorials in particular was a highlight of the unit. Jamie appreciated that the structure and content of the unit catered effectively towards teaching science at a primary school level in relation to environmental science. She perceived *Environmental Science and Technology* as her favourite unit within her degree and felt that the course reader and group presentations were a real highlight. Kate shared that she enjoyed the unit for similar reasons, stating:

I enjoyed going to the lectures...I think because it was environmental science, it was something we could really relate to. But relate to on a personal level, because it was implementing pedagogy and how we could teach it to kids. It was not just, "Oh global warming sucks", but what you could do right now to make a difference. (Kate, interview Aug. 13)

In August 2013 at the start of the *Primary Science* unit, the in-depth interview participants also had experience of tertiary science through the practical experiences they had as part of their degree. As previously discussed, the university that the preservice teachers were attending had a high practical experience component incorporated into teaching degrees, which was greater than AITSL requirements and a point of difference between other universities in Western Australia. At the start of the *Primary Science* unit, Jamie, Mark, John, Toni, Sarah and Kate had completed a 10-week practical experience in their second and third year of their degree, as well as a two-week immersion in their first week. Kerrie, Lucy and Alan had completed a 10-week practical experience and two-week immersion, as Kerrie and Lucy were mid-year enrolments and Alan was enrolled in a Master of Teaching (Primary) degree. Maria was the only in-depth interview participant who had not completed practical experiences, due to the fact that she was a practising teacher and practical experiences were not a requirement of her degree.

Practical experiences of quality science were varied for the participants. Kerrie, Jamie, John and Sarah all had at least one practical experience where they saw limited or no science taught. For Kerrie and Jamie, these were both in early childhood settings, with Jamie experiencing limited science in both a Kindergarten classroom and in her childcare centre practicum. Alternatively, Mark, John and Kate had one experience where they were able to plan and teach a series of science lessons after strong modelling and support from their cooperating teacher. All of these participants felt that, as a result, student engagement was high and felt fulfilled in the experience. Similarly, Sarah, in the most recent practical experience before beginning the *Primary Science* unit, was able to observe and assist a passionate and highly skilled cooperative teacher with his science lessons.

Toni, Lucy and Kate had one practical experience where a science specialist teacher provided release time for their cooperating teachers, which meant that their only experiences of observing science was limited. For Toni and Lucy, they attended some of these lessons and offered support to the science specialist teacher, but for both, having a science specialist teacher did not always translate to quality learning and teaching. However, Kate decided that she wanted an opportunity to teach science and

convinced her cooperating classroom teacher to run a series of science lessons, in addition to the science specialist classes.

Mark, Toni and Alan all had practical experiences where the resource *Primary Connections* was used to teach science. However, these in-depth participants shared that the resource was used as more of a checklist and their cooperating teachers shared an ambivalence or dislike of teaching science. When Mark and Toni were asked to do a science lesson from the resource, both experienced challenges in understanding what they were required to do and were given limited support by their cooperating teachers. Alan observed the students enjoying science, but also significant behaviour management issues, which further limited the quality of the learning and teaching.

Further exploration of how these science units and practical experiences influenced the science teaching efficacy beliefs of in-depth interview participants will be discussed in Chapter Five.

4.3.5 Other Factors that Influenced Beliefs about Science Learning and Teaching

Throughout their science learning experiences, other factors impacted on the in-depth interview participants' learning and beliefs about science. Two participants, John and Kerrie, emphasised that it was their own personal changing perceptions of the importance of science that influenced them as they began the *Primary Science* unit. John shared that as he became more mature and moved into an education degree, that this had positively impacted on his feelings towards science:

I've come to uni and actually being able to teach it to kids, I've found it way more interesting, but I think it's just a maturity thing as well. Being older, I'm generally more interested in how the world works and how different things work in the world. (John, interview Aug 13)

The peer group during their schooling was also identified by Alan and Sarah as important influences for their personal science learning, by impacting on the teacher's ability to effectively teach science, peer pressure and personal engagement. This is illustrated in the following comment by Sarah who identified

that classroom management impacted on her teacher's ability to cater for her needs as a science learner:

There was just no follow up. The teacher didn't seem to really care and when you generally wanted help, you couldn't get it because there were too many other factors going on in the classroom where they had to tend to the needs of others. I did go to a pretty rough high school, so there was a lot of trouble in the class. (Sarah, interview Aug 13)

Maria and Lucy shared how their families contributed to their perceptions of science. Lucy explained that having an older sister discussing her difficulty with her science studies in Years 11 and 12 actually influenced her own mindset when beginning the subjects herself. Lucy described this as a negative influence on her own science learning. However, Maria shared that the most positive influential factor on her own science learning was her informal science experiences during her childhood with her family. This is described in the following comment:

Spending time, you know, in the environment, sort of at the beach, in the water, in the rainforests and looking at things and going, "Oh I wonder how that works, or why that's happening," and then that process of self-discovery. (Maria, interview Aug 13)

Another significant influence for Maria, who already had a degree in secondary education, was her current school employment. The school in which she was employed, an International Baccalaureate School, had an emphasis on inquiry learning and science was considered as important as English or Mathematics. She explained the positive aspects that she saw within this approach:

[The emphasis] is good and the boys enjoy it and they have at the end of the year a big science show and they all either invent a product or create something that could be based on something that has really engaged them and that they are passionate about. (Maria, interview Aug 13)

4.3.6 Discussion of the Influence of Prior Science Experiences on the In-Depth Participants' Science Teaching Efficacy Beliefs

From the qualitative data presented, it was clear that prior experiences of science had an impact on the in-depth interview participants' perceptions of science. It is important to state that these perceptions are relative to each individual and will be impacted by differences in individual preferences, likes and dislikes (Hechter, 2011). This may be considered a limiting factor of the current study, but this is rectified by identifying key themes and patterns in responses by the in-depth participants.

Results from the current study indicate that the nature of previous science experiences impacted on the in-depth interview participants' perceptions of science. The research findings showed that there was an overwhelming emphasis on textbook based learning and a lack of hands on exploration in all of the in-depth interview participants' previous science studies in high school, particularly in Years 11 and 12. This led to issues with learning and engagement, supporting the findings of previous research by Mulholland and Wallace (2002), who identified that disengagement, content difficulties and poor quality teaching in high school led to individuals lacking self-efficacy with science in preservice teacher education. For six of the participants, their previous science experiences led to some level of doubt over their content knowledge, which varied for different participants. These findings are in line with previous research by Swars and Dooley (2011) who found that poor science content knowledge limits the healthy development of science teaching efficacy.

For the other participants, there had been enough positive prior science experiences or learning success for them to have an optimistic view of science overall. Findings of the current study suggest that for these participants, higher science teaching efficacy beliefs were present. Previous studies conducted by Bleicher (2003), Hechter (2011) and Mansfield and Woods-McConney (2012) found that positive prior experiences of science led to higher levels of science teaching efficacy. It is therefore logical to suggest that negative experiences can have the opposite effect. The findings of the current study may help to support the idea that the nature of previous science experiences influences efficacy beliefs, but a note of caution exists when interpreting these findings and identifying strong causality, due to the fact that the findings were from participants' perspectives (Hechter, 2011).

One of the most significant aspects that participants referred to as impacting on the quality of science learning and beliefs towards science was their teachers. The majority of the in-depth participants had negative memories of high school science teachers in this current study, and nine of the participants believed that the teacher was the most influential factor on their personal feelings and beliefs about science. The majority of participants recalled negative experiences of teachers, which included a transmission approach to teaching, too much emphasis on content, a lack of passion and weak teaching skills. In meta-analysis completed by Hattie (2009), characteristics of high quality teachers are that they are passionate, understand the needs of their students and have strong levels of pedagogical content knowledge. The positive traits of previous science teachers that the in-depth participants identified included enthusiasm, an ability to make the content interesting and relate to students, the incorporation of hands-on activities, and an ability to explain harder concepts. This ability to explain harder concepts and provide hands-on experiences was previously identified as contributing to an individual's positive attitude towards science (Hudson et al., 2011).

Other strong influences that were identified in this current study included how participants viewed their learning success and their previous tertiary science experience. Perceptions of learning success, whether positive or negative, seem to corroborate the results of Hechter (2011), who found that perceptions of achievement, rather than the actual achievement itself, was most influential in the development of science teaching efficacy beliefs. Other findings showed that the four participants who have been involved in other science study at a tertiary level all had higher levels of science teaching efficacy beliefs than the other participants. This supports previous research by Odgers (2007), Utley et al. (2005), Mulholland et al. (2004) and Yilmaz-Tuzun (2008), who all found that more science study at tertiary level led to higher science teaching efficacy beliefs. The other in-depth participants had not completed any additional science units at tertiary level outside of their degree, which replicates the findings of Hechter (2011).

4.4 Summary: Prior Experiences of Science Teaching and Learning and the Influence on Science Teaching Efficacy Beliefs

This chapter has presented the results and discussion of the first research question of this study, exploring how prior experiences of science teaching and learning influence science teaching efficacy beliefs. The wider preservice cohort in the Primary Science unit had varying levels of PSTE and STOE at the beginning of the unit, which was consistent with previous studies. Those students enrolled in the Bachelor of Education (Early Childhood & Care 0-8 years) had a lower PSTE mean, while those enrolled in the Other category had the highest STOE mean. Those enrolled in the Other category had the lowest STOE average, with those enrolled in the Master of Teaching degree had the highest STOE average. The difference in means between males and females in both PSTE and STOE scores was minimal. The qualitative findings of the in-depth participants showed variance in perceptions of science teaching efficacy beliefs.

A number of influences were identified as contributing to the in-depth interview participants' current science teaching efficacy beliefs:

- Science in high school revolved around theory and textbook-based learning experiences. This contributed to negative views about science and for some in-depth participants, led them to not pursue science, particularly when this corresponded to difficulties learning science.
- The quality of the teacher during high school was identified as the most significant contributor to the in-depth participants' science teaching efficacy beliefs.
- Five of the in-depth interview participants (Alan, Maria, Lucy, John and Kate) had completed some science tertiary study, in addition to or before their completion of teaching degrees. For three of these participants (Maria, Lucy and Kate), this experience contributed to higher science teaching efficacy beliefs.
- Six of the in-depth interview participants (Mark, John, Kate, Sarah, Jamie and Toni) had previously completed a science methods unit called *Environmental Science and Technology* as part of their teaching degrees.

Four of these participants (Mark, John, Kate and Jamie) expressed satisfaction with the unit, citing the structure and resources provided as beneficial. The other two participants (Sarah and Toni) found aspects of the unit helpful to their science teaching efficacy beliefs, but the timing of the unit and the ability of one participant to apply the practical resources to a practical experience were cited as limitations by these participants.

- Three of the in-depth participants (Alan, Kerrie and Lucy) had completed 12 weeks of practical experience at the beginning of the *Primary Science* unit and six (Mark, John, Sarah, Toni, Kate and Jamie) had completed 22 weeks. The participants had varying perceptions of the quality of the science learning and teaching experiences in these practical experiences, which influenced their own science teaching efficacy beliefs.
- Other factors that were acknowledged to impact on the in-depth participants' science teaching efficacy beliefs included the peer group, the learner themselves and family.

Chapter 5

Preservice Teacher Preparation and the Influence on Science Teaching Efficacy Beliefs

5.0 Introduction

The previous chapter presented the results and discussion of the first research question, which examined how prior experiences of science teaching and learning influenced the science efficacy beliefs of preservice teachers enrolled in a science methods unit. This chapter will describe the results and discussion of the second research question: How, why and to what extent does preservice teacher preparation influence science teaching efficacy beliefs?

As previously discussed in Chapter 2, Australia has governing body requirements for how universities must develop teacher education degrees to ensure that early childhood and primary graduates are prepared to teach all learning areas (ACECQA, 2013; AITSL, 2011a). The development of tertiary units and provision of practical experience for prospective teachers is specified, but there is scope within these requirements for universities to cater to their specific context (AITSL, 2011a). In relation to science, undergraduate degrees must include two science units that are logically sequenced and that connect theory to practice. However, universities have flexibility about whether the units are science content units, science pedagogy units or science methods units, where science content and pedagogy are integrated (AITSL, 2011a). Requirements also exist for practical experiences, but for early childhood and primary degrees it is not a requirement that science is taught by preservice teachers during such experiences (ACECQA, 2013; AITSL, 2011a). The university in this study had developed several AITSL and ACECQA accredited programs for early childhood and primary education, as described in Chapter 3 section 3.2.1.

To answer this research question, the findings are presented examining the impact of both science units and practical experiences on the science teaching efficacy beliefs of preservice teachers. Quantitative and qualitative data about the influence of the science units on science teaching efficacy beliefs are discussed in light of current literature. The influence that practical experiences had on the in-depth interview participants beliefs about teaching and learning science are also examined.

The chapter addresses key gaps in the current literature. The mixed methods qualitative-dominant design of the study is underrepresented in current literature and illuminates the meanings that the participants prescribe to their beliefs, which is not possible in quantitative designs (Klassen & Usher, 2010). By exploring these meanings in-depth, an understanding of how and why beliefs are developed or changed can be ascertained. Similarly, the findings in this chapter help to address a gap in the current literature about how science methods units help to support preservice teachers who have varying science teaching efficacy beliefs at the beginning of a unit (Menon & Sadler, 2016).

A discussion of the science teaching efficacy beliefs of the wider preservice cohort at the end of the *Primary Science* unit and the in-depth interview participants at the end of the unit and then again at the end of their degrees are presented. An exploration of key aspects of the science methods units that contributed to the development of science teaching efficacy beliefs are then discussed, followed by a closer aspect of how practical experiences also influenced these beliefs. Finally, key overall findings about how the university catered for the in-depth interview participants in order to effectively teach science as they begin their careers is explored.

5.1 Science Teaching Efficacy Beliefs at the Conclusion of the *Primary Science* Unit: STEBI-B Results

As discussed in Chapter 3, section 3.2.1- 3.2.3 this research study involved two groups of participants. In order to ascertain changes to the science teaching efficacy beliefs of the wider preservice cohort enrolled in the unit *Primary Science*, the quantitative STEBI-B questionnaire was administered at the end of the unit in November 2013. One hundred and thirty-six preservice teachers completed this questionnaire as a post-test. The other group of participants were 10 individuals who were involved in longitudinal, in-depth interviews throughout the research study. The results are discussed in the following section.

5.1.1 STEBI-B Results from November 2013

The STEBI-B was administered to the wider cohort for the second time at the conclusion of the *Primary Science* unit in November 2013. The results of this showed a mean PSTE of 52.15 and STOE of 36.99. This is in comparison to the pre-test PSTE of 46.35 and mean STOE of 34.54 in August 2013. Table 5.1 shows the increase of PSTE and STOE means from August to November for males and females.

Table 5.1
Total Mean STEBI-B PSTE and STOE scores broken down by gender - Comparison of August 2013-November 2013

Gender	Total Mean PSTE Aug. 2013	Total Mean PSTE Nov. 2013	Total Mean STOE 2013	Total Mean STOE Nov. 2013
Male	46.05	51.8	34.62	37.55
Female	46.41	52.21	34.53	36.84

The changes to the wider cohort's PSTE and STOE means can also be examined through university degrees in which the preservice teachers were enrolled. Table 5.2 shows this comparison, with the mean of both scales increasing for all degrees.

Table 5.2

Total Mean STEBI-B PSTE and STOE scores broken down by university degree- Comparison of August 2013 - November 2013

Degree	Total Mean PSTE Aug. 2013	Total Mean PSTE Nov. 2013	Total Mean STOE Aug. 2013	Total Mean STOE Nov. 2013
Bachelor of Education (Early Childhood and Care 0-8 years)	42.95	50.25	34.00	37.33
Bachelor of Education (Primary)	47.18	53.29	34.81	36.29
Master of Teaching (Primary)	48.31	51.08	36.25	39.50
Other	50.45	52.86	33.10	37.5

The comparison between the items means and standard deviations for the two scales for August and November 2013 are presented in Table 5.3. For both scales, the item means were higher when the STEBI-B was administered at the end of the *Primary Science* unit.

Table 5.3

STEBI-B Item Means and SDs: August and November 2013

Scale	No. of items	August 2103 (N = 136)		November 2013 (N = 135)	
		Mean	SD	Mean	SD
PSTE	13	3.58	0.58	4.02	0.44
STOE	10	3.47	0.39	3.71	0.41

Table 5.4 displays the results of a paired two-sample t-test comparison for the preservice teachers who completed the STEBI-B in August and November 2013 (N=119). This table shows that the PSTE scale mean increased from 3.53 in August (SD=0.58) to 3.99 in November (SD=0.48). The STOE scale mean also increased from 3.45 in August (SD=0.41) to 3.71 (SD=0.42) in November. These changes were significant ($p < 0.001$).

Table 5.4
Paired Two-Sample t-test Comparisons

Scales	Means		SD		Df	t	Sig.
	Aug. 2013 (N=119)	Nov. 2013 (N=119)	Aug. 2013 (N=119)	Nov. 2013 (N=119)			
PSTE	3.53	3.99	0.58	0.48	118	-10.26	<0.001
STOE	3.45	3.71	0.41	0.42	116	-6.27	<0.001

As part of the data analysis of the STEBI-B results following the *Primary Science* unit, results of individual items were examined to determine key areas of concern and strength of the preservice teacher cohort as discussed in Chapter 3, section 3.4.3. Table 5.5 shows the change in the STEBI-B PSTE items and Table 5.6 shows the change in the STOE items from August to November.

Table 5.5

Individual Mean Scores from the STEBI-B PSTE Scale - August and November 2013

STEBI-B Item (PSTE Scale)	Preservice Cohort Mean Aug. 2013	Preservice Cohort Mean Nov. 2013
Item 2 - I will continually find better ways to teach science.	4.20	4.51
Item 3 - Even if I try very hard, I will not teach science as well as I will most subjects (Reverse score).	3.71	3.91
Item 5 - I know the steps necessary to teach science concepts effectively.	2.90	4.13
Item 6 - I will not be very effective in monitoring science experiments (Reverse score).	3.84	4.21
Item 8 - I will generally teach science ineffectively (Reverse score).	4.06	4.19
Item 12 - I understand science concepts well enough to be effective in teaching elementary science.	3.19	4.00
Item 17 - I will find it difficult to explain to students why science experiments work (Reverse score).	3.51	3.90
Item 18 - I will typically be able to answer students' science questions.	3.36	3.76
Item 19 - I wonder if I will have the necessary skills to teach science (Reverse score).	2.90	3.51
Item 20 - Given a choice, I will not invite the principal to evaluate my science teaching (Reverse score).	3.46	3.65
Item 21 - When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand it better (Reverse score).	3.58	3.96
Item 22 - When teaching science, I will usually welcome student questions.	4.23	4.37
Item 23 - I do not know what to do to turn students on to science (Reverse score).	3.57	4.13

Table 5.6
Individual Mean Scores from the STEBI-B STOE Scale - August and November 2013

STEBI-B Item (STOE Scale)	Preservice Cohort Mean Aug. 2013	Preservice Cohort Mean Nov. 2013
Item 1 - When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	3.94	4.05
Item 4 - When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	4.01	4.17
Item 7 - If students are underachieving in science, it is most likely due to ineffective science teaching.	3.23	3.48
Item 9 - The inadequacy of a student's science background can be overcome by good teaching.	3.90	4.10
Item 10 - The low science achievement of some students cannot be blamed on their teachers (Reverse score).	2.74	2.95
Item 11- When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	3.46	3.64
Item 13 - Increased effort in science teaching produces little change in some students' science achievement.	3.51	3.55
Item 14 - The teacher is generally responsible for the achievement of students in science.	3.56	3.75
Item 15 - Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	3.49	3.70
Item 16 - If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	3.39	3.83

All items in both scales increased from August to November 2013. Across all items, the preservice cohort mean increased by an average of 0.36, with a range of 0.04 to 1.23. However, Item 10 from the STOE scale remained an item of concern. This item was previously identified as a concern in the findings from the August 2013 STEBI-B results and while the mean had increased by 0.21, the cohort still seemed to be uncertain about the ability of teachers to directly influence student performance in science. Although other items were not identified as areas of concern as described by the criteria described in Chapter 3, section 3.4.3, the other items to have a mean score

lower than four all related to the ability of the teacher to influence the students' science achievement.

These results show an increase in the number of items that were considered strengths for the preservice cohort. One significant change was that Items 5 and 12, which at the beginning of the *Primary Science* unit had been considered areas of concern, were now considered strengths. Both of these items were explicit goals of the *Primary Science* unit, as described in Table 3.1 in Chapter 3.

Figure 5.1 shows the change in PSTE for the in-depth interview participants from the beginning to end of the *Primary Science* unit. For all of the participants excluding Kate, John and Sarah, there was an increase in PSTE score from August to November. While Sarah's PSTE score of 46 was similar to the wider cohort mean in August 2013, this score was the same in November and lower than the wider cohort mean by 6.15. John's PSTE score decreased from 49 to 48 from the August to November STEBI-B results, and his November PSTE score was lower than the wider cohort mean by 3.15. Although Kate's PSTE score also decreased from August to November, her score in November was slightly higher than the wider cohort mean. For all other participants, their PSTE score was higher than the wider cohort mean. The most significant increases were for Kerrie and Toni, who both had PSTE scores of 37 at the August administration of the STEBI-B, below the wider cohort mean of 46.35. However, when re-administered in November, Kerrie's PSTE score had increased to 50, while Toni's had increased to 57, in comparison with the wider cohort mean of 52.15.

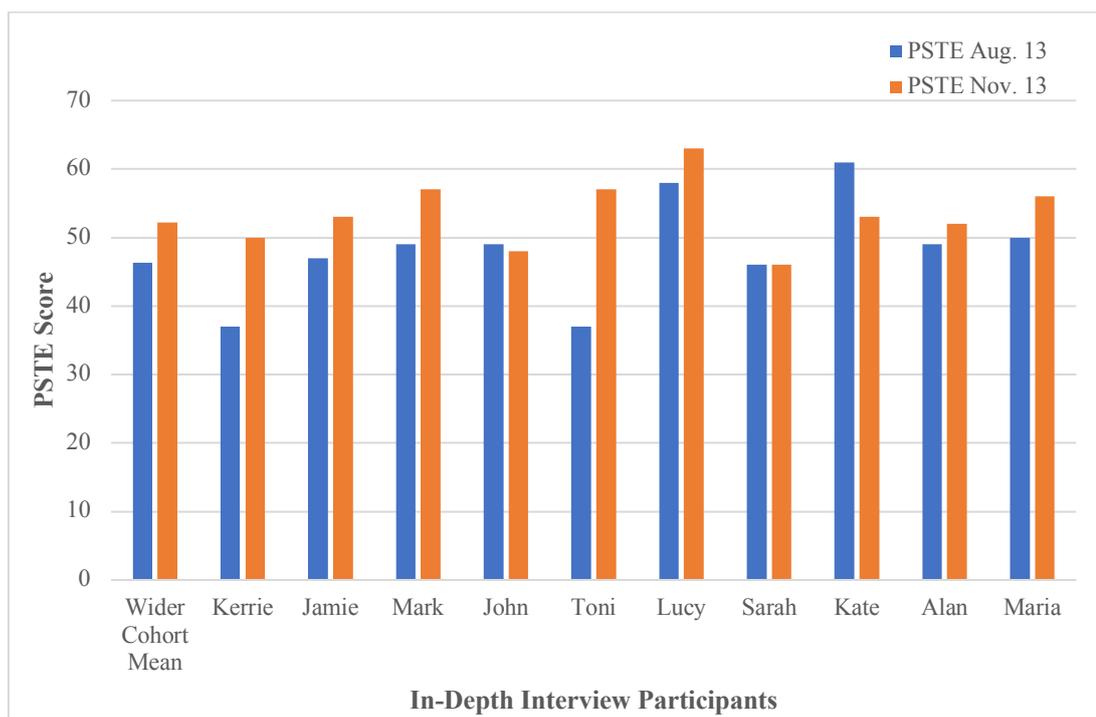


Figure 5.1 The comparison of PSTE scores of in-depth interview participants in August and November 2013.

Figure 5.2 shows the change in STOE score for the in-depth interview participants from the beginning to end of the *Primary Science* unit. For all participants, the STOE score increased from August to November. In the November STEBI-B results, Toni’s STOE score still remained significantly lower than the wider cohort mean of 36.99 and her score only increased from 27 to 28 from August to November. Sarah also experienced limited growth in her STOE score of 35 to 37 from August to November, although both scores were similar to the wider cohort mean. Kerrie and Maria experienced the largest increase in their STOE scores. Both their scores from the August administration of 29 and 27 respectively were below the wider cohort mean of 34.54, but by November, both of their STOE scores were 37, which was similar to the wider cohort mean.

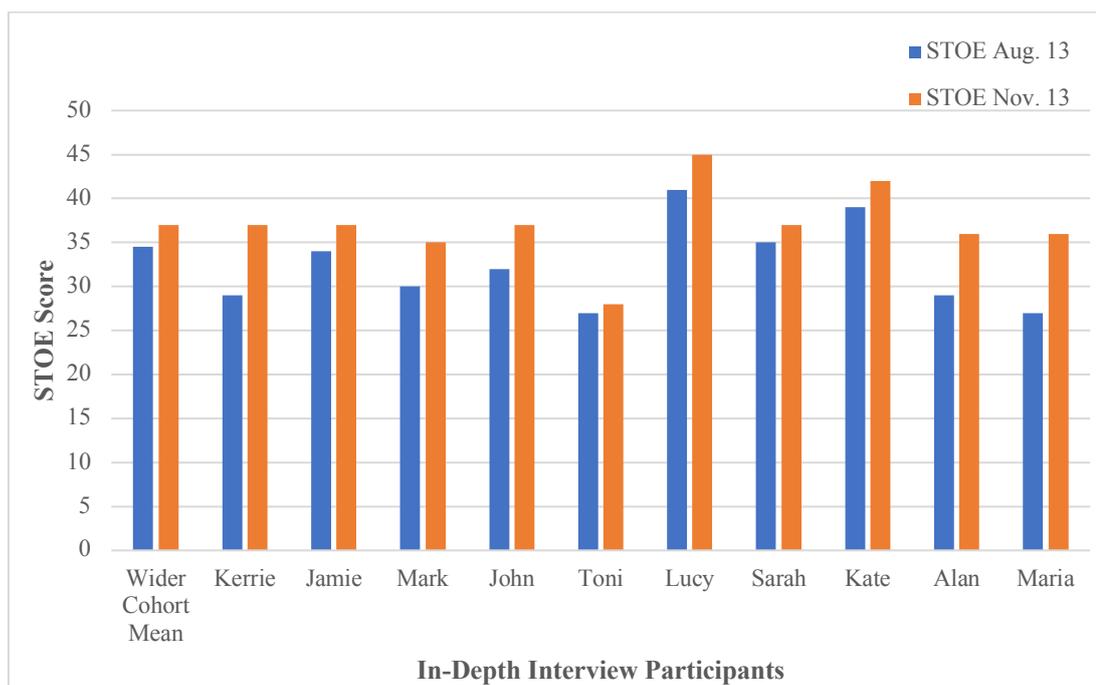


Figure 5.2 The comparison of STOE scores of in-depth interview participants in August and November 2013.

5.1.2 Discussion of STEBI-B Findings: November 2013

At the end of the *Primary Science* unit, the wider preservice cohort results for the STEBI-B are comparable to the results of Bleicher (2007), where the average post PSTE score was 51.27 and STOE 37.80. However, the mean STOE score was much higher than those presented by Mulholland et al. (2004), where the mean STOE score at the end of science methods units was 27.80. This can possibly be explained by the amount of practical experience students at the current institution complete, which was a significant factor in the study by Mulholland et al (2004) where the preservice teachers in their study had completed little practical experience. Overall, the quantitative data suggests that the *Primary Science* unit did positively contribute to the science teaching efficacy beliefs of the preservice teacher cohort, which Buss (2010) argues should be a fundamental aim of any tertiary science methods units. Similarly, the item analysis of the STEBI-B indicates that the unit was successful in assisting the wider preservice teacher cohort with developing higher levels of pedagogical content knowledge. These findings are consistent with the view of Howitt (2007) in relation to the purpose of a science methods unit.

Similar to the pre-test findings from the August 2013 administration of the STEBI-B, there was negligible difference between the mean PSTE and STOE scores of males and females in November 2013 following the *Primary Science* unit shown in Table 5.1. This finding again supports the findings of Bayraktar (2011), Mulholland et al. (2004) and Yilmaz and Çavaş (2008), who found little statistical difference between STEBI-B scores based on gender. The results of the August 2013 STEBI-B showed variance between the PSTE scores of those enrolled in different degrees within the unit. The mean PSTE score of those enrolled in the Bachelor of Education (Early Childhood and Care: 0-8 years) of 42.95 was lower than the other degrees, particularly those enrolled in the Other category. However, by the end of the unit, Table 5.2 shows that less variance between the mean PSTE scores was evident between those enrolled in different degrees and mean scores for all groups had increased. This table also depicts that the STOE scores of those enrolled in different degrees within the unit also all increased from August to November. These findings suggest that the *Primary Science* unit was successful in catering for preservice teachers who entered the unit with varying degrees of science teaching efficacy beliefs. This provides some evidence to address the question raised by Menon and Sadler (2016) about the extent to which a science methods unit can effectively cater for enhancing the science teaching efficacy of preservice teachers who begin the course with varying levels of science teaching efficacy.

Figures 5.1 and 5.2 illustrate that seven of the in-depth interview participants increased their PSTE score from the beginning to end of the *Primary Science* unit. However, for John and Kate, their PSTE score decreased, while Sarah's PSTE score remained stagnant. For this period, there was an increase in all of the participants' STOE scores. There are several possible explanations for the results. These participants may have overestimated their science teaching capabilities, as identified in research by Cantrell (2003) and Hechter (2011). These researchers suggest that preservice teachers completing a pre-test of the STEBI-B may not have a realistic view of what primary science teaching is about and may overinflate their perceptions of their capabilities. The finding seems similar to a study by Avery and Meyer (2012), who found that some participants who began science methods units with higher science teaching efficacy, actually had their score worsen by the end of the unit. A possible explanation presented by Avery and Meyer (2012) is that different types of preservice students

may benefit from different approaches to science units at university, which may help to enlighten the findings of the current study.

5.2 Science Teaching Efficacy Beliefs at the Conclusion of the *Primary Science* Unit and end of degree: In-Depth Interview Findings

5.2.1 In-Depth Interview Findings: November 2013

The qualitative findings from the November 2013 semi-structured interviews with the in-depth interview participants helps to explain the findings from the STEBI-B data. Again, to assist with following the trajectory of each of the participants through the research study, findings for each participant will be presented and reflected upon in light of their perceptions from the beginning of the *Primary Science* unit in August 2013.

As a mid-year intake student into the Bachelor of Education (Early Childhood and Care: 0-8 years), the *Primary Science* unit was the only science unit Kerrie would complete as part of her degree. She shared some concerns with teaching science in her interview at the beginning of the unit, and this was reflected in her PSTE and STOE scores of 37 and 29, which were lower than the wider cohort mean at the point. Kerrie had completed 12 weeks of practical experience at the beginning of the unit, with a 10-week block in a Pre-Primary class. Science was minimally integrated with other learning areas through the concept of weather, but her cooperating teacher had an emphasis on literacy development. Kerrie was able to conduct a small number of lessons exploring colour through rainbows, but this was the extent of her science experience.

At the end of the *Primary Science* unit which is shown in Figures 5.1 and 5.2, her PSTE score from the STEBI-B had increased significantly to 50, although it was still lower than the wider cohort mean of 52.15. Her STOE score also increased to be similar to the cohort mean. In her November interview, Kerrie expressed that her confidence to teach science had increased, particularly as she had become more familiar with the resources and curriculum of science. However, she also shared that

to further enhance her beliefs, another science unit targeted to early childhood would have been beneficial.

Jamie was also enrolled in the Bachelor of Education (Early Childhood and Care: 0-8 years) degree. At the beginning of the *Primary Science* unit, she expressed a positive attitude towards science, particularly biology. Her pre-test PSTE score of 47 and STOE of 34 were similar to the wider cohort means. Jamie had very limited opportunities to observe quality science learning and teaching during her practical experiences. Her first 10-week block included no science, other than a series of short lessons she led and her second 10-week block in a childcare centre included no explicit links to science. Jamie's frustration with her practical experiences were attributed by her as due to the fact that her cohort were the first to trial changes to the early childhood degree. However, in contrast to Kerrie, she completed the *Environment Science and Technology*, which she highly rated due to her interest in the subject matter and practicality of unit.

At the end of *Primary Science* which is shown in Figures 5.1 and 5.2, Jamie's PSTE score was 53 and STOE was 37, again similar to the November 2013 wider cohort mean for both scales. Jamie shared that she felt confident with teaching science to primary school children particularly in early childhood. She expressed improved understanding of the *Australian Curriculum* and *Primary Connections* resources, but particularly felt that she could effectively plan and teach an extended science unit of work after completing the unit.

Mark was enrolled in the Bachelor of Education (Primary) degree. In August, his PSTE was 49, above the wider cohort mean, but his STOE was 30, lower than the mean. In the August 2013 interview, he shared his dislike of science particularly during high school, although he recognised the importance of it in the primary school curriculum. Mark had previously completed the unit *Environmental Science and Technology*, which he enjoyed, and he particularly appreciated the resources provided to him in the unit. He had completed 22 weeks of practical experience at the beginning of the *Primary Science* unit. In his first 10-week experience, he was able to observe quality science learning and teaching, and then had an opportunity to teach an extended investigation himself. However, in his second 10-week practical experience, he

observed his cooperating teacher teach directly from the *Primary Connections resource*, which he perceived as being like working through a checklist. Mark only taught one science lesson in this experience which he perceived was the worst lesson he taught during his practicum.

Following the *Primary Science* unit, Mark's perspective had shifted. In the November 2013 interview, he shared an improved confidence with science, specifically when planning and teaching it to primary age children. This was also reflected in the increase to his PSTE score to 57 and STOE to 35 which is shown in Figures 5.1 and 5.2. Mark shared:

I'd be quite confident presenting science to primary school kids, given the fact that we have been exposed to a lot of material across a broad range of age groups and content type activities for different year levels. I would feel confident enough, with reference to the notes and stuff we've got in class, to walk into any classroom and teach that (Mark, interview Nov. 13).

John was also enrolled in the Bachelor of Education (Primary) and shared in the August 2013 interviews that he was ambivalent in his feelings towards science, but also about being back at university completing coursework after an extended practical experience. John had previously begun a degree in sports science before transferring to teaching, and felt maturity was a big influence on his feelings towards science. He had enjoyed the unit *Environmental Science and Technology*, particularly the hands-on and experiential nature of the tutorials. At the beginning of the *Primary Science* unit, John had completed 22 weeks of practical experience. In his first 10-week block, he was able to teach a series of science lessons with support from his cooperating teacher, which he found positive due to the hands-on nature of the lessons and high student engagement.

John's August 2013 PSTE score of 49 was higher than the wider cohort mean, but this decreased slightly to 48 when the STEBI-B was administered in November which is shown in Figure 5.1. However, his STOE score of 32 in August, lower than the cohort mean, increased to 37 in November which was similar to the cohort mean and is shown in Figure 5.2. In the November 2013 interview, John expressed the view that he was relaxed with the prospect of teaching science after completing the unit. He maintained

that the biggest learning he had from the unit was the development of confidence and curiosity for science and recognising that he did not have to have complete knowledge of all aspects of science in order to be able to teach it effectively. He shared the following thoughts:

I think that I have enough confidence to be able to teach science for sure. You know you can never have perfect skills, you still need to always develop them and work on them. But I still think that I have enough skills at the moment to be able to deliver a relatively successful science lesson to kids (John, interview Nov. 13).

Toni was also enrolled in the Bachelor of Education (Primary) degree. At the August 2013 interviews, she expressed concerns about beginning the *Primary Science* unit due to negative experiences of science in high school. Her PSTE score of 37 and STOE of 27 were significantly lower than the wider cohort mean at the beginning of the unit. Toni had completed the unit *Environmental Science and Technology* and had mixed feelings about it. While she valued the resources shared in the course reader, she could not find opportunities to use them in her practical experiences and she felt that the lectures were not beneficial to her learning. At the beginning of *Primary Science*, Toni had completed 22 weeks of practical experience. In her first 10-week practicum, there was a science specialist teacher providing her cooperating teacher with release time, but Toni was able to observe and help out with a few lessons. However, her most recent 10-week experience was overly negative due to an unsupportive cooperative teacher, which led to her questioning her ability to teach science effectively.

Toni had a dramatic shift in perspective towards science by the end of the *Primary Science* unit. This is reflected in her November PSTE score of 57, higher than the wider cohort mean. However, interestingly her STOE score of 28 increased only slightly from her August score of 27 and remained lower than the wider cohort mean. These results are shown in Figures 5.1 and 5.2. While Toni shared in the November 2013 interviews a strong understanding of the science curriculum and the 5E teaching and learning model, she still expressed some concerns about her science content knowledge, which, with her negative practical experiences and weak science background may explain her STOE score. In her reflections of the unit, she expressed surprise in her perceptions towards science:

I was so negative about the science because I just had that really bad experience and I didn't have any support, so from there to now... I'm quite excited to actually be able to do it (Toni, interview Nov. 13).

Lucy was enrolled in the Bachelor of Education (Primary) degree, after she had previously begun degrees in nursing and biomedicine. Due to course credits from these degrees, her primary specialisation was science. Her STEBI-B results from both August and November 2013 were higher than the wider cohort mean. However, through the in-depth interview in August, Lucy explained that her confidence with science had been varying in different stages of her life, but that since she began tertiary studies she had felt more confident. Due to the course credit she received through some of her units from her previous degrees, the arrangement of her units was different to her peers and she was completing *Environmental Science and Technology* concurrently to *Primary Science*. At the point of the August 2013 interviews, Lucy had completed 12 weeks of practical experience. In her 10-week block, a science specialist teacher provided release time for her cooperating teacher. However, Lucy chose to attend these lessons, but was disappointed that they were primarily worksheet based.

At the completion of the *Primary Science* unit, Lucy shared that she was confident with her skills in teaching science, particularly with younger students. Her PSTE score had increased from 59 to 62 from August to November and her STOE score had increased from 41 to 45 which is shown in Figures 5.1 and 5.2. She expressed the following about the unit:

It's really ignited my passion for science, because it's been so hands-on and I've really been given the opportunity to see how science can be implemented effectively in a classroom, and how it can be really engaging (Lucy, interview Nov. 13).

Also enrolled in the Bachelor of Education (Primary) degree, Sarah began the unit *Primary Science* with reluctance after mixed experiences of science during her schooling and teaching degree. In August 2013, Sarah's PSTE score was 46 and STOE score was 35, both slightly lower than the wider cohort mean. While she enjoyed the content from the unit *Environmental Science and Technology*, she was hesitant in her

overall perceptions of the unit, due to its timing in her first year of her degree. She believed that the unit would have been better placed later in the degree in order to be most effective. Sarah's experience of science during her 22 weeks of practical experiences was also mixed. In her first 10-week practicum, Sarah observed a unit taught by her cooperating teacher exploring the human body, but her perception was that it was primarily theory-based rather than experiential. However, in the most recent practical experience, Sarah shared that the passionate and hands-on nature of her cooperating teacher when teaching science had helped shift her perception of science.

At the end of the *Primary Science* unit, Sarah continued to express concerns about science. This was reflected in her November 2013 PSTE score remaining at 46 and her STOE score increasing slightly to 37. While her STOE score was equivalent to the wider cohort mean, her PSTE score was lower than the wider cohort mean at the end of the unit. The results are shown in Figures 5.1 and 5.2. Sarah shared that if placed in a classroom without resources or explicit guidance, she would not feel able to effectively teach science. When asked how confident she would be to teach science after the unit, Sarah stated:

If I had the resources, fine; if I didn't and I was left to just drown, no. If they gave me what topic they wanted me to teach, then I could work with that; if it was come up with your own, I'd sit there going, "Oh, God" (Sarah, interview Nov. 13).

Kate was specialising in science as part of her Bachelor of Education (Primary) degree. She had always been fascinated by science throughout her education and had enjoyed the additional tertiary science units that she had completed as part of her specialisation. Her positive view of science was reflected in her high PSTE score of 61 and STOE score of 39, both higher than the wider cohort mean. Kate considered the unit *Environmental Science and Technology* to be well-structured and she particularly liked the group presentations. She had completed 22 weeks of practical experience at the start of the *Primary Science* unit. For both of her 10-week practicums in her second and third years of studying, Kate shared a desire to take an active part in the science teaching in her classrooms and described the success she felt when implementing her learning and teaching programs.

Interestingly, at the end of the *Primary Science* unit, Kate's PSTE score dropped to 53, which was similar to the wider cohort mean. However, her STOE score increased to 42, higher than the mean which is shown in Figures 5.1 and 5.2. Kate shared positive feelings about the unit and felt that learning about the science curriculum and the *Primary Connections* resources were particular highlights. She stated:

My specialisation is science, I'm a science lover and I can't wait to teach it. It's something that I value highly (Kate, interview Nov. 13).

Alan was enrolled in the Master of Teaching (Primary) degree after previously completing a degree in geophysics. At the beginning of the *Primary Science* unit, his PSTE score of 49 was slightly higher than the wider cohort mean, while his STOE score of 29 was below the mean. *Primary Science* was the only science unit embedded within the Master of Teaching program, but Alan had extensive experience in science through his previous degree. However, he did not view his science learning in university as positive because he felt that the view of science presented did not match his vision of what science should be. He had completed 12 weeks of practical experience at the start of the unit. On his 10-week recent experience, he felt that his cooperating teacher had a negative view of science and the quality of her teaching was impacted by behaviour management issues in the classroom.

Following the *Primary Science* unit which is shown in Figures 5.1 and 5.2, Alan's PSTE score had increased to 52, slightly below the wider cohort mean. However, his STOE had increased to 36, similar to the wider cohort mean. At the beginning of the unit, Alan expressed a strong disconnect between the reality of his teaching degree and his own personal philosophy. This dissonance still existed at the end of the unit, and Alan shared that he felt science should be more holistic and authentically integrated with the arts. However, he stated:

Our teacher's been really fantastic and really excited about science and of course that lives into you, you really feel that. It's been very hands on, we've had the luxury of seeing our fellow peers conduct lessons, which is always good, and we've been given the opportunity to collaboratively work and yeah, it's been great. I think it's been a very good course, very engaging course (Alan, interview Nov. 13).

Maria was enrolled in the Graduate Diploma of Education (Primary) and was working in an all boys high school in the area of art. She had previously studied neuroscience, but found that she preferred to engage with people, hence completing a secondary degree. Maria chose to complete *Primary Science* as one of her units and this was the only science unit she would complete in this degree. The degree also did not have a practical component. Maria's November 2013 PSTE increased to 56 and it was 50 at the August administration, with both scores higher than the wider cohort mean. Her STOE in August was 27 and this increased to 36 in November, similar to the wider cohort mean. Maria expressed high levels of satisfaction with the unit and she stated that she felt confident in her understanding of the science curriculum, appropriate resources and planning age-appropriate activities.

Based on the qualitative data presented above from the November 2013 interviews, following the *Primary Science* unit, nine of the in-depth interview participants expressed higher levels of self-belief in relation to their ability to teach science to primary students. Sarah was the only participant to share ongoing concerns about her ability to teach science at this point in time.

5.2.2 In-Depth Interview Findings: October 2014

The in-depth interview participants were interviewed again in October 2014. For most of the participants, this interview was at the end of their degrees, following their final 10-week practical experience, called an internship. Due to beginning their degrees as mid-year intakes, Kerrie and Lucy had a further semester to complete, which included their internship. Maria was the only participant not interviewed at this point, as the Graduate Diploma was a one-year qualification that did not involve a practical component.

At the October 2014 interviews, Kerrie had recently completed her second 10-week practical experience in a childcare centre as well as other coursework as part of her Bachelor of Education (Early Childhood and Care: 0-8 years). Due to the nature of her practical experience, her experience of seeing quality science learning and teaching was limited. Science was not explicitly considered by the childcare staff in their

planning and teaching. When asked how Kerrie perceived science in October, she shared:

I haven't really improved on my science skills, not having the opportunity. But I think I'd still be, with all the programs and the things we learned in the Primary Science, able to teach it well (Kerrie, interview Oct. 14).

Jamie had completed her 10-week internship in a Kindergarten classroom prior to the October 2014 interview. Jamie shared that her cooperating teacher had a literacy focus and science was not an explicit focus in the classroom. However, Jamie decided to use the children's book *The Rainbow Fish* as a stimulus for some activities about living things. Jamie had previously expressed an interest in the area of biology in particular and moderate science teaching efficacy. At the end of her teaching degree, she stated:

I'd say I feel more confident teaching science over some of the other areas. I quite enjoy science, so I rate myself higher in teaching science than teaching like English or something like that...I would focus quite a lot on it because of those two units, I feel quite prepared to teach science (Jamie, interview Oct. 14).

By October 2014, Mark had recently completed his university coursework and 10-week internship in a Year 4 classroom. During this practical experience, he had the opportunity to team-teach science with his cooperating teacher exploring the chemical science area of materials. Although Mark stated that he initially had concerns about the lessons being scheduled on a Friday afternoon, he was pleasantly surprised by the high student engagement. He attributed this to the hands-on and investigative nature of the lessons that he and his cooperating teacher implemented. When asked about his beliefs about teaching science, he stated:

I feel quite confident and comfortable teaching it...The more I teach it the more I like it. I think that's because, as a teacher I suppose you realise, like I said before in the previous interview, you don't actually have to be a genius, like a scientific expert to teach it successfully. You've just got to have a bit of curiosity and I suppose as soon as you have that then it all falls into place. You naturally just want to learn about it (Mark, interview Oct. 14).

By the end of his degree, John had completed his 10-week internship in a Year 6 classroom. He was not required to program for science, but he did take a few lessons

on the concept of energy. John observed high student engagement in all science lessons and felt there were aspects such as collaborative groups and the 5E's model from the *Primary Science* unit that he could apply to his lessons. When asked about how he now rated his feelings towards science as he was about to embark on his teaching career, John expressed the following:

I think I would be confident in my abilities to teach it. Obviously, I wouldn't be able to walk in and just bring on these fabulous, fantastic, flawless lessons, but I think I could deliver some solid lessons that were really content driven (John, interview Oct. 14).

At the time of the October 2014 interviews, Toni was also almost finished her Bachelor of Education (Primary). She had finished a 10-week internship in a Year 3 classroom and she shared that her cooperating teacher was particularly enthusiastic about science. Due to this and with no university expectations to plan for science, Toni instead focused on developing five-week learning and teaching programs for literacy, numeracy, history and health. Unfortunately, Toni's cooperating teacher became unwell during the practical experience which limited the number of science lessons taught. This was further compounded by many interruptions to the teaching program, including sports carnivals and excursions. However, when reflecting on her perception of teaching science as she was concluding her time at university, Toni stated:

I'm not really nervous about it, I'm quite excited because after Primary Science I felt a lot more confident about it anyway. I actually understood it a little bit more. And knowing that there are those resources out there, I think it will be good as long as I don't get year sevens (Toni, interview Oct. 14).

Switching to a primary teaching degree after beginning tertiary studies in biomedicine and nursing, Lucy still had a semester to complete with her degree at the time of the October 2014 interviews. This semester included her final internship, after having recently completed her third year 10-week practical experience in a Year 2 classroom. On this practical experience, Lucy planned the whole term's science program in the area of biological science. She stated that she was able to use the *Primary Connections* resources, as well as some ideas shared in the unit *Environmental Science and Technology*, to assist her in developing a successful program. In the October 2014

interview, Lucy expressed confidence in teaching science, but shared some limitations about teaching older students:

I'm fairly confident in teaching science to students. I've only ever taught year ones and twos science. I suppose I'm not sure how I'd go with the older students, but overall fairly confident (Lucy, interview Oct. 14).

At the time of the October 2014 interviews, Sarah was also completing her Bachelor of Education (Primary) degree. She had recently completed her 10-week internship in a Year 4 classroom, as well as her final units in her degree. Sarah expressed disappointment in the quality of her final practical experience, particularly as she felt her 10-week experience in her third year had been so high quality. Her cooperating teacher was also the Assistant Principal of the school and had administration time on Fridays, so a partner teacher came in on this day and science was one of the areas she taught. The teacher used *Primary Connections* as a resource and Sarah was able to teach lessons in the Explain, Elaborate and Evaluate lessons of the unit. She also expressed frustration with the number of interruptions to the teaching and learning program. However, she expressed that as she was not able to teach the more hands-on component of the unit, her lessons seemed to not engage the students. When asked her current perception of teaching science, Sarah stated:

I feel like it's gone down a bit since this prac, because I walked in there and I was thinking to myself 'I know I can teach this', because I had had such a good experience previously and I was thinking, 'this school's really good', on my visit before I started prac. And then walking in and seeing how they did it and I was just shocked. I definitely feel like if I was to walk into a classroom right now and pick up a science program, I would be just looking at it with a blank face (Sarah, interview Oct. 14).

Science specialist Kate was also completing her degree at the time of the October 2014 interviews. She had recently completed her final internship in a Year 7 classroom and was responsible for teaching science to 60 students in total for the full 10 weeks. Kate focused on the area of biological science and explored with the students the concept of classification. She shared an enjoyment of developing a full unit of work and she was satisfied that she had been able to explore science inquiry skills and science as a human endeavour within her program of work. At the October 2014 interview, Kate

expressed the following perception of teaching science as she was about to embark on her teaching career:

I think beginning is always a little bit nerve racking, but I think you've gone through four years of teaching and stuff and you are confident in your ability to adjust where you need to and do the best you can I guess. So relatively confident but not cocky (Kate, interview Oct. 14).

In October 2014, Alan was about to graduate from the Master of Teaching (Primary) degree. He completed his 10-week internship in a Year 2 classroom and was responsible for teaching about water through the area of earth and space science. Alan shared several challenges with teaching science in his final practical experience, namely time pressure and a feeling that the students' questions about the topic did not align with the science curriculum. He expressed a level of dissatisfaction that his holistic view of science did not seem to be part of the curriculum in primary schools, nor was it taught within what he perceived as conventional university degrees. When asked about his perceptions of his ability to teach science at this point of time, he stated:

Still a little bit uncertain, given my two pathways that I'm trying to merge and to see where that goes. So a little bit uncertain. Looking forward to the challenge (Alan interview Oct. 14).

5.2.3 Discussion of In-Depth Interview Findings: November 2013 and October 2014

The quantitative results from the STEBI-B in November 2013 was supported by the qualitative data, which indicated that all but one participant expressed a sense of confidence and belief about their ability to teach science at the end of their science methods units. The changing science teaching efficacy scores from the beginning to the end of the unit reflect the malleability or instability of self-efficacy beliefs for this period of teacher preparation, corroborating the research of Labone (2004) and Berg and Smith (2016). The results of this current study seem to be consistent with the findings of Bleicher (2007, 2009), and Brand and Wilkins (2007), who found that a well-designed science methods unit can increase the confidence of preservice teachers in learning and teaching science.

Toni and Maria's PSTE and STOE scores from the beginning to end of the science methods unit are interesting to analyse. At the beginning of the *Primary Science* unit, Toni's PSTE and STOE scores were the lowest for the in-depth participants and significantly lower than the wider cohort mean. By the end of the unit, her PSTE score had improved dramatically, but her STOE score had only slightly increased. These results are shown in Figures 5.1 and 5.2. Supported by the qualitative data, Toni indicated that her science pedagogical skills had improved, as had her knowledge of some science content, hence explaining the increased PSTE score. However, research by Ling and Richardson (2009) suggest that minimal changes in outcome expectancy such as those reflected in Toni's STOE score can be the result of the small amounts of science or poor-quality science in practical experiences. This may help to understand Toni's STOE result considering her lack of previous science teaching opportunities.

Maria, enrolled in a Graduate Diploma already with a secondary education degree and a previous interest in science, had a very high PSTE of 50 at the beginning of the *Primary Science* unit and a STOE score of 27. By the end of the *Primary Science* unit, these scores were 56 and 36 respectively. As an experienced educator, Maria was confident in her teaching abilities and the science methods unit was able to provide some assistance in her outcome expectancy beliefs.

All participants, other than Maria, participated in the October 2014 interviews. Despite varying opportunities to observe and teach science in their most recent practical experiences, seven of these participants shared a high level of confidence about their own science teaching abilities. The participants did share some aspects that they felt may limit their overall ability, including teaching older students, resources and support from others within the school. For these participants, the qualitative data seems to suggest that their higher self-efficacy beliefs from the end of the *Primary Science* unit were durable for 11 months, despite having varying experiences of science during practical experience and no other science coursework. This finding seems to be in agreement with Palmer (2006a), in that if timing of a high-quality science unit was generally completed one year before the end of the degree, the higher level of science teaching efficacy can prevail as preservice teachers began their teaching careers. The higher levels of self-belief in their ability to teach science

seemed to be manifested by high levels of enthusiasm for teaching science, supporting the findings of Praetoris et al. (2017) and Skaalvik and Skaalvik (2010).

However, at the end of his Master of Teaching (Primary) degree, Alan remained uncertain about his ability to effectively teach science. From the start of the in-depth interviews, Alan expressed a disconnect between his own personal philosophy and that which was presented to him throughout his degree, particularly in relation to what was perceived some of the more traditional aspects such as planning and assessment. His practicum placements also emphasised this dichotomy, as he encountered classes with behaviour management issues or more traditionally-styled teachers. The recommendations of Avery and Meyer (2012) in relation to the idea that different students may benefit from different types of teaching and learning approaches may be particularly relevant in understanding these findings.

The case of Sarah throughout the research study was unusual, as she was the only participant to express poor self-confidence in her ability to teach science at the end of her teaching degree. Sarah's PSTE score did not change from the beginning to the end of the *Primary Science* unit and there was a minimal increase in her STOE score. All of her interviews expressed some limitations about her ability to teach science, and she indicated that she would require more content knowledge and step-by-step pedagogical support to assist her to teach science effectively. Sarah may be an example of findings in a study by Varma et al. (2009), which identified that some participants found it difficult to overcome prior science experiences and retained their self-doubt about their ability to teach science, which led to them wanting more explicit instruction of how to teach science. Increasing the number of quality inquiry-based science units at university that focused on the specific learning needs of preservice teachers may have supported Sarah to develop more confidence and content knowledge, which is a recommendation from the research of Hechter (2011).

5.3 The Influence of Science Coursework on Science Teaching Efficacy Beliefs

The following section of the chapter discusses the findings that were shared by the in-depth interview participants in relation to the influence that their tertiary science

coursework had on their emerging beliefs. Following these findings is a discussion of how these findings relate to key literature will be presented.

As previously discussed, the *Primary Science* unit was the only requisite unit focusing on science content and pedagogy that all preservice teachers enrolled in Bachelor of Education and Master of Teaching degrees were required to complete. Maria, as a qualified secondary teacher completing the Graduate Diploma of Education, had selected the unit as an elective. All of these participants, through the semi-structured interviews in August and November 2013, and October 2014, shared aspects of their science coursework that had influenced their science teaching efficacy beliefs. The following themes emerged: the structure and nature of the units, the function of assessment, the role of the science teacher educator, and the development of science pedagogical content knowledge.

5.3.1 The Structure and Nature of Science Methods Units

The structure and nature of science tertiary units offered to the preservice teachers as part of their degrees was considered a significant influence on how the in-depth interview participants perceived the learning and teaching of science. For those participants who had completed the unit *Environmental Science and Technology*, structured as a one-hour lecture and two-hour tutorial for 13 weeks, there were mixed perceptions about the structure of the units. The majority of the participants found the unit valuable, but two participants described some issues with the unit's structure which impacted their perceptions. Toni enjoyed the tutorials, but was dissatisfied with the quality of the lectures:

The lectures were pretty terrible. I think the tutes were really great...It felt like everything that she was saying was literally just on the lecture notes, [the lecturer] didn't take attendance or anything, so we could've just read the lecture notes (Toni, interview Aug. 13).

Lucy completed the unit at the same time as *Primary Science*, due to her degree schedule being impacted by the course credit she received for some of her previous tertiary study. For her, the issue with the structure of *Environmental Science and Technology* was related to the disconnect between the content covered in the unit and

the weekly readings. Lucy described herself as a self-motivated learner, who would often spend additional time to prepare for the units she was completing. She stated the following:

The subject itself, I'm enjoying it, but I'm finding there is a big difference between what we've actually learning and then the readings. They're sometimes not very connected, and so I'm having to do a lot of background reading on lecture concepts and it's hard to sometimes find the appropriate resources to do that (Lucy, interview Aug. 13).

All participants commented on the structure and nature of the *Primary Science* unit. This unit was structured as a two-hour workshop for 13 weeks, which was essentially quite different to *Environmental Science and Technology*. All participants stated that this structure positively contributed to their science teaching efficacy beliefs, with participants sharing that this structure allowed for variety, clear expectations and led to higher levels of attendance. Participants described the unit as well-organised, a balance between theory and practice, and supported by quality resources. The following is Jamie's perception of the structure of the unit:

The unit was, I can't really fault it. It had a really good structure, our expectations have always been clear through the entire thing, but [our science teacher educator] is just terrific with how she runs it (Jamie, interview Nov. 13).

The benefit of structuring both units as science methods units, as opposed to science content units was identified as beneficial by eight of the participants in their in-depth interviews. One comment that illuminates this was from Kate, who was completing a science specialisation as part of her degree. She shared the following thoughts:

A lot of my specialisation units came from just the concepts of science and this unit was all about how to teach it and that was very important because there's no point knowing heaps of science things if you don't know how to teach it (Kate, interview Nov. 13).

When asked to reflect on aspects of the *Primary Science* unit that could have been improved, Toni and Sarah both shared ideas that related to the overall structure of the unit. Toni felt that the workshop could have been extended for a further hour to assist with the development of content knowledge. Sarah would have preferred to have a

more teacher-directed structure, as opposed to the use of peer teaching and collaborative work, because she felt that she learnt best from listening. Both of these in-depth participants expressed that the reason for this related to their own poor science background.

The nature of the science tertiary units was also critical to the in-depth interview participants' science teaching efficacy beliefs. Both units were overwhelming characterised as hands-on in nature, with every participant describing the *Primary Science* unit in this capacity. The hands-on nature was described as experiential, contributing to the participant's engagement and allowed for high levels of collaboration with peers. This is explained by Kerrie in the following way:

I really enjoyed it, it's been lots of hands-on activities and engaging and you learn something new each week (Kerrie, interview Nov. 13).

5.3.2 Assessment within the Science Methods Units

As part of the designated structure of tertiary units, the quality of assessment was identified as a strong theme by all of the in-depth interview participants when reflecting on the *Primary Science* unit. The unit had two main assessment tasks, worth 60 percent of the unit total, with an examination component equalling 40 percent. These assessment tasks were connected and are described in Chapter Three in more detail. Of the in-depth interview participants, nine identified the development of the forward planning document as beneficial to their understanding of science. Reasons for this as described by participants included developing a concept from beginning to end and the ability to share these documents to develop their own resources. Mark explained:

The Forward Planning document assignment really started to bring it home for myself, as to how useful science was. The fact that we were able to create our own Forward Planning document and also look at the way that other students had done their Forward Planning documents for different year levels, different topics, that type of thing, really opened the doors for me to show all the different possibilities that we could achieve through science (Mark, interview Nov. 13).

Only one participant, Alan, expressed some concerns with this assessment task. While he felt that the 5E's framework was helpful for him to produce a coherent plan and he felt that the assessment task was useful for him to organise his ideas, he shared that the process was a challenge. This seemed to also be connected to his wider philosophical issues that he experienced with mainstream approaches to education. Alan shared his thoughts:

I have quite a holistic way of thinking and so when I get a forward planning document I'm like "How am I going to fit this all in?" ... who I am I want to try and get my underlying philosophies in there as well as marrying the mainstream and so I find it a huge challenge. I wasn't actually completely happy with my forward planning document and my procrastination has also lead to it being quite rushed (Alan, interview Nov. 13).

Kerrie, John, Toni, Kate and Alan also expressed the benefits they perceived by completing the lesson presentation. These participants explained the lesson presentation was useful for several reasons. Kerrie, John and Kate noted that it allowed them to work collaboratively with a few peers to develop a hands-on science lesson. Alan use the term *luxury* to describe the opportunity to observe his peers conduct their own lessons. Toni believed that the lesson presentation was highly useful in that it allowed them to trial their ideas in a safe environment. Only one participant, Sarah, expressed dissatisfaction with this assessment task, which related to her learning style preference:

[My peers] would present a lesson off a topic from Primary Connections aimed at a specific year group and a lot of them taught as if they were teaching that year group, which I found a little bit demeaning. At uni, I prefer to be spoken to as a peer and not a student... I found the way [the science teacher educator] explained things a lot clearer (Sarah, interview Nov. 13).

5.3.3 The Role of the Science Teacher Educator

Another theme that emerged as contributing to the in-depth interview participants' science teaching efficacy beliefs at the conclusion of the *Primary Science* unit was the role of the science teacher educator. When analysing the responses from the participants, seven of them commented on the positive impact the science teacher

educator had on their experiences within the unit. Words such as *passionate* and *engaging* were used by these participants to describe the science teacher educators that the participants had experienced. However, other characteristics that emerged were the science teacher educator's time management, modelling of teaching techniques and organisation. The following comment by John illuminates this:

I think a lot comes down to [the science teacher educator] who always incorporates a lot of digital technologies and is very engaging in how she teaches. I think that's contributed quite heavily as to why I've definitely enjoyed this unit. (John, interview Nov. 13).

Despite identifying and describing many positive traits of the science teacher educator, this seemed to contribute to lower levels of confidence for Sarah:

I still don't feel like I could go out into a classroom and teach it 100% to the standard that [the science teacher educator] demonstrated to us, which is what I want to aim for. I don't want to go out there and teach it mediocre (Sarah, interview Nov. 13).

5.3.4 Improvement of Science Teaching Understanding and Skills

All of the participants also reflected on improvements in their understanding of key science resources, pedagogical approaches, and curriculum understanding. Every participant found that their understanding of the 5E's inquiry approach was highly valuable, with reasons shared including the ability to systematically teach a concept and helping them conceptually understand how to teach an inquiry unit over a longer period of time. Connected to this, each of the participants were appreciative of the emphasis on the *Primary Connections* resources, which use the 5E's model as their base. Mark, Toni and Kate also mentioned the benefits they felt in the other resources that were presented in the unit, including information about science excursions and useful websites.

All of the participants also considered that they felt a stronger understanding of science within the *Australian Curriculum*. Participants shared that activities within *Primary Science* allowed them to become more familiar with the science curriculum and how

to develop a program of work from it. This was expressed in the following way by Maria:

[The science teacher educator] gave us a lot of time in class to look at the curriculum and she went through and explained the aspects of it. This was really useful to actually get an understanding of it. We could then choose a concept from it suited to a different year level and develop our program of work (Maria, interview Nov. 13).

5.3.5 Discussion of the Influence of Science Coursework on the In-Depth Interview Participants' Perceptions of Science Learning and Teaching

The present study showed that the two science units *Environmental Science and Technology* and *Primary Science* unit had a positive impact on all of the in-depth interview participants' science teaching efficacy beliefs. Several key themes emerged, including the role of the science teacher educator, the nature of the units and pedagogical skills developed.

The structure and nature of the science methods units was endorsed as positively contributing to the in-depth interview participants' science teaching efficacy beliefs. Aspects that were specifically referred to were the perceptions of the structure and expectations of the unit, and the mixture of practical and theoretical experience provided, as well as assessments included within the unit. Participants reflected that both science units were structured in a way to enhance learning, in a way that participants identified maximised relevance, and with clarity of expectations, supporting the research of Bleicher (2007). The findings suggest that the units were hands-on in nature, which was considered a positive attribute by all of the in-depth participants. These results are consistent with the findings of previous studies by Bleicher and Lindgren (2005), and Howitt and Venville (2009).

For units designed as science methods units, there is always some tension in how content and pedagogy are balanced, as science methods units have the aim of increasing pedagogical content knowledge (Howitt, 2007). However, science methods units that are well-designed can simultaneously improve science content knowledge, pedagogical skills and lead to improvements in science teaching efficacy (Bleicher &

Lindgren, 2005; Brand & Wilkins, 2007; Palmer, 2006b). Most of the participants of this current study reflected upon a good mix of theory and practical activities, which positively influenced their beliefs. Two participants did mention that more content would enhance their experience, either through less practical activities or the addition of another science unit into the degree. Although previous studies have been mixed in terms of the benefits of science content units on perceptions towards science (e.g. Bayraktar, 2011; Morrell & Carroll, 2003; Moseley & Bryant, 2005; Palmer et al., 2015), the fact that they had not completed any other science content units may have been a contributing factor for these participants.

The in-depth interview participants also positively reflected on the assessment within the *Primary Science* unit. Several participants shared the advantages of the peer presentations, due to the opportunity of being able to trial strategies, supporting previous research by Palmer (2006b). The development of a forward planning document for science was perceived by most participants as beneficial for their development, improving their confidence in being able to develop a teaching and learning program for a science content area.

Science teacher educators have an important role in shaping the attitudes, beliefs and skills of preservice teachers in science. Characteristics that have been identified as positively contributing to this role include a passion for teaching science, having a good sense of humour and being approachable (Howitt, 2007). In both units, the participants reflected on the positive characteristics of passion and engagement demonstrated by the science teacher educator, as they were almost in contrast to how the participants viewed their science teachers in high school. Also reflected on by some participants were the benefits of seeing the science teacher educator model various teaching strategies. This observation supports the findings of Bleicher (2007) and Howitt (2007), who identified that science teacher educators who modelled and used effective science teaching strategies had a positive influence on the science teaching efficacy of preservice teachers.

Another key theme prevalent in participants' reflections on the science units, was the noticeable improvement in their perceptions of their own pedagogical skills. These skills included an increased understanding of the curriculum, associated planning

skills and knowledge of resources to support the teaching of science. These findings corroborate the studies of Tuchman and Isaacs (2011) and Edwards et al. (2007), which both found that improving participants' sense of their instructional skills had a positive influence on teaching efficacy. Having access to the high-quality curriculum resource of *Primary Connections* has been identified as a factor that can improve the science teaching efficacy of primary teachers in Australia (Cooper et al., 2012; Skamp, 2012). In this present study, all of the in-depth participants commented on the advantages of learning how to effectively use resources, particularly the *Primary Connections* professional learning approach which included learning about the curriculum resources, but more importantly, the underlying 5E's inquiry approach advocated. These findings seem to be consistent with Cooper et al. (2012) who found that utilising a quality teaching and learning resource during a science methods unit increased the science teaching efficacy of all participants, regardless of previous negative experiences of science.

5.4 The Influence of Practical Experiences on Science Teaching Efficacy Beliefs

In the current study, practical experiences have also influenced the in-depth interview participants' science teaching efficacy beliefs, as noted by the researcher in the August 2013 and October 2014 interviews. As opposed to the in-depth interview participants' overly positive experience of their science coursework, the quality of science in their practical experiences was more varied. Key aspects of these experiences that were major influences on their beliefs were identified and key themes emerged. These were the quality of teaching by the cooperating teacher, the opportunity to teach science, the engagement of students, the perception of science within the school and the issue of resources. Each of these themes is discussed below.

5.4.1 Quality of Science Teaching by Cooperating Teachers

The opportunities for the preservice teachers to observe quality science teaching by their cooperating teachers were highly varied for all participants. In some experiences, preservice teachers saw no science teaching during their 10-week practical experiences. Kerrie, Jamie, John and Toni all had at least one practical experience

devoid of science. For Kerrie and Jamie, their experience in a childcare centre proved to be the most negative of their experiences. This was compounded by the lack of clear guidelines by the university and the dysfunctional relationships that existed in the childcare centres, and neither saw any explicit teaching of science. They both had very little opportunity in any of their practical experiences to observe quality science teaching, as both participants shared experiences in early years classrooms that were predominantly literacy and numeracy based. This is best documented by Jamie, as she reflected on her internship in a Kindergarten classroom:

I followed what the teacher had planned and what her expectations were and what she was going to do with the kids. She really didn't have any science at all planned for the children...It was really mainly English, it was pretty much all we did (Jamie, interview Oct. 14).

Several of the in-depth interview participants shared negative observations of cooperating teachers and poor-quality science teaching. Mark, Lucy, Sarah, Kate and Alan all shared negative observations when their cooperating teachers taught science in an obligatory way, without passion and in way that was largely theory-based. These participants felt that this led to a lack of student engagement as a result of the perceived poor-quality teaching. The following comments from Alan and Mark illuminate this theme:

It was one class that the teacher never looked forward to. I think mostly because she didn't feel like she had the ability to teach it. I'm not sure. But she felt uncomfortable certainly (Alan, interview Aug. 13).

It was worked through and it was almost like it was going through a checklist because they had to do it. There was no sense of "I'm enjoying this and the kids are going to enjoy this" (Mark, interview Aug. 13).

Mark, John, Sarah and Kate had practical experiences where their cooperating teacher was passionate about science and delivered highly engaged science learning opportunities for their students. For these participants, they felt inspired by the high quality of teaching. Sarah, in particular, felt that this positive practical experience was most influential on a renewed interest in science as she began the *Primary Science* unit:

My prac teacher actually changed it for me and was brilliant. So much passion for science and always trying to get the kids involved and every science experiment we did was hands-on (Sarah, interview Aug. 13).

Kate also reflected upon the positive qualities of her cooperating teacher during her internship. She had had previous positive experiences of teaching science but valued the opportunity of observing and working closely with her cooperating teacher, particularly as she was teaching Year Seven students. She stated:

[The teacher] was really into science as well and she really enjoyed teaching it. She was always eager to try new things with the students. She was really good and she had a good outline of how the students learn best and she gave me quite a few ideas as well which was good (Kate, interview Oct. 14).

Science specialists present in primary schools were referred to by Mark, Toni, Lucy, Sarah and Kate in their reflections of their practical experiences. While the aim of science specialist teachers was to ensure a higher quality of science teaching and provide release time for classroom teachers, for these preservice teachers it did reduce the amount of science that they were exposed to during their practical experience. However, for Lucy and Sarah, observing a science specialist teacher did not guarantee a higher quality science experience. Sarah stated the following about the science specialist teacher she observed:

The fact that she had to do 6 classes of science, I think it kind of made her just see it as quite clinical, get it done, got to plan it... She did try and get pretty hands-on with the younger classes... but I think as they got older, it was just lots of writing and lots of pretty boring experiments (Sarah, interview Oct. 14).

5.4.2 The Opportunity to Teach Science

The opportunity to teach science during their practical experiences was also perceived by the in-depth interview participants as influencing their science teaching efficacy beliefs. Both early childhood in-depth participants, Kerrie and Jamie, were limited in their capacity to teach science in all of their practical experiences, other than sporadic lessons. Both shared that these lessons seemed to engage the students and that they enjoyed developing their ideas. However, both of these participants still expressed a

desire to include science within their own teaching as they began their careers, due to their experiences during science coursework at university.

Experiencing difficulties in their personal science teaching during practical experiences was considered significant by four participants. Both Mark and Toni experienced these challenges in the practical experience before the *Primary Science* unit and considered these lessons the worst that they taught on their practical experiences. For Toni, the lack of support offered to her by her cooperating teacher following this lesson contributed significantly to her negative perception of science at the beginning of the unit.

Sarah and Alan both found elements of their science teaching in their final internships challenging. For Sarah, teaching her own program in the final five weeks of the experience, she was required to take on more content-based lessons, with the more hands-on aspects covered by her cooperating teacher in the first five weeks. This led to Sarah feeling that her own program was too theory based and did not engage the students, which she attributed to contributing to her reduced science teaching efficacy as she concluded her degree. Alan planned and taught a unit on water but felt that he was not able to develop hands-on lessons or answer the questions of the students because he was too focused on meeting all of the requirements of the curriculum. Upon reflection of what he would do differently if completing the experience again, he stated:

I would try and not cram so much in. I would cover less. I would try and make it as experiential as possible. Getting them to work more in groups. Investigating things themselves. And try and really answer their questions, and not be so focused on "I've got to get this Australian Curriculum, I have to get good outcomes" (Alan, interview Oct. 14).

However, having positive experiences of teaching science at least once during the practical experiences were also described by participants as contributing to their positive science teaching efficacy beliefs. Mark, John, Lucy, Sarah and Kate reflected on these experiences by stating that they enjoyed the challenge of planning and teaching science, as well as finding and using resources, and they were particularly pleased with the way students engaged in their lessons.

5.4.3 The Level of Student Engagement

The engagement of students was considered a significant factor that influenced the in-depth interview participants' beliefs about science. A connection was made by all of the participants when recognising that student engagement in science was high when lessons were meaningful and hands-on, while low engagement existed when the science lessons were more theory based and less experiential. Witnessing high student engagement in their or their cooperating teacher's lessons, positively impacted their feelings towards science. The following comment from Lucy illuminates this:

[The students] were very excited about it. From then on, I'd have "When is science? When are we doing science?" It really did engage them in the topic. They loved it. it got to the point where they wanted to discuss it every morning in the day's introduction. That was great that they obviously were engaged enough in it that they wanted to bring it up every day (Lucy, interview Oct. 14).

5.4.4 The Priority of Science within the Curriculum

Each of the preservice teachers experienced a range of educational settings during their practical experiences. From the responses from the in-depth interview participants, quality science experiences were more prevalent in schools where science was considered a higher priority. Based on the interviews from the in-depth participants Kerrie and Jamie, there was no emphasis given to science in the childcare centres, which limited their own ability to create science experiences. This was described by Kerrie:

I don't think [the educators] consciously knew that they were or weren't incorporating science. If I was to do the prac again, I think I would have used the opportunities to tap into the children's interests. But I felt constricted by the centre environment and felt a lack of support from the staff (Kerrie, interview Oct. 14).

Several of the participants reflected on school-based environments where there was a clear emphasis on literacy and numeracy. This was reported as evident in the early childhood classrooms that Kerrie and Jamie experienced, but the findings from this

study also show it to have been particularly evident in Catholic schools that Mark, John, Toni and Alan experienced. John shared the following:

[The school does] have a perception of it, but it's obviously not as strong as your numeracy and your literacy blocks; they pretty much dominate every day in primary school (John, interview Aug. 13).

However, other schools experienced by Mark, John, Lucy, Sarah and Kate had a strong focus on science within the curriculum. These participants observed many things around schools to indicate this priority, including visible science displays, staff meetings focused on science and science curriculum leaders. All of these participants stated that this led to a stronger prevailing view about science in their classrooms.

Time to adequately teach science was referred to by Toni, Sarah and Alan. For these in-depth participants, they shared a perception that science was not being prioritised in one of their practical experiences due to interruptions such as whole school events or not being timetabled well by the classroom teacher. All three of these participants expressed frustration as a result of these timing issues.

5.4.5 Availability of Science Resources

A final theme to emerge from the in-depth interview participants' reflections on their practical experience was the availability and quality of science resources. Mark, Toni, Lucy, Sarah, Kate and Alan commented on the benefit of having the *Primary Connections* resources available in schools. This often did not just refer to the learning and teaching program, but associated resources boxes that schools had purchased. For Kate, the access to high quality resources contributed to her confidence in teaching science:

The resources really gave me the confidence to know that I was doing the right thing and the fact that my teacher always stuck by the curriculum closely, I knew that what I was teaching was relevant...instructional strategies like using ICT, using books, all the resources were great, so I think just all of it bundled together to make me feel like I was capable of teaching (Kate, interview Oct. 14).

A further illuminating comment was made by John who in his final internship, had access to a significant amount of technology. He perceived that having access to these resources contributed to the quality of science lessons he observed. John stated:

They had smart boards and 1-to-1 iPads, so being able to have the PowerPoints and video links and having it accessible to each individual student was invaluable. I can't tell you how much that influenced the success of the lesson (John, interview Oct. 14).

5.4.6 Discussion of the Influence of Practical Experiences on the In-Depth Interview Participants' Perceptions of Science Learning and Teaching

The results of the current study showed more variance in how the in-depth interview participants reflected upon their practical experiences in relation to the teaching and learning of science, in comparison to their university coursework. The following key themes emerged: the varying nature of the quality of science teaching, the impact of actually teaching science, student engagement, and science in the curriculum.

All of the participants attend a university with high levels of practical experience included within the degree but the results of this study show the quality of science teaching observed during these experiences was diverse. Some participants observed engaging, inquiry science, others saw teaching that relied heavily on curriculum resources, and there were some instances where science teaching was not seen at all. When participants viewed science teaching by mentor teachers in a positive light, a common point of reference was the passion these teachers had for teaching science and the support offered by their cooperating teacher.

Previous research has identified that in some circumstances, preservice teachers may have limited opportunities to see science being taught or have the opportunity to teach science themselves (Mullholland & Wallace, 2001; 2003). For the participants who saw low quality or no teaching of science in their final practicums, all, excluding Sarah, remained optimistic about their capabilities for teaching science, which indicates a level of durability of their science teaching efficacy. Durability in the context of teacher efficacy is the ability to maintain their beliefs for a sustained period of time. These findings support previous studies by Palmer (2006a), Utey et al. (2005)

and Settlage et al. (2009) which identified positive changes to science teaching efficacy after a science methods course were able to be sustained over a nine or ten-month period. The findings may also support those of Howitt (2007) who suggested that when a practical experience does not provide an optimal experience of science learning and teaching, positive perceptions of a science methods unit are of importance. However, Sarah's experiences may support these studies, in that they also identified that for some participants, there was a decrease in science teaching efficacy beliefs due to a lack of opportunity or negative experiences of teaching and viewing science (Palmer, 2006a; Settlage et al., 2009; Utley et al.2005).

Being given opportunities to teach science whilst on practicums was highlighted by participants as positively contributing to their beliefs and perception of teaching science. Again, experiences of this were varying in nature. When personal science teaching efficacy beliefs were viewed in a positive light, it was connected to either high levels of student engagement or positive feedback from the mentor teacher. When preservice teachers see children motivated by the topic, enthusiastic and engaged, there can be positive ramifications for their teaching efficacy beliefs (Swars & Dooley, 2011). Several in-depth interview participants mentioned the positive impact of having children engaged in the learning experiences they had designed as being beneficial for their perceptions of their own capabilities. The findings of this research suggest that the students were more engaged when the lessons were hands on, supporting their own perceptions on the nature of science, as they shared in the initial in-depth interviews. However, for Sarah, there were more challenges in teaching the later parts of the 5E model, which were more structured and theory based. Despite this, she was still optimistic about using the model to teach science because she recognised the benefits of being able to teach the more hands-on aspects that are present in the Engage and Explore phases of the model. This finding is similar to the research of Fazio et al. (2010) which identified that, even when preservice teachers experienced challenges in teaching using inquiry models during practical experiences, they remained positive about using inquiry when they began their teaching careers.

The role of the cooperating teacher during practical experiences had an impact on how participants perceived the teaching and learning of science. Positive qualities of teachers that participants observed included a passion for science, a clear enjoyment

of teaching science and an understanding of how the students learnt best, which is attuned to Hattie's (2009) view of quality teachers. The importance of support by cooperating teachers and the impact this has on the science teaching efficacy of preservice teachers has been highlighted by previous research by Hamman et al. (2006) and Bhattacharyya et al. (2009). A key negative quality identified in this current research was preservice teachers observing their cooperating or science specialist teacher teaching science in a prescriptive way. Some participants mentioned how in one of their experiences the teachers taught in a way that were described as clinical or working through a checklist. This may reflect a misunderstanding of the 5E's inquiry model that underpins the *Primary Connections* resources that were being used.

The priority of science within different school's curriculum was another key influence on the in-depth interview participants' science teaching efficacy beliefs. The varying experiences of participants in this study highlight the diversity of science learning experiences that seem to prevail in Australian primary schools (Rennie et al., 2001). In this current research, there were varying levels of priority placed on science within the curriculum at different schools, particularly in terms of timetabling science and an overcrowded curriculum. For some of the participants, this was also represented in the number of science resources within the school. These findings corroborate the research of Andersen et al. (2004) in that the availability of resources and materials, and timetabling constraints impacted on the perceptions of preservice teachers in relation to teaching science. Another of the most influential aspects of the context was the time available to teach science. Indeed, there have been questions about the pressure on primary teachers in Australia in relation to time constraints to teach science effectively (Angus et al., 2007; Crook & Wilson, 2015). As discussed by the in-depth interview participants this current study supports this concern, with aspects such as fitting in all the required content, the many interruptions that exist within schools, and how science is timetabled into the weekly curriculum all mentioned.

When reflecting on student engagement, high engagement was connected to hands-on activities and the use of digital technologies. This notion supports a previous study by Swars and Dooley (2011), which identified that observing high levels of student engagement can have a positive influence on science teaching efficacy. The

behavioural needs of students were also reflected on by four in-depth interview participants in relation to how they perceived the science learning experiences.

5.5 The In-Depth Participants' Perceptions of the Quality of their Tertiary Science Preparation and Concerns Moving into their Early Career

5.5.1 October 2014 Interviews

At the time of the October 2014 interviews, the in-depth interview participants were asked to reflect on what aspect the university could have done differently to better prepare them for teaching science in their early career and what factor would most influence the quality of their science teaching. In relation to suggested changes to the structure within the university degree, only five of the participants provided an idea for this, with the other five participants being satisfied with the opportunities made available to them during their degrees. For Kerrie, Sarah and Toni, increasing the number of science units within the degree was perceived as important to them. Kerrie acknowledged that for her, the newly created *Science in Early Childhood* unit now offered to those completing the early childhood degree would have further enhanced her confidence to effectively teach science. Sarah expressed that while she felt the unit *Primary Science* was beneficial, she wanted more units that focused specifically on the skill of planning. In contrast, Toni recommended that a science unit should be scheduled in every year within their degrees. She shared the following thoughts:

We did primary science with you which was good because we got all the strategies, figured out resources and all of that, and we had a lot of experience in that unit, but I just don't think we have enough. We need at least one [science unit] every year I think, just too continually build on what we're learning. Even if there were just more electives available to increase that knowledge without being too intimidating with the titles (Toni, interview Oct. 14).

John and Kate's recommendations related more to the requirements of the practical experiences. Both of these participants expressed satisfaction with the quality of the science units, but Kate felt it was necessary to create a forward planning document for science for the 10-week internship, as was required for English and Mathematics. John

raised his concern that for some preservice teachers, there was not the opportunity to see quality science taught. John stated:

I think if you're unfortunate enough to have a prac where science is not taught or heavily focussed, I think that impacts you more than what we're taught at uni (John, interview Oct. 14).

In relation to what the in-depth interview participants felt may be critical to their successful teaching of science as they begin their careers, all of the participants other than Toni and Sarah stated that the quality of resources would be highly significant. Additionally, Alan, Maria and Jamie expressed the importance of having sufficient time to teach science within the busy primary school schedule. For Toni, she felt that her content knowledge would be the critical factor in her ability to teach science in her early career. However, Sarah commented that the factor that she perceived would be most influential to the quality of her science teaching would be the school's perception of science as evidenced in what was taught:

Especially if they don't regard it as a highly important subject area, then you know, you can try and reinvent the wheel however much you want and it's not going to make much of a difference really. It definitely needs to have a whole school approach, otherwise you could have the kids for an entire year do this really great science program throughout the year go into next year and it's gone (Sarah, interview Oct. 14).

5.5.2 Discussion of October 2014 Interviews

The results of this study provide some illumination into the impact of university course design may impact on the beliefs of preservice teachers in relation to teaching and learning science. Through the qualitative data from the October 2014 interviews, all preservice teachers excluding Sarah and Alan indicated that they had a level of confidence in teaching science through the development in their understanding of the subject, their knowledge of the curriculum and their knowledge of appropriate teaching strategies. This provides some evidence that the students had met the relevant AITSL (2011) graduate requirement in this area. This was also supported by the students' ability to pass required units and practical experiences as part of their degree. The university involved in the present study did meet the AITSL Initial Teacher

Education requirements for the number of science units incorporated within the degree, designed as science methods units in a way relevant to the context. The university also well exceeded the AITSL and ACECQA practical experience requirements, with undergraduate students completing 160 days of practical experience, and graduate students completing 100 days. This supports recommendations from the review into the *Australian Curriculum*, which highlights the importance of a balance between theory and practical experience (Australian Government, 2014).

However, meeting these minimum requirements may not create optimum experiences for preservice teachers in relation to their perceptions of teaching and learning science. As previously discussed, the majority of students who entered the undergraduate teacher education program at the university had limited positive previous science experiences and content knowledge, which supports data from previous research (e.g. Goodrum, Druham & Abbs, 2011; Moscovici & Osioma, 2008). Both units in this current study, *Environmental Science and Technology* and *Primary Science* were viewed positively by the in-depth participants, which was supported by the wider STEBI-B findings, in relation to their perceptions of teaching and learning science. This finding endorses previous studies that found that science methods units positively influence science teaching efficacy (Bleicher, 2007: 2009; Brand & Wilkins, 2007; Palmer 2006a). However, questions could be raised as to whether increasing the number of science methods units in the degree could have further enhanced these perceptions, as discussed by Utley et al. (2005) and Mulholland et al. (2004). Having another science unit was referred to by three participants in this current study as a way to further enhance their beliefs and understanding, and it was particularly important for the participants who were experiencing the transition to the new early childhood degree.

Research by Ling and Richardson (2009) has raised questions as to whether the timing of the units within a preservice degree course structure can possibly further optimise engagement and learning in science. This current study provides an answer to this question to some extent. For Sarah, the *Environmental Science and Technology* unit being scheduled in the first year of her teaching degree was a factor that she cited as reducing her engagement with the unit, as she perceived it was too close to the negative

experiences of science that she had had in high school. The *Primary Science* unit, scheduled for most participants in the second semester of their third year, still positively influenced seven of the participants at the October 2014 interviews, 11 months after the completion of the unit. These findings are in accord with Palmer's (2006a) recommendation that a science unit should be scheduled towards the end of a teaching degree, in order for positive gains in science teaching efficacy to flow into the preservice teacher's early career.

As part of their degrees, preservice teachers could also choose science electives offered through a different school within the university to increase their knowledge of science content. Previous studies have found that only a minority of primary preservice teachers complete any other science units at tertiary level (Hechter, 2011). As outlined in the demographic information in Chapter 3, only a small percentage of the wider preservice teacher cohort and the in-depth participants had actually completed any other science units at university. This may be explained by preservice teachers having lower levels of self-efficacy in relation to teaching and learning science, caused by their perceptions of previous science experiences, which leads them to choose what they perceive to be easier subjects (Hechter, 2011). At the current university, other science units are offered through a different school and are general in design, in that they cater for students from various degrees. One way that this might be rectified is through the provision of science content courses that are tailored specifically to early childhood and primary preservice teachers. The work of Palmer et al. (2015) have shown that there were positive gains in science teaching efficacy, which were sustained for over 10 months that used this approach to support preservice teachers with the development of their science content knowledge.

Also of importance in this current research is that the university had no specific requirements to teach science during any practical experiences and did not have any formalised approach to science mentoring, which had varying impacts on the in-depth interview participants' perceptions of teaching and learning science. Formal collaborative partnerships between universities and schools that focus on changing attitudes towards science for both preservice and inservice teachers, has been found to improve science teaching efficacy beliefs (Hudson & McRobbie, 2003; Jones, 2010). Poulou (2007) and Hubbard and Abell (2005) raise the importance of collaboration

between science teacher educators and mentor teachers in order to optimise science teaching and learning experiences for preservice teachers. In order for this to occur most effectively, it is vital that mentor teachers are selected that are considered exemplars of science teaching (Petersen & Treagust, 2014). These questions will be explored further in the Recommendations in Chapter Seven.

The experiences of the participants involved in an early childhood degree are worth exploring further. For these participants, two aspects were significant to their perceptions of teaching and learning science. Firstly, the university was transitioning to a degree called Early Childhood and Care 0-8 years, which would include a specifically designed early childhood in science methods unit, replacing the unit *Environmental Science and Technology*. For Kerrie, enrolled in this new degree, she did not complete the *Environmental Science and Technology* unit, but was also not able to complete the dedicated early childhood science unit as it was not ready and did not appear on the schedule of units. Like many other students in this predicament, and reflective of many others expressing low self-efficacy for teaching and learning science, this caused heightened levels of concern as she entered the *Primary Science* unit, as it was the only science unit she would complete in her degree. Kerrie's PSTE and STOE scores were significantly below the mean at the start of the unit. However, there was a dramatic improvement by the end of the unit, where her PSTE score was 50 and her STOE score was 37, which was supported by the qualitative data presented in her interviews. This supports Bautista's (2011) argument that a well-designed science methods unit can have a positive impact on outcome expectancy and science teaching self-efficacy, despite other obstacles occurring.

As part of this new degree, one requirement was for preservice teachers to complete a 10-week practical experience in a childcare centre, meeting requirements for ACECQA approval (2013), which involves preservice teachers working with children from the ages of birth to age five. This is a requirement that cannot be fulfilled in traditional primary schools and therefore the university sought out partnerships with childcare centres. The degree was being established at the time of the current study and the university, similar to other tertiary providers, was beginning to provide such practical experiences (Garvis et al., 2013). Jamie's cohort was the first group to complete a practical experience in a childcare centre. In her interview at the beginning

of the *Primary Science* unit, Jamie expressed several disappointments with this practical experience, including organisation, lack of support and lack of guidance. Jamie's perceptions support previous research by Rouse et al. (2012), who identified high levels of dissatisfaction with practical experiences provided in childcare centres.

The influences of science teacher preparation can be further analysed to identify sources of efficacy information. The researcher used the expanded model of Palmer (2006b) for this analysis, as it specifically related to the development of science teaching efficacy beliefs. Although this model related specifically to sources of efficacy beliefs developed in science coursework, the application to practical experiences was also useful. Based on the information shared with the researcher by the in-depth interview participants, evidence of all sources of information were referred to through either science units or practical experiences, which supports previous research by Palmer (2011). It is important to state that these sources of information can be either positive or negative, and individuals cognitively process these sources of information in varied ways due to past experiences or by considering other factors such as effort, task difficulty and assistance (Phan, 2012b).

Mastery experiences have been described by Bandura (1997, 1994) as the most powerful source of personal efficacy beliefs. In the current study, enactive mastery, described by Palmer (2006b) as the successful experience of teaching science to a child, was only present through practical experiences. The in-depth interview participants for who this source of information positively influenced their efficacy beliefs were Mark, John, Lucy and Kate. For Toni, Sarah and Alan, opportunities to teach science during practical experience was associated more with a negative view of their abilities, while several of the in-depth participants reported limited or no chance to teach science in their practical experiences. Considering the item analysis of the November 2013 STEBI-B shown in Tables 5.5 and 5.6, which highlighted the wider preservice teacher cohort experiencing some uncertainty of a teacher's ability to influence the science performance of students, it could be hypothesised that many of the preservice teachers had limited enactive mastery experiences through practical experiences.

Evidence of cognitive content mastery, which is defined as having a successful science learning experience in relation to understanding science concepts (Palmer, 2006b), was present solely through science coursework for some of the in-depth participants. This was evidenced also through the item analysis of the STEBI-B, which indicated an improvement in science content knowledge. For some of the in-depth participants, cognitive content mastery was developed through their additional science study at tertiary level.

Cognitive pedagogical mastery, described by Palmer (2006b) as the successful learning involving the understanding of science teaching techniques, was referenced in both coursework and practical experiences. Examples of this included the completion of the peer presentation and forward planning document assessment in the *Primary Science* unit, as well through the development of teaching and learning programs in practical experiences. The item analysis of the November 2013 STEBI-B shown in Tables 5.5 and 5.6 indicated improved pedagogical knowledge for the wider preservice cohort, also supports this source of efficacy information. Palmer (2006b) also expanded the mastery experiences to include a category he called unspecified cognitive mastery, to describe successful experiences that participants could not attribute specifically to content or pedagogy. The positive reflections of the in-depth participants in relation to the structure and nature of the science content, as well as improved understanding of science resources were categorised by the researcher as unspecified cognitive mastery. Also evidence of this source of information were experiences shared by in-depth interview participants when they were able to successfully team-teach science with their cooperating teacher on their practicums.

Bandura's (1997, 1994) second main source of efficacy information was vicarious experiences, referring to observing the modelling of a task from other individuals. This was evidenced in the current study in both coursework and practical experiences through modelling by the science teacher educator, cooperating teachers and science specialist teachers. The demonstration of science teaching by the science teacher educator was widely viewed in a positive light by the in-depth interview participants, but for Sarah, this led to self-doubt as she perceived she would not be able to teach to this standard. Vicarious experiences during practicums were more varied in terms of

quality, but several participants shared examples of carefully observing their cooperating teacher, which assisted them in implementing their own successful science teaching programs. Palmer's (2006b) expanded aspects of vicarious experiences, namely cognitive self-modelling and simulated modelling, were also present in the current study. Cognitive self-modelling, defined as preservice teachers imagining themselves teaching (Palmer, 2006b), was referenced by a few participants sharing the benefits of the lesson presentation during the *Primary Science* unit. Simulated modelling, or role-playing a primary class (Palmer, 2006b) was also discussed by several of the in-depth participants. The experience of this was again discussed in relation to the peer presentations, but also in the experience of completing hands-on tasks connected to the content. While perceptions of the hands-on tasks developed by the science teacher educator were perceived positively, Alan and Sarah shared contrasting views of the benefits of this during peer presentations.

Verbal persuasion, or the reception of feedback (Bandura, 1997; Palmer, 2006b), was only briefly referred to throughout the practical experiences. Only a few of the in-depth interview participants mentioned the role of verbal persuasion from the cooperating teacher as being significant to their practical experience and no participant specifically mentioned the role of feedback in relation to the science teacher educator. This finding may be explained by the retrospective interview design of the study. There was some evidence of the fourth source of efficacy information also in practical experiences, known as physiological states, relating to aspects such as individuals coping with stress, fear or anxiety (Palmer, 2006b). These same emotions can contribute to the cognitive processing of the sources of efficacy information (Phan & Nyu, 2012).

However, as described by Mansfield and Woods-McConney (2012), other factors influence science teaching efficacy beliefs for practising teachers. Most of the in-depth interview participants identified resources as the factor that they believed would most influence the quality of their science teaching as they began their careers. Access to quality teaching resources such as *Primary Connections* have been identified as positively impacting on the science teaching efficacy of practising teachers (Skamp, 2012). Availability of resources is also one of the factors previously identified by Mansfield and Woods-McConney (2012). However, the varying science resourcing

that was recalled by participants as they reflected on their practical experiences indicates that high availability of science resources would not be guaranteed for all preservice teachers as they began their careers.

Sarah was the only participant who felt that the way the school prioritised science would most impact on the quality of her own science teaching as she began her career, again supporting the research of Mansfield and Woods-McConney (2012). Bandura (1994) refers to this as collective efficacy, and several studies have identified that collective efficacy can positively impact on teaching efficacy beliefs (Goddard & Goddard, 2001; Goddard et al., 2004; Klassen, 2010). This perception of Sarah may be due to the positive whole school culture that she experienced in her third-year practicum.

5.6 Summary: Preservice Teacher Preparation and the Influence on Science Teaching Efficacy Beliefs

This chapter described the results and discussion of the second research question, which investigated how preservice teacher preparation influences science teaching efficacy beliefs. Upon completion of the *Primary Science* unit in November 2013, the results of the STEBI-B for the whole preservice cohort mean PSTE was 52.15, as compared to the start of the unit, where the mean PSTE was 46.35. This scale of the STEBI-B measures the changes in personal science teaching efficacy beliefs. For the second scale, the STOE mean was 36.99 in comparison to the mean STOE of 34.54 in August 2013. This scale measures the changes of beliefs about science outcome expectancy. Figure 5.1 shows that seven of the in-depth interview participants showed an increase in PSTE scores from August to November, with one participant staying the same, and two participants decreasing. All in-depth interview participants showed increases in the STOE score shown in Figure 5.2. Qualitative data at the end of the unit supported improved overall feelings of confidence towards the teaching and learning of science for all but one of the in-depth participants. Interview data from after the final practical experience and into the first year of teaching showed a maintenance of improved science teaching efficacy beliefs towards the teaching and learning of science for 8 of the in-depth interview participants.

The in-depth interview participants had varying perceptions of the teaching and learning of science during the science coursework at university and their practical experience. In relation to the science methods units completed, the following were key observations:

- Both science methods units were considered overwhelmingly positive in relation to the teaching and learning of science.
- Factors that influenced science teaching efficacy beliefs included the structure and nature of the units, the science teacher educators, the assessment within the units and the improvement of pedagogical content knowledge.

There was more variation in the key influences of practical experience that impacted science teaching efficacy beliefs of the in-depth interview participants. Key findings were:

- Experiences ranged from seeing little or no science being taught to seeing a lot of science being taught. Experiences also varied in the quality of science teaching and learning experienced.
- There were varying perceptions about the profile of science within the schools that the participants completed their practical experience in.
- Factors that influenced science teaching efficacy beliefs included the quality of the mentor teacher, the resources of the school, the engagement of students, and the way that the participants were supported or encouraged to teach science themselves.

Upon reflection of their science teacher preparation at the end of their degrees:

- Mark, Alan, Lucy and Jamie were satisfied completely with the way the university prepared them to teach science in their early careers.
- Having more units to focus on content was identified as a way to improve the science coursework offered by the university by Kerrie, Sarah and Toni.
- John and Kate identified that science needed to be a requirement of practical experiences in order to enhance the skills of preservice teachers.
- When asked what they anticipated would most impact the quality of their science teaching, access to resources was identified by most of the participants

as critical. Only one participant believed that the whole school culture of the school she got employed it would be the most significant influence.

Chapter 6

Early Career Science Teaching and the Influence on Science Teaching Efficacy Beliefs

6.0 Introduction

Chapters 4 and 5 have discussed the findings of the first two research questions. In Chapter 4, the science teaching efficacy beliefs of the wider preservice cohort and in-depth participants were ascertained at the beginning of a science methods unit. Exploration of what prior science experiences had influenced the science teaching efficacy beliefs of the in-depth interview participants were also presented. Chapter 5 investigated how science coursework and practical experience affected the science teaching efficacy beliefs of preservice teachers. This chapter describes and analyses the results and discussion of the third research question: How, why and to what extent does the first year of teaching influence science teaching efficacy beliefs?

This chapter helps to attend to a gap in the current literature in that it longitudinally follows preservice teachers into the first years of teaching. There currently exists an absence of studies exploring the science teaching efficacy beliefs as preservice teachers move into their early careers. This stage of career development can be challenging for early childhood and primary teachers. Early career teachers face challenges with learning about their new school, encountering challenging student behaviour, implementing an overcrowded curriculum, managing parents and developing their own teaching skills. There is also a lack of Australian research in this area which this current study helps to address.

The science teaching efficacy beliefs of the in-depth interview participants are presented in this chapter, as collected in January 2016, over a year after they were last interviewed. Following this analysis, key themes of what the participants believed influenced their science teaching efficacy beliefs in their early careers will be discussed.

6.1 Science Teaching Efficacy Beliefs of Early Career Teachers In-Depth Interview Findings

6.1.1 In-Depth Interview Findings: January 2016

The researcher made contact with all in-depth interview participants in January 2016 to schedule an opportunity to complete the final interviews. Of the 10 participants, six agreed to complete this interview, namely, Kerrie, Mark, John, Lucy, Alan and Maria. As per the previous data chapters, each of the participant's perceptions are presented, to assist in understanding the trajectory of their beliefs.

Kerrie graduated from the Bachelor of Education (Early Childhood and Care 0-8 years) mid 2015. Previously she had a limited science background as she began the *Primary Science* unit, but this unit contributed to an increase in science teaching efficacy beliefs (see Chapter 5, Figures 5.1 and 5.2). However, the practical component of her teaching degree provided inadequate opportunities to observe quality science teaching or even have the chance to teach science for an extended period of time. She completed her internship in the beginning of 2015 in a Kindergarten classroom and as per her previous experiences, science was not considered a priority in the classroom. Kerrie expressed the view that the development of literacy and numeracy skills was the emphasis in the play-based classroom she was placed in and her cooperating teacher did not teach any science lessons during this experience.

At the time of the January 2016 interviews, Kerrie was employed in a relief capacity in a childcare centre. This was not her ideal employment, but she had not been able to secure a position in an early childhood classroom at this point. Kerrie shared that she had not had any opportunity to plan and teach science within this centre and felt little agency in being able to raise the issue with her employers. When asked about her current science teaching efficacy beliefs, Kerrie stated:

I think I can teach science, but I have had no opportunities to demonstrate this in any of my pracs or my current job. Science does not seem to be a priority in any of these places (Kerrie, interview Jan. 16).

Mark completed his teaching degree in December 2014, graduating with a Bachelor of Education (Primary) degree. While Mark had had mixed experiences with science at the start of the *Primary Science* unit, he expressed increased science teaching efficacy beliefs by the end of this unit, which was reflected in his STEBI-B results shown in Chapter 5, Figures 5.1 and 5.2. In fact, Mark felt that both science methods units at university were useful for his development and had mostly positive experiences of science teaching in his practical experiences. As he completed his degree, he expressed a strong interest in teaching science, which he felt had continued to increase since the *Primary Science* unit and his internship.

Mark had secured a job in the school where he completed his internship, which was a large Catholic primary school, teaching Year 4 students. He shared his enjoyment of his first year of teaching and was grateful for the supportive school environment and high level of resources available to him. Mark did express some of the difficulties he faced when dealing with the behavioural issues of some of his students. His school had a science specialist teacher, which reduced his opportunities to teach science. However, Mark stated that he had deliberately aimed to integrate science into other curriculum areas, particularly technology and enterprise. He described his current perceptions of his ability to teach science:

I would say that I am comfortable in teaching science at primary school level, and I feel that I can do a good job of it. I have tried to integrate science with technology that I have done in the classroom and even geography. Aside from having a science specialist doing the main science teaching for us, I still feel that science is a very important part of learning for students and should have a place in the classroom (Mark, interview Jan. 16).

John also graduated from the Bachelor of Education (Primary) degree in December 2014. He expressed a lack of interest in science during high school, which he felt was connected to his lack of maturity. His STEBI-B results from August to November 2013 minimally changed (see Chapter 5, Figures 5.1 and 5.2), but in the November interviews, he expressed stronger science teaching efficacy beliefs. John was satisfied with both science methods units he completed at university, particularly enjoying the hands-on nature of the units. He was able to observe quality science teaching during his practical experiences and was also given opportunities to teach science. At the end

of his degree, again John expressed moderate science teaching efficacy and seemed relaxed in his science teaching capabilities.

At the time of the January 2016 interviews, John had been working in a moderate sized Catholic primary school since January 2015. He had a Year 5 class and he felt that high levels of support pervaded the school. He described a sense of accomplishment that he felt for successfully completing his first year of teaching. John's school also employed a science specialist and he stated that this led to a consistent emphasis on science within the school. However, this did mean that he was not required to teach science at all during his first year of teaching. He shared:

I still think I am pretty capable of teaching science. I know where to look for resources and understand the curriculum, which I think helps. I think if I had to teach it I would be fine (John, interview Jan. 16).

Lucy completed her Bachelor of Education (Primary) in July 2015, after successfully completing her final teaching internship earlier that year. While she had mixed experiences of science prior to the *Primary Science* unit, she had developed a strong interest in it through her tertiary study. Lucy had high levels of science teaching efficacy beliefs before and at the end of the unit (see Chapter 5, Figures 5.1 and 5.2), and shared a strong enjoyment and learning within both science methods units. She had completed one practical experience where a science specialist teacher taught science but was able to plan and teach science on her final two experiences. Of her recent internship, she was particularly proud of her achievements, and felt that science was one of her best teaching programs.

In January 2016, Lucy was about to begin a new position teaching Year 2. She had completed a six-month temporary position teaching Year 1 in another school after her graduation and she shared a high level of satisfaction with her teaching. She shared some challenges with taking over a class six-months into the year, but the students were well behaved and highly engaged in their learning, which was perceived by Lucy as beneficial. When reflecting on her science teaching capability, she stated:

My science has gone really well. The school used Primary Connections, which I learnt at uni and got to use on both my pracs. I have been able to integrate it

with other learning areas and have used the 5E's with my planning. So I have been really happy with it (Lucy, interview Jan. 16).

Throughout the research study, Alan was experiencing a conflict between changes in his personal life philosophy and his tertiary education degree. He had previously completed an undergraduate degree in geophysics, but his personal experience led to him embracing aspects of the deep ecology and Steiner philosophy. Alan's November 2013 STEBI-B scores were similar to the wider preservice cohort mean (see Chapter 5, Figures 5.1 and 5.2), and he appreciated aspects of the *Primary Science* unit and practical experiences. However, in both his science coursework and practical experiences, Alan experienced some concerns with aspects of the curriculum and traditional schooling due to his emerging interest in the deep ecology movement.

Alan was employed part-time in a small, alternative, community school for 2015. This school had a focus on personalised learning and authentic project-based inquiry. While the school was still required to teach the *Australian Curriculum*, the teachers had a lot of freedom in how this was implemented. Simultaneously, he was working as a community organiser with his deep ecology movement. By the time of the January 2016 interview, Alan had quit his teaching position for several reasons. He felt that he lacked support from other teachers within the school and disliked the feeling of imposing ideas on his students. However, the primary reason was that he felt that his true calling was in community facilitation and that he was never truly comfortable teaching. In relation to his science teaching during this period, he shared his thoughts:

I guess I wasn't confident in teaching, in diversifying enough. I was teaching a lot in an old style where you know I'm on the stage, on the stage, on the stage. I guess I needed more support in understanding how to make more learning spaces and areas so that science could just arise out of its own joy and interest (Alan, interview Jan. 16).

Maria, already with a degree in secondary education, graduated with a Graduate Diploma (Primary Conversion) during 2014. She was an experienced teacher in the arts and had begun a neuroscience degree before moving to education. She expressed a strong interest in science, due in part to her strong memories of science experienced with her family. Maria completed the *Primary Science* unit as an elective and she had

high science teaching efficacy, particularly reflected in her high PSTE score in the November 2013 STEBI-B administration (see Chapter 5, Figures 5.1 and 5.2). While other science units or practical experience were not a requirement of the unit, Maria shared that *Primary Science* had been one of the best units she completed as part of her degree.

At the time of the final interview, Maria had worked part-time in the same school in which she had been employed since the beginning of the research study. However, she was now working in the primary campus of the school and was required to teach science. Maria felt that science was a success in her classroom and that the boys in her class were highly engaged in their learning. She enjoyed using an inquiry approach to science and stated:

I have really enjoyed teaching science this year. I will continue to do so in 2016 and look forward to this experience. I continue to have positive perceptions about my science teaching in the primary school setting (Maria, interview Jan. 16).

6.1.2 Discussion of In-Depth Interview Findings: January 2016

As mentioned in the literature review, high science teaching efficacy beliefs of inservice teachers have been associated with improved student performance (Lumpe et al., 2012) and can be predictive of a teacher's intention to teach science (van Aalderen-Smeets & Walma van der Molen, 2013). Through the qualitative data from the January 2016 interviews, five of the in-depth interview participants shared moderate to high science teaching efficacy beliefs. For three of these participants, this was despite not having an opportunity to teach science in the first year of teaching. Only one participant, Alan, communicated lower science teaching efficacy beliefs. These findings provide tentative support for the long-term positive impact that a well-designed science methods unit can have on science teaching efficacy beliefs, an issue that had been previously highlighted by Menon and Sadler (2017).

The results of the January 2016 interviews for Lucy and Maria indicate that both retained higher science teaching efficacy beliefs after inservice science experience. Both of these participants, through previous interviews and STEBI-B data, have

maintained strong science teaching efficacy beliefs throughout the research study. Both indicated an enjoyment of science and could identify many aspects of their science teacher preparation that positively contributed to their perceptions. The qualitative data indicated that both demonstrated enthusiasm for their science teaching, which seems to support previous studies by Praetoris et al. (2017), Skamp (2012) and Skaalvik and Skaalvik (2010). However, uncertainty remains as to whether their science enthusiasm led to their higher science teaching efficacy beliefs across the research study, or whether enthusiasm and efficacy beliefs are interrelated, both simultaneously influencing each other. These participants stated that they were using aspects learnt through their preservice experiences in their own teaching, supporting the findings of a previous study by Ozder (2011).

Mark, John and Kerrie were unable to teach science in their first year of teaching, due to the circumstances of their employment. For Mark and John, this was due to their schools employing science specialist teachers and Kerrie was employed as a relief teacher in a childcare centre. Through the qualitative data, they all stated that they remained confident to some degree in their science teaching capabilities. While these comments continue to indicate the durability and resiliency of their beliefs (Palmer, 2006a; Settlage et al., 2009; Utley et al., 2005), it is important to bear in mind the possible bias that may exist in these responses. Kerrie's response in particular needs to be interpreted with caution. Of these three participants, she had the most limited science experience through both her coursework and practical experience and had had very few tangible science opportunities since completing the *Primary Science* unit. Further evidence of her science teaching efficacy beliefs may have been useful to support the interview findings.

Only one in-depth interview participant, Alan, expressed low science teaching efficacy in the January 2016 interviews. However, this also seemed reflective of his wider teaching efficacy after his first year of teaching, which concluded by his resignation at the end of 2015. He had previously shared some concerns about his science teaching efficacy in the October 2014 interviews (see Chapter 5, section 5.5.1). At this point, he seemed to attribute this to the requirements of meeting curriculum requirements and the contrast of his experience to his own personal philosophy of education. On reflection of his first year of teaching, Alan shared negative experiences of his science

teaching, which again seemed connected to his perceptions of the restrictions of the curriculum. Alan's case may be indicative of previous findings by Fry (2009), who maintained that individuals with lower teaching efficacy beliefs often exhibited more negative professional attitudes and lower levels of resiliency. However, throughout the research study, it was evident that Alan experienced uncertainty about whether teaching was his desired profession. Whilst at university, this was more easily connected to the philosophical differences that existed between mainstream education and his own personal views. After a year of teaching, Alan had more clarity that teaching was not what he wanted to do as a career, which provides some explanation for both his wider teaching efficacy, as well as his science teaching efficacy beliefs.

6.2 The Influence of the First Year of Teaching on Science Teaching Efficacy Beliefs

The six in-depth interview participants reflected on several aspects of their first year of teaching that influenced their perceptions of science teaching and learning. This section of the chapter will present the findings that were shared by the in-depth interview participants in relation to these influences. A wide range of influences were described by participants, which may be reflective of their different teaching contexts. These were the support of other teachers, time, the availability of resources, student experience, the school environment, and personal situations.

6.2.1 Influences from the First Year of Teaching

The influence that was most frequently mentioned was the role of support by other teachers in the school. This was mentioned by all the in-depth interview participants, but the quality of this support differed. The support did not directly relate always to their science teaching but was an overall perception of their first year of teaching. There was no commonality of support programs offered within the in-depth participants' employment. Maria and Lucy both reflected on high levels of support for their first year of teaching, provided through leadership, relationship with mentor teachers and other staff in the school. Although Mark and John were not required to teach science as science specialist teachers were employed in their school, both felt an overwhelming sense of support in their first year of teaching by the other teachers in

the school. Both suggested that while they had formal mentors, it was the relational aspect of their school communities that provided the most support. John maintained that this led to him experiencing both personal and professional growth throughout his first year. He shared the following thought:

My school has a science specialist so I didn't teach any science in my first year. But, even if I did teach science, I would have had lots of help from my mentor and from other teachers. It is a really supportive school (John, interview Jan. 16).

For Kerrie and Alan, both described feeling unsupported by other staff during their first year. Kerrie's casual employment in a childcare centre was unsatisfying, which she attributed to as being the result of the poor relationships present between the leadership of the centre and staff. Kerrie felt unable to initiate change to the way the centre operated or the curriculum it focused on. In Alan's context, he shared a lack of connection with his mentor teacher and felt this pervaded all aspects of his teaching. Alan stated:

I struggled, I guess I feel like I didn't have the full support. I didn't have the support I needed in my first year of teaching to really teach effectively (Alan, interview Jan. 16).

Time was considered a crucial influence for all of the in-depth interview participants in relation to their first year of teaching, other than Kerrie, which can be explained by her relief teaching role in the childcare centre. For the other participants, as teachers employed in primary schools and being responsible for all areas of the curriculum, all shared numerous time constraints. These included interruptions to their timetable, pressures of other curriculum areas and managing their own time effectively. Interruptions to timetables included whole school events such as incursions, sports carnivals and other extra-curricular activities, while the curriculum areas of literacy and numeracy were most dominant in the schools that Mark and John were employed at. However, all five in-depth interview participants expressed challenges with managing their own time effectively, which they felt was connected to the numerous responsibilities of being an early career teacher.

The availability of resources was another one of the influences mentioned most by the in-depth interview participants. For three participants, they felt the high availability of resources in their school contributed to the high-quality science teaching they either observed or taught. Mark, Lucy and Maria described benefits including access to hands-on materials and familiarity with *Primary Connections*. In Mark's context, this did not directly impact on his teaching, as science was taught by a science specialist teacher. However, he did observe that the use of *Primary Connections* and bountiful hands-on resources led to well-organised and engaging lessons, despite behaviour management issues in his class. Lucy and Maria both shared that access to resources made their science teaching easier to organise. Lucy in particular, coming from a 6-month temporary role in a school located in a high socioeconomic area that was highly resourced, expressed some concerns about her new employment:

Coming from a school where you could spend absolutely anything, request anything and then going to a school where from what I've seen as far as resources go, I'm very limited. I suppose I now just need to come up with ways of doing things a little bit more cost effective (Lucy, interview Jan. 16).

The impact of participants' experiences with students was referred to by three of the in-depth interview participants as influences in January 2016. However, Mark, Lucy and Maria had different contexts, which influenced their perceptions. In her temporary position, Lucy observed high student engagement in her science lessons, which she perceived as being connected to her own enthusiasm for the learning area. Maria's school was an all-boys school and she had shared in a previous interview the high engagement boys demonstrated in science. Her own experiences of teaching science in 2015 mirrored this observation:

I feel science has been a big hit with the boys in my classroom. It gives a wonderful balance to the teaching and learning program. I find that boys enjoy this subject area and I have learned just as much from my students as they have from me (Maria, interview Jan. 16).

In contrast, although Mark was not responsible for teaching science, he could identify some challenges based on some of the experiences with the class that he taught. He shared that his class were diverse in learning and behavioural needs, which could potentially make it difficult to effectively teach them when the lessons were less-

structured and hands-on. At this point in his development, he indicated that this would be something he would need ongoing support with and even suggested that should be considered within the tertiary teaching preparation. Mark explained:

The behaviour of my students was an issue. I would have loved to do more teaching of science and run more tests/ experiments with them, but their behaviour made it too hard and time consuming. In some cases, it was also a safety risk for some students (Mark, interview Jan. 16).

The role of the school environment was also identified by two in-depth interview participants as influencing their perceptions of science. Mark and Alan described how their school environment was a hindrance for the development of authentic science experiences. Alan shared his perception that the lack of natural environment in his school reduced his ability to meaningfully incorporate his philosophy of deep ecology into his science teaching. For Mark, the physical environment of his class was a negative factor in his ability to teach and shared:

It was hard having enough room to work. It was tricky at times to get the class on a task when they were inside and cramped for room. If we went outside, it became disruptive to other classes (Mark, interview Jan. 16).

For Alan, the biggest influence on his first year of teaching was his own personal life experiences. While other factors contributed to his perceptions, the conflict he felt between his calling to facilitation within the deep ecology community and his role as classroom teacher. For most of the research study, Alan had experienced this tension, but the reality of classroom teaching accentuated this for him. He described this in the following way:

I think there was a lot of internal dilemma which meant that my mind wasn't as flexible as it could have been. Just the overwhelm of being first year out teaching, new classroom, new kids, new community, new ways of teaching, it's a lot to take on. I think that stress means that I sort of reverted to do things in quite an authoritarian manner (Alan, interview Jan. 16).

6.2.2 Discussion of the Influence of the First Year of Teaching on the Participants' Perceptions of Science Learning and Teaching

The influences identified above by the six in-depth interview participants involved in the January 2016 interviews are highly varied, reflective of the different experiences and contexts of the participants' first year of teaching. Early career teachers face numerous challenges as they begin their careers including difficulty in achieving a work-life balance, time management, school expectations and challenging classroom behaviour (Burke et al., 2013; Hudson, 2012; Mulholland & Wallace, 2000). For those employed in early childhood and primary settings, science is only one area of the curriculum to plan for and implement, and particularly in early childhood settings, the priority of science is often not considered on par with literacy and numeracy.

Support for early career teachers by other teachers in the education settings was identified as a major influence in the findings of the current study. This support referred to assistance provided from leadership teams, mentor teachers and other staff, and was experienced differently in different schools. Previous studies have identified the importance of support to help early career teachers adjust to changing demands after finishing their university preparation (Australian Science Teachers' Association & Office of the Chief Scientist, 2014; Bullough et al., 2004; Hudson, 2012; Smith & Jang, 2011). In this study, four of the in-depth interview participants shared an appreciation of the support they received, all of whom shared moderate to high science teaching efficacy beliefs in January 2016. For Alan, he felt that he required more support to assist him with the many challenges he faced. It could be argued that this particular finding is more connected to the internal conflict he had been facing throughout the research study, rather than a reflection of the support offered by Alan's school.

For one other participant, being employed in a childcare centre had a negative impact on her opportunity to teach science. For Kerrie, the experience of working in a childcare centre was similar to her practical experiences, in that there were limited opportunities for explicitly teaching science. A causal factor identified by Kerrie was the lack of qualified teaching support in the context of childcare centres, which has previously been identified in the research of Onnismaa et al. (2015). However, this

issue seems to be multi-faceted, in that other possible explanations may be that the educators in these centres had difficulties understanding how science is part of the holistic nature of early childhood education as outlined in *The Early Years Learning Framework*. Kerrie may have been better supported to initiate change in these centres if she had had access to the early childhood science unit that was scheduled to be included in the Early Childhood and Care 0-8 years degree at the university. However, both Kerrie and Jamie's experiences across the research study have highlighted the dominance of literacy and numeracy in early childhood settings. This may be a reflection of an overcrowded curriculum in early childhood which has been previously discussed in reviews of the national curriculum (Australian Government, 2014). To develop a full picture of the influence of support on early career teachers in the area of science, additional studies are required.

It is also perhaps unsurprising that one of the influences to be cited by the in-depth interview participants relates to the availability of resources. This is particularly relevant as it was predicted by the in-depth interview participants in the October 2014 interviews as the influence that would be most significant to impact on the quality of their science teaching. Considering that early career teachers are time poor as they learn how to navigate all aspects of their teaching role (Burke et al., 2013), easy access to high quality resources is understandably important. The participants becoming familiar with the *Primary Connections* resources through their teacher education degrees, which has been associated with improved pedagogical content knowledge and higher science teaching efficacy (Skamp, 2012). However, the discrepancy in the quality of resources that in-depth interview participants reported throughout the research study is of concern and may need to be a focus of future investigation, particularly considering the emphasis that STEM subjects are currently receiving in Australia (Department of Education and Training, 2017; Office of the Chief Scientist, 2014).

From the January 2016 interviews, as well as identified throughout the research study, there were some in-depth interview participants who were not required to teach science because science specialist teachers were employed in the school. Having science as a specialist area in a school can be useful in that it assists classroom teachers deliver the curriculum and reduces the chances of science being taught by teachers lacking

confidence in teaching science (Ardzewska et al., 2010). Based on the comments from the January 2016 interviews, one of the participants still attempted to find opportunities to teach science in his classroom because he recognised opportunities for science to be integrated with other learning areas. However, having science specialist teachers employed in schools may limit science teaching performance for classroom teachers and may also have a long-term impact on the teaching efficacy beliefs and enthusiasm for science. In the current study, while these participants still described a positive attitude towards teaching science, it was evident that it was not a priority as they dealt with other challenges of being an early career teacher. Exploring the long-term impact of science specialist teachers on the science teaching efficacy beliefs of classroom teachers is an important issue for future research.

Early career teachers face increasingly complex challenges as they begin their careers. Previous international research has identified that 25-45% of early career teachers resign or experience burn out within their first five years of teaching (Burke, Schuck, Aubusson, Buchanan, Louviere & Prescott, 2013), although Australian data is limited in this respect (AITSL, 2016). In this current study, Alan resigned at the end of his first year of teaching, falling into this category. There were numerous reasons for his decision, including his personal life philosophy, the complexity and challenges of teaching, and a different career opportunity. By following his trajectory throughout the research study, a sense of inevitability seems to have been present from the beginning of Alan's enrolment in his postgraduate education degree.

The findings of this current study can be examined through the lens of the model of the development of science teaching efficacy beliefs for inservice teachers developed by Mansfield and Woods-McConney (2012). This model highlights the role of the science teaching context and wider school context as significant in the ongoing refinement of science teaching beliefs. This current study supports their findings, by identifying the influence of resources, time, student learning needs, collaboration and general teaching skills on science teaching efficacy beliefs. However, this study has been unable to demonstrate the influence of professional development and whole school science events on science teaching efficacy because none of the in-depth interview participants described these in their reflections on their first year of teaching.

Some of the influences raised by the in-depth interview participants highlight the need for ongoing partnerships between tertiary institutions and education providers. Participants raised aspects that had impacted on them in their first year of teaching such as locating cost-effective resources, dealing with behaviour management issues, time-management and curriculum integration. Ongoing support by universities may help early career teachers overcome such obstacles. This is in agreement with previous research by Smith and Yang (2011) and Mintzes et al. (2013), who maintain that tertiary institutions and education providers must work in close partnership to maximise the preparedness of early career teachers and support them in their ongoing development. As advocated by Anderson et al. (2004), there are benefits for all stakeholders when partnerships occur between universities and schools. Universities may also be able to assist with creating opportunities for science specialist teachers to work in partnership with classroom teachers. This has been a prior recommendation from Dinham (2014).

6.3 Summary: The First Year of Teaching and the Influence on Science Teaching Efficacy Beliefs

This chapter has described the results and discussion of the third research question exploring how the first year of teaching influences science teaching efficacy beliefs. In January 2016, six of the previous in-depth interview participants agreed to be interviewed after their first year of teaching. The qualitative data indicated that five of these participants maintained moderate to high science teaching efficacy beliefs despite varying employment contexts. However, for three of these participants, they had not taught science in their first year of teaching. At this point in the research study, one participant shared low confidence about his ability to teach science, but this was also reflective of his wider teaching beliefs. This same participant had resigned from his teaching position at the end of his first year.

The in-depth interview participants had varying perceptions of what influenced their science teaching beliefs in their first year of teaching:

- The role of support was identified as a significant influence by all in-depth participants in this current study. Time was also referred to as an influence that had impacted on five of the in-depth participants.

- Having access to quality resources was discussed by three participants as influencing their beliefs.
- Other influences included personal experiences, students and the school environment as contributing to the participants' beliefs.

Chapter 7

Conclusions, Limitations, Recommendations and Directions for Future Research

7.0 Introduction

This final chapter presents the conclusions, limitations, recommendations and directions for future research in relation to the current study. The first chapter presented the rationale and background of the study, and key literature relevant to the theoretical framework and area investigated were discussed in Chapter 2. Chapter 3 outlined the methodology of the study, including the research design, data collection and analysis methods. The findings of the study were presented in Chapters 4 to 6, as they related to each of the research questions.

This chapter draws together the conclusions of this study, exploring the self-efficacy beliefs of preservice teachers and their perceptions of teaching and learning science as they complete their final years of tertiary study and begin their teaching careers. A recapitulation of the purpose of study is presented, followed by a summary of the key findings for each research question. Limitations and problems encountered within the study are discussed. Finally, recommendations for future research and for changes to policy and practice are then outlined.

7.1 Purpose of the Study and Findings

This study arose from the researcher's personal observations as a science teacher educator when preservice teachers displayed negative attitudes and low science teaching efficacy beliefs towards science as they began a science methods unit at university. The researcher was interested to explore the reasons for this and whether science coursework and practical experiences could change the preservice teachers' science teaching efficacy beliefs. Also of significance, was whether these perceptions changed as these individuals began their careers and what the key influences were to impact on these beliefs.

The purpose of the study, therefore, was to explore how and why science teaching efficacy beliefs changed over time, from university teacher preparation to early career. An overarching research question was designed:

- How, why and to what extent do science teaching efficacy beliefs change over time from preservice teacher education to first year teaching?

From this problem, three research sub-questions were developed. The findings for each research question are discussed below.

7.1.1 Findings for Research Question 1: How, why and to what extent do Prior Experiences of Science Teaching and Learning Influence Science Teaching Efficacy Beliefs?

To determine the science teaching efficacy beliefs of the wider preservice cohort, the *Science Teaching Efficacy Belief Instrument for Preservice Teachers* (STEBI-B) was administered at the beginning of the data collection period. The quantitative results showed that the wider preservice teacher cohort entered a science method unit with low science teaching efficacy (see Chapter 4, section 4.1). There were negligible differences between males and females at this point of the study. However, differences were evident based on degree of enrolment, with those enrolled in Master of Teaching and the Other category having higher Personal Science Teaching Efficacy (PSTE) scores than the other degrees. However, those in the Other category experienced lower Science Teaching Outcome Expectancy (STOE) scores than those enrolled in the Bachelor of Education and Master of Teaching degrees.

This quantitative data was supported by the qualitative data from the semi-structured interviews which illustrated that most of the in-depth interview participants shared concerns about their ability to teach and learn science as they began the science methods unit (see Chapter 4, sections 4.2). Only three of these in-depth interview participants expressed positive science teaching efficacy beliefs, which corresponded with an enthusiasm towards science.

The study has identified that prior experiences of science teaching and learning do influence the development of science teaching efficacy beliefs (see Chapter 4, sections 4.3). The key influences identified by the in-depth interview participants were

negative experiences of science in high school, particularly during the final years. These experiences were described as being textbook-based and unengaging, which differed from their perceptions of what science should be like as hands-on and investigative in nature. However, what seemed to be most significant to their beliefs was the influence of science teachers. The participants identified key attributes of enthusiasm, ability to relate to students and pedagogical skills. Another key influence connected to this was the participants' perceptions of their learning success in science.

For those in-depth interview participants who had higher science teaching efficacy, other influences had contributed to their beliefs. All three had engaged with additional science studies at tertiary level and shared an interest in science. For two of these participants, the influence of family was also described as being important to their science teaching efficacy beliefs.

7.1.2 Findings for Research Question 2: How, why and to what extent does Preservice Teacher Preparation Influence Science Teaching Efficacy Beliefs?

The quantitative findings from the *Science Teaching Self-Efficacy Beliefs Instrument for Preservice Teachers* (STEBI-B) administered at the end of the science methods unit showed an overall increase in both scales of the questionnaire for the wider preservice cohort (see Chapter 5, section 5.1). Again, the mean score for males and females were similar and in contrast to the earlier assessment, there was more consistency between preservice teachers enrolled in different degrees. Analysis of mean item scores found that the wider preservice cohort perceived improvements in their science content knowledge and pedagogical skills (see Chapter 5, tables 5.5 and 5.6).

There was an improvement in seven of the in-depth participants' PSTE scores. All of their STOE scores improved, with only one in-depth participant to have a STOE score significantly lower than the overall mean. The overall improvement in science teaching efficacy beliefs was also reflected in the qualitative data from the in-depth participants (see Chapter 5, section 5.2). All but one participant described feeling

more positive about their science teaching efficacy at the end of the science methods unit.

The study investigated how preservice teacher preparation, namely science methods units and practical experiences, influenced science teaching efficacy beliefs. The findings show that science methods units contributed positively to the self-efficacy beliefs of the in-depth interview participants (see Chapter 5, section 5.3). Key influences of these units that were significant and viewed positively were the clear structure and hands-on nature of the units, assessment that allowed participants to develop their understanding of content and teaching skills, modelling by the science teacher educator and improved understanding of quality science resources. A recommendation for other high-quality science units that focused on early childhood, planning in science and that explored the development of more science content knowledge were recommendations from the participants as to how their science coursework could have been further enhanced.

However, the study found that practical experiences had a more mixed influence on the participants' efficacy beliefs (see Chapter 5, section 5.4). Due to the high varied nature of these experiences, the influences were viewed as being both negative and positive by the participants. The positive influences described were opportunities to teach science with the high support of a cooperating teacher, observing high quality science teaching, observing high student engagement in science and experiencing well-resourced schools with science as a high priority within the curriculum. Conversely, negative influences were described as seeing no or limited science taught, poor support by cooperating teachers, observing unengaging lessons and lack of student engagement, and science not valued within the school's curriculum. Recommendations for how practical experiences could have been enhanced were ensuring preservice teachers had a requirement to teach science and to develop science forward planning documents.

Approximately one year after the end of the unit, the in-depth interview participants were interviewed again as they approached the ends of their degrees (see Chapter 5, sub-sections 5.2.2 and 5.5.1). Most of these participants indicated strong science teaching efficacy beliefs despite varying science experience since completing the

science methods unit. This was tempered with a recognition that they still had a lot to learn about science, but they shared an enthusiasm and optimism to teach science in their first year. Only two participants expressed concern about their abilities to teach science. The participants anticipated that the biggest influence that would impact on their ability to teach science effectively would be their access to science resources.

7.1.3 Findings for Research Question 3: How, why and to what extent does the First Year of Teaching Influence Science Teaching Efficacy Beliefs?

Following up with the in-depth interview participants after the first year of teaching revealed that most still described a moderate to high science teaching efficacy and an interest in teaching science (See Chapter 6, section 6.1). This was despite obstacles that they had experienced in their first year of teaching. Some participants had not had any opportunity to teach science due to a science specialist teacher being employed in their school or only being employed in a relief capacity in a childcare centre that had no explicit focus on science in their programs. Only one participant described a low confidence to teach science, which was reflected in his overall teaching efficacy. This participant had resigned from his teaching position at the end of his first year.

It was evident by the responses from all participants that their science teaching was one element that they needed to negotiate in their significant development as early career teachers (See Chapter 6, section 6.2). The key aspects of their first year of teaching that were identified by participants as most influential on their perceptions of science were the support they experienced within the school. This support manifested in various ways including through leadership, assigned mentor teachers and general relationships between staff. When a lack of support existed, it contributed to participants feeling overwhelmed by their first year of teaching. Managing time and the availability of quality science resources was also discussed by some participants as contributing to their beliefs. Other influences shared by participants were responding to student needs, the school environment and personal uncertainty about teaching as a career.

7.1.4 Overall Findings for the Research Problem: How and Why do Science Teaching Efficacy Beliefs Change over Time from Preservice Teacher Education to First Year Teaching?

This study has shown that science teaching efficacy beliefs can change over time in the context of preservice teaching efficacy. The preservice teachers in this study began a science methods unit with low science teaching efficacy beliefs, findings which are consistent with previous research by McKinnon (2010) and Palmer (2006a). These beliefs improved by the conclusion of the unit, evident in both the quantitative and qualitative data, complementing previous studies by Menon and Sadler (2017), Bleicher (2007), and Brand and Wilkins (2007). For most of the in-depth participants, these improved science teaching efficacy beliefs persisted to the end of their degrees and were evident after their first year of teaching. This was despite varying experiences throughout the final year of their degrees and contexts of their employment.

The influences on these science teaching efficacy beliefs also changed over time, reflecting different stages of the development of preservice teachers. The lower science teaching efficacy beliefs at the beginning of the unit were reflective of negative experiences of science in high school, disengagement with science teachers, a lack of learning success and poor content knowledge. These findings are broadly in line with Swars and Dooley (2011), who identified that these experiences can hinder the healthy development of science teaching efficacy beliefs. For the participants with higher efficacy beliefs, this was connected to a strong interest in science and more positive science experiences, findings that are in harmony with Hechter (2011), Mansfield and Woods-McConney (2012) and Bleicher (2003).

Teacher preparation through tertiary study was instrumental in the sharp shift of science teaching efficacy beliefs for most of the participants. Aspects of the coursework that positively influenced the durability of these stronger science teaching efficacy beliefs included the hands-on nature and clear structure of units, assessment that allowed preservice teachers the opportunity to develop their content knowledge and teaching skills, modelling by the science teacher educator and improvement in the understanding of quality science resources. These findings are consistent with the

research of Palmer (2006b), Bleicher and Lindgren (2005) and Cooper et al. (2012). Practical experiences also contributed to the maintenance of these beliefs, and elements including opportunities to teach science within a supportive classroom environment and experiencing students engaged in science. However, a key theme to emerge in the research study was that these benefits of practical experiences were not consistently felt by participants, with several seeing no or limited science taught, observing poor quality lessons and having little encouragement from their cooperating teachers. Considering that most of the participants reported moderate to high science teaching efficacy at the end of their degrees, this finding seems to corroborate the study by Howitt (2007) which identified that in the absence of quality practical experiences, science methods units play a critical role in science teaching efficacy beliefs.

From the qualitative findings at the end of the participants' first year of teaching, the changes to the science teaching efficacy beliefs that were improved through the science methods unit were still evident for most of the participants. This seems to address questions in previous research by Menon and Sadler (2017) which questioned whether improvement to science teaching efficacy beliefs from a science methods unit could persist into the first year of teaching. In exploring how participants experienced the complexities in their early careers (Menon & Sadler, 2017), key influences were identified in the current study. Positive influences included high levels of encouragement and assistance from other staff, access to high quality resources and for some of the participants, engaged students. However, hindrances included time constraints and low support, which manifested as minimal guidance and assistance from other staff. Different contextual situations including employment in a childcare centres and science specialist teachers limited some of the participants' ability to teach science.

While it was evident that the influences on participants did change over time to reflect their current experiences, one critical aspect that was present throughout each point in the study was the influence of support. This was through the science teachers in primary and high school, the science teacher educator and cooperating teachers in university, and then school leadership and teaching colleagues in their early career. Support was not always perceived in a positive light, but this study provides insight

into specific attributes that enhance perceptions, as well as practical applications that are discussed further in the recommendations section of the chapter.

The current study has followed the trajectory of the participants' beliefs and provided contextual details for how their beliefs are influenced by and help to construct their own experiences. There has previously been a lack of research in this area in Australia (Klassen & Usher, 2010) which has been the context of the current study. The key strength of this study was that the research design allowed for more accurate and descriptive reasons for how participants' perspectives changed and to what extent this occurred and how various influences interplayed over time.

This study contributes to existing knowledge through the confirmation of the crucial role that science methods play in the development of science teaching efficacy beliefs. Well-designed science methods units can contribute to reversing negative perceptions of science from previous experiences. Once this perception has shifted, beliefs can become durable and resilient despite varying experiences of science through practical experience and into an individual's early teaching career. Different influences impact on these beliefs in different stages of preservice teacher development, enhancing the current understanding of the formation of science teaching efficacy beliefs in early childhood and primary preservice teachers.

7.2 Limitations of the Study

The analysis conducted by the researcher of this study has principally concentrated on how participants perceived their own science teaching efficacy and the meanings that the participants attributed to this. The findings of this study are therefore limited to the self-perceptions of the participants. The nature of the data does not allow for an external validation of the participants' actual science teaching capabilities or wider perceptions of the university and teaching context.

Due to the qualitative dominant design of the study, other limitations are evident. The unique structuring of school-based practical experience and science methods units at the university means that some of the findings may not be applicable to other preservice education programs in Australia. Similarly, this research is situated at only

one institution with a relatively small sample, therefore there may be difficulty generalising the findings of this particular study to other education programs.

7.3 Issues arising during the Study

Several issues did occur during the design and data collection of the study. A decision was made during the research design in relation to the points of the longitudinal study at which the STEBI-B would be administered. Logistical challenges of administering the questionnaire to the wider preservice cohort at the end of the degree was one significant concern. Additionally, the unfeasibility of administering it to such a large number of participants working in various schools and systems, led to the researcher deciding to only administer it at the beginning and end of the science methods unit. However, the study would have been strengthened by the administration of the STEBI-B at all interview points within the study.

A second key issue encountered within the study was the use of an alternate interviewer for the interviews at the end of the science methods unit. While this interviewer was sufficiently briefed about the purpose of the interview and supplied with the interview guide, there were occasions where the quality of the interview was influenced by the interviewer going off on a tangent about other units within the university degree. This limited the quality of the interviews but was resolved to an extent through the member checking that occurred following the actual interview.

The retention of participants was also a significant challenge in the current study, particularly at the point of the final interviews. This has previously been identified as an issue with longitudinal research (Cohen et al., 2011; White & Arzi, 2005). Although measures were put in place by the researcher to reduce the impact of this, personal circumstances of the in-depth interview participants could not have been foreseen. In the current study, the researcher maintains that this was compounded by the time management issues that are often experienced by early career teachers (Hudson, 2012).

7.4 Recommendations

Recommendations from this study are presented in two ways. Firstly, the researcher discusses recommendations for further research that have become evident from the findings from this study. Following this, practical recommendations for policy and practice are outlined.

7.4.1 Recommendations for Future Research

A finding of this study with this sample highlighted the negative perceptions of science through the formative years of high school and the lack of early childhood and primary preservice teachers engaging in science in Years 11 and 12. This is a worrying trend and supports previous research by Goodrum et al. (2011). Further research might examine targeted intervention, and approaches to improving student engagement and involvement in secondary science courses. From the perspective of this current study, these improvements may lead to stronger science teaching efficacy beliefs of preservice teachers and stronger science interest as preservice teachers begin tertiary science coursework.

The experiences of early childhood preservice teachers in this study indicate that more research is required in two different domains. Firstly, considerable more studies need to be undertaken to explore the impact of practical experiences in science in childcare centres. This work could investigate ways to more effectively support preservice teachers and staff of childcare centres during practical experiences. Secondly, the role of science within the early childhood curriculum is worthy of further research. This would be a fruitful area of research in that it would allow researchers to examine more closely the issues that early childhood educators face when implementing science in the curriculum.

Future trials investigating the impact of primary schools employing science specialist teachers would also be an interesting area for further research. The qualitative findings of this study indicate that this is influencing the role of science in primary classrooms. The tentative findings of this study suggest that science specialist teachers in primary school does not always lead to improved student engagement and learning and

removes the responsibility for science teaching from classroom teachers. Further research could examine whether this improves student outcomes and engagement, or whether this influences the science teaching efficacy beliefs of Australian classroom teachers in the long term.

This study has provided some insight into the experiences of early career teachers. Further research might usefully focus on investigating ways of most effectively supporting early career teachers to authentically integrate science into their classrooms.

7.4.2 Recommendations for Policy and Practice

Several key recommendations have emerged from the current study in relation to policy and practice. A key area for improvement is the necessity of incorporating science within practical experiences during preservice teacher preparation. Considering the importance of science for Australia's future (Office of the Chief Scientist, 2014), it is vital that all preservice early childhood and primary teachers are required to observe high-quality science teaching and learning and have an opportunity to teach it themselves. This needs to be considered at a national level in relation to AITSL policy but could still allow flexibility for universities to respond to their local contexts. However, if not added as criteria to AITSL policy, this recommendation needs to be investigated more closely at a university level.

Connected to this policy issue, is a further recommendation for stronger partnerships to be established between universities and schools. The reciprocity of such partnerships is beneficial to all stakeholders. Universities can establish science teaching expectations as part of their practical experience requirements and provide stronger support for cooperating teachers to assist them in working with preservice teachers. Universities can also provide ongoing professional development for inservice teachers to ensure that their science teaching is reflective of best practice. Schools can assist this partnership by identifying science teaching exemplars and taking preservice teachers for practical experiences in these classrooms. Schools can also allow university classes to observe or work with students in the area of science.

Several recommendations need to be considered for science teacher preparation. This study points to universities providing more opportunities to rectify science content concerns at tertiary level. Considering the low science teaching efficacy beliefs of preservice teachers presented in this study, this should ideally happen through targeted science content courses cognisant of the needs of preservice teachers, rather than through more general tertiary units. A further recommendation would be to increase the number of science methods units in teacher education degrees to assist preservice teachers to authentically integrate science into their early childhood and primary classrooms. Units should be developed that explore STEM integration, and enhance the confidence of preservice teachers to deliver meaningful and inspiring inquiry-based STEM experiences. Knowledge gained in such units can assist preservice teachers in managing the time pressures and an overcrowded curriculum in their early careers, as well as improve student engagement and learning.

7.5 Conclusion

My experiences as a researcher have been both invigorating and challenging. I have felt that I have experienced sharp shifts in my own knowledge and have overcome personal and professional hurdles to reach this point. The longitudinal nature of the research has been a blessing in my opinion, as it has allowed me to experience both gradual growth and sudden epiphanies, which I feel has strengthened the quality of the overall thesis.

My strongest reflection at the end of this journey is the honour I have felt to follow the in-depth participants in their formative years as developing teachers. It has been a true privilege to have their thoughts and opinions shared with me, and I am deeply appreciative of the wisdom that this has led me to. Their insights have guided me to critically reflect on my own practices as a science teacher educator, but also as a teacher and leader within the Australian education system.

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Appendices

Appendix 1

Primary Science Unit General Information

Delivery Mode	Internal		
Assumed Prior Knowledge /Special Skill Requirements	Students have prior experience with lesson planning.		
Pre-requisite Unit/s	Nil	Co-requisite Unit/s	Nil
Contact Hours per Week	Workshop: 2 hours per week		

Assessment Details

Item 1:	LESSON PRESENTATION	15%
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Students must choose a science topic or concept as listed on the last page of this outline and design an interactive lesson to teach the essential elements of that topic.

Expectations of the presentation:

- Students will work with a group of three (3). (It is each student's responsibility to ensure participants contribute equally as each student in the group will be awarded the same mark. Should unresolvable problems regarding workload distribution arise, dissatisfied group members should speak with their tutor **immediately**).
- Students must **teach** the lesson to their peers. This lesson **MUST** be an **Engage** or **Explore** lesson from the 5E's model.
- The lesson is to take 20-30 minutes and should involve all presenters equally.
- The lesson should be interactive and use hands-on materials.
- Lessons should incorporate collaborative learning principles, that is, strategies for working in pairs/ small groups should be demonstrated.
- Complete and copy for each participant a 1-2 page summary of the main points about the **concepts taught** in the lesson.

Please note: Students must produce the summary and provide sufficient photocopies for each person in the tutorial group on the day of the presentation.

Item 2:	SCIENCE PROGRAM OF WORK	45%
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Program of Work is due by 4:00pm on the Monday following your lesson presentation.

Each student must produce a program of work based around the science topic taught in the micro lesson.

The program of work must include the following components:

Part One: Rationale (500 words) (Weighted 10% out of a total 45%)

Students need to write a brief paper to address the following statement:

Describe why science is a required and necessary component of the curriculum in primary school.

The readings for Week 1 will be useful in beginning to frame your discussion.

The following components need to be included:

- Include a brief introduction about what the paper will discuss.
- Use paragraphs to organise the discussion.
- Conclude your paper appropriately.
- Headings and subheadings may be used.
- All sources need to be cited and referenced correctly. Please revise the APA Referencing Guide.
- Diagrams, charts, tables and graphs may be used to support the information that you include.

Part Two: Forward Planning Document (Weighted 35% out of a total 45%)

The following components need to be addressed:

- Year level clearly stated.
- Links to *The Australian Curriculum* (and *Early Years Framework* for ECE) need to be shown on the overview pages.
- A description of at five (5) possible lesson ideas (in a developmental sequence, which describe the introduction, body and concluding activity of the lessons).
- These lessons should follow the Engage, Explore, Explain, Elaborate and Evaluate phases as advocated in the *Primary Connections* inquiry model.
- Strategies to assist with extension/ students who experience difficulty need to be provided.
- Assessment techniques to match each of the lessons should be incorporated.
- Worksheets (to match lesson ideas) should be included **where necessary**.
- Ideas for integration- with three (3) other learning areas (may be shown on the integration concept map or on the actual FPD).
- Relevant health and safety considerations. This needs to be made explicit on the FPD.

Item 3:	FINAL INVIGILATED EXAMINATION	40%
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Section One:

Forty (40) multiple choice questions on science content presented in the unit. This will be based on the revision sheets that will be focused upon from Weeks 5 to 13 and will related to the science strands from the Australian Curriculum:

- Earth and Space Sciences
- Biological Sciences
- Chemical Sciences
- Physical Sciences

Section Two:

Written essay answers to three (3) questions. Some choice will be given and questions will be selected from the study questions provided for the majority of weekly readings. These questions relate to the key science pedagogical topics that are focused on in the unit, which are:

- The importance of finding out prior knowledge in science
- The 5E's
- Inquiry and investigative approaches
- The literacies of science
- Assessment in science
- Ethics and values in science
- Effective teaching in science
- Science and ICT

Unit Program

Please note: Readings need to be completed prior to the weekly workshop.

Week	TOPICS/ CONTENT/ LEARNING EXPERIENCES	
	Workshop Topics	Readings / Prior Preparation
1	<ul style="list-style-type: none">• Explanation of Unit Outline• Ascertaining beliefs about teaching and learning science• Discussion of the science learning area and its role in the ECE/ primary school curriculum• Overview of science and its role in the society <i>AITSL Standard 6</i>	<p>WEEK 1 Readings</p> <ul style="list-style-type: none">○ Westwell, M., & Panizzon, D. (2012). Becoming explorers of our world: the purpose of science education. In Gregson, R. (ed.). <i>Connecting with Science Education</i>. Victoria: Oxford University Press, Ch. 1.○ School Curriculum and Standards Authority. (2013). <i>The Western Australian Curriculum- Science</i>. Retrieved from http://wacurriculum.scsa.wa.edu.au/Science/Rationale○ Ferrari, J. (2010). Children can't get enough science lessons. <i>The Australian</i>. Retrieved from http://www.theaustralian.com.au/national-affairs/children-can't-get-enough-science-lessons <p>ECE STUDENTS</p> <ul style="list-style-type: none">○ Worth, K. (2010). <i>Science in Early Childhood Classrooms: Content and Process</i>. Paper presented at STEM in Early Childhood Education and Development Conference. <p>PRIMARY STUDENTS</p> <ul style="list-style-type: none">○ Aubusson, P. (2011). An Australian science curriculum:

		competition, advances and retreats. <i>Australian Journal of Education</i> 55(3), 229-244.
2	<ul style="list-style-type: none"> • An introduction to constructivist approaches to science education • Exploration of the importance of prior knowledge and its role in primary science • Introduction to the Primary Connections science teaching and learning program <i>AITSL Standards 1, 2 and 6</i> 	<p style="text-align: center;">WEEK 2 Readings</p> <ul style="list-style-type: none"> ○ Keeley, P. (2012). Misunderstanding misconceptions. <i>Science Scope</i> 35(8), 12-15. ○ Keeley, P. (2013). When is the next full moon? Using K-2 concept cartoons. <i>Science and Children</i> 51(1), 32-34. ○ Santos, J., & Centurio, T. (2012). Mystery box marvel. <i>Science and Children</i> 49(10), 38-43. ○ Loxley, P., Dawes, L., Nicholls, L., & Dore, B. (2014). <i>Teaching Primary Science: Promoting Enjoyment and Developing Understanding</i>. New York: Routledge, pp.13-20, 41-47.
3	<ul style="list-style-type: none"> • An introduction to the 5E's instructional approach • Exploration of forward planning in science using the Australian Curriculum: Science and the Early Years Learning Framework (ECE students). <i>AITSL Standards 1, 2 and 6</i> 	<p style="text-align: center;">WEEK 3 Readings</p> <ul style="list-style-type: none"> ○ Ansberry, K., & Morgan, E. (2010). <i>Picture- Perfect Science Lessons</i>. Arlington, USA: National Science Teachers Association, Ch. 4. <p>ECE STUDENTS</p> <ul style="list-style-type: none"> ○ Nolan, A. (2012). Science in the national Early Years Learning Framework. In Campbell, C., & Jobling, W. (eds.). <i>Connecting with Science Education</i>. Victoria: Cambridge University Press, Ch. 1. <p>PRIMARY STUDENTS</p> <ul style="list-style-type: none"> ○ Hudson, P. (2013). Learning to teach primary science. In Hudson, P. (ed.). <i>Learning to Teach in the Primary School</i>. Victoria: Cambridge University Press, Ch. 8. <p style="text-align: center;"><i>Please bring a device to class- Australian Curriculum app.</i></p>
4	<ul style="list-style-type: none"> • Exploration of what it means to 'think and work scientifically' • Examination of inquiry and investigative approaches to science, and the link to science inquiry skills in the Australian Curriculum: Science 	<p style="text-align: center;">WEEK 4 Readings</p> <ul style="list-style-type: none"> ○ Feasey, R. (2012). Thinking and working scientifically. In Skamp, K. (ed.) <i>Teaching primary science constructively</i>. Victoria: Cengage Learning Australia, 61-77. <p>ECE STUDENTS</p>

	<i>AITSL Standards 1, 2 and 6</i>	<ul style="list-style-type: none"> ○ Aitken, J., Hunt, J., Roy, E., & Sajfar, B. (2012). <i>A Sense of Wonder: Science in Early Childhood Education</i>. Victoria: Teaching Solutions, Ch. 3.
5	<ul style="list-style-type: none"> ● Explanation of the concepts of ‘scientific literacy’ and ‘literacy products in science’. ● Examination of literacy strategies relevant to ECE or Primary Science ● Biological Sciences focus- <ul style="list-style-type: none"> ○ What makes something alive?- living/ not living/ never living. ○ Needs of living things ○ Classification- why is it important? <p><i>AITSL Standards 1 and 2</i></p>	<p style="text-align: center;">WEEK 5 Readings</p> <ul style="list-style-type: none"> ○ Prain, V. (2007). Learning the literacies of science. In Dawson, V., & Venville, G. (eds.). <i>The art of teaching primary science</i>. NSW: Allen and Unwin, Ch. 10.
6	<p style="text-align: center;"><u>EXCURSION- SCITECH</u> City West, Sutherland St West Perth Excursion is for 1 hour <i>AITSL Standard 6</i></p>	<p>Details will be provided in the first few workshops. An independent reflection about the Scitech excursion needs to be completed prior to the Week 7 workshop</p>
7	<ul style="list-style-type: none"> ● Lesson presentation ● Feedback and discussion of Scitech excursion ● Discussion of the role of assessment in a constructivist science classroom ● Identification of assessment methods relevant to science ● Biological Sciences focus- <ul style="list-style-type: none"> ○ Flowers and fruits- role in pollination ○ Food chains as simple feeding relationships <p><i>AITSL Standards 1, 2 and 3</i></p>	<p style="text-align: center;">WEEK 7 Readings</p> <ul style="list-style-type: none"> ○ Koch, J. (2010). <i>Science stories: science methods for elementary and middle school teachers</i> (4th ed.). Canada: Wadsworth Cengage Learning, Ch. 13. ○ School Curriculum and Standards Authority (2013). <i>Assessment principles and practice</i>. Retrieved from http://k-10_outline.scsa.wa.edu.au/assessment_principles_and_practice
8	<ul style="list-style-type: none"> ● Lesson presentation ● Revision of the <i>Primary Connections</i> collaborative learning approach ● Discussion of examples and challenges when using collaborative approaches ● Chemical Sciences focus- <ul style="list-style-type: none"> ○ Characteristics of solids, liquids and gases 	

	<i>AITSL Standards 1, 2 and 3</i>	
9	<ul style="list-style-type: none"> • Lesson presentation • Exploration of ‘science as a human endeavour’- the ethics and values inherent in science • Chemical Sciences focus- <ul style="list-style-type: none"> • Materials and their properties • Physical and chemical changes- evidence in everyday life <p><i>AITSL Standards 1, 2 and 3</i></p>	<p style="text-align: center;">WEEK 9 Readings</p> <ul style="list-style-type: none"> ○ Reiss, M. (2008). Science and ethics. <i>Primary science 103</i>, 4-8. ○ Australian Curriculum and Reporting Authority. (2012). <i>Ethical Understanding</i>. Retrieved from http://www.australiancurriculum.edu.au/GeneralCapabilities/Pdf/Ethical-understanding
	University Break	
10	<ul style="list-style-type: none"> • Lesson presentation • Discussion of health and safety issues relevant to ECE and Primary science • Earth and Space Sciences focus <ul style="list-style-type: none"> • Composition of the earth (Guest presenter- Earth Science WA) <p><i>AITSL Standards 1, 2 and 3</i></p>	<p style="text-align: center;">WEEK 10 Readings</p> <ul style="list-style-type: none"> ○ Skamp, K. (2012). Thinking and working scientifically. In Skamp, K. (ed.) <i>Teaching primary science constructively</i>. Victoria: Cengage Learning Australia, 388-390.
11	<ul style="list-style-type: none"> • Lesson presentation • Exploration of effective teaching skills and approaches in science • Earth and Space Sciences focus- <ul style="list-style-type: none"> • Day and night- the earth, moon and sun • Our solar system <p><i>AITSL Standards 1, 2 and 3</i></p>	<p style="text-align: center;">WEEK 11 Readings</p> <ul style="list-style-type: none"> ○ Fitzgerald, A., Dawson, V., & Hackling, M. (2009). Perceptions and pedagogy: exploring the beliefs and practices of an effective primary science teacher. <i>Teaching Science 55(3)</i>, 19-22. <p><i>Note: Evaluations for the unit will take place in Week 11</i></p>
12	<ul style="list-style-type: none"> • Lesson presentation • Examination of the role of digital literacy in science • Exploration of useful apps and websites • Physical Sciences focus- <ul style="list-style-type: none"> ○ Static electricity ○ Potential and kinetic energy <p><i>AITSL Standards 1, 2 and 3</i></p>	<p style="text-align: center;">WEEK 12 Readings</p> <ul style="list-style-type: none"> ○ Ng, W. (2011). Why digital literacy is important for science teaching and learning. <i>Teaching Science 57(4)</i>, 26-32.
13	<ul style="list-style-type: none"> • Lesson presentation • Exam preparation and revision • Physical Sciences focus- <ul style="list-style-type: none"> ○ Magnets ○ Current electricity 	

	<i>AITSL Standards 1, 2 and 3</i>	
	Study Week	
	EXAM WEEK 1	
	EXAM WEEK 2	

Appendix 2

Semi-Structured Interview Question Guide

Kvale and Brinkmann (2009) state, “the research interview is an interpersonal situation, a conversation between two partners about a theme of mutual interest” (p. 123). The interviews used in this research will be semi-structured and will therefore use a guide with an outline of topics that will be covered as well as suggested questions for each stage of the interview process (Kvale & Brinkmann, 2009). However, the researcher will use different strategies to further elicit information from the participants. These include, but are not limited to, the following: pausing; nodding; using probing questions, such as ‘can you tell me more about that?’ or ‘can you give me more detailed description of what happened?’ and seeking clarification about what the participants meant in their specific response (Kvale & Brinkmann, 2009).

Interview 1- August 2013

Interview Briefing

Thank you for your willingness to participate and be interviewed here. I am conducting a longitudinal study of the self-efficacy of pre-service teachers in teaching and learning about science. I am interested in finding out some of the factors that might influence this as well as your experience with science on your 3rd year practicum. It will take approximately 45 minutes and be audio recorded. Do you have any questions?

Suggested Interview Questions

1. What does it mean to learn science effectively?
2. What do you think an effective ‘learner’ in science does?
3. What are the different roles that the science learner may take?
4. Can you tell me about your experience of science when you were at primary or high school?
5. Could you describe for me in as much detail as possible a memorable science experience from primary or high school?

6. Can you identify for me what you think are the most important factors that impacted on your learning of science at primary or high school?
7. Tell me about your experiences of science teachers in primary or high school.
8. How would you describe your overall feelings about science?
9. What do you think have been the most significant factors that have impacted on your feelings towards teaching science?
10. Did you complete the unit 'Environmental Science and Technology'? Could you tell me about your experience of this unit?
11. Have you experienced any changes in your feelings about science from primary school to high school and now university? If so, can you explain this?
12. Can you tell me about your experience of science when you completing your practical experiences?
13. How would you describe your mentor/ supervising teacher's perception of science and its role in the classroom?
14. How would you describe the importance of science in the curriculum in the class/school?
15. Could you describe in as much detail as possible any topics or strategies that were used in the class that you found interesting?
16. How did the students respond to science lessons in your class?
17. How would you describe your role in teaching science during this practical experience?
18. If you have taught science, how consistent is what you said earlier about how we learn science, with how you think about learning when you are actually teaching science?
19. How would you describe your feelings about completing your practical experience and returning to your coursework?

Interview Debriefing

Thank you again for participating. Do you have anything more that you wish to say?
Can you tell me about your experience of the interview?

Interview 2- November 2013

Interview Briefing

Thank you for your willingness to participate and be interviewed here. I am conducting a longitudinal study of the self-efficacy of pre-service teachers in teaching and learning about science, and I am interested in finding out your perceptions of science as a result of the unit ED 3221/4221 Primary Science. It will take approximately 45 minutes and be audio recorded. Do you have any questions?

Suggested Interview Questions

1. Can you tell me about your experience of science in the unit ED 3221/4221 Primary Science?
2. Do you remember any significant learning experiences during this unit that has resonated with you for a particular reason? If so, can you describe this?
3. Can you describe which activities or tasks most contributed to your own learning of science?
4. (Referring to the work products brought in)- Can you describe which activities or tasks least contributed to your own learning of science?
5. How did the assessment tasks impact on your feelings and/or perceptions of science?
6. If you were placed in a classroom tomorrow, how would you rate your confidence to teach a science unit to primary students? Can you explain this?
7. How would you now rate your skills of teaching science to primary students?
8. Can you tell me about any areas or skills that you feel you would still need to develop in order to teach science effectively?
9. How did the unit activities influence your perceptions of science as part of the curriculum in primary school?
10. Have your perceptions about teaching science in primary school changed in any way? If so, can you describe this in more detail?
11. Have your perceptions of science learning changed in any way since the unit began?
12. Can you think of any factors that will impact on whether you can teach science effectively on your final internship?

13. Can you think of any other ways in which this unit could cater more effectively to third year students to better prepare them to teach science?

Interview Debriefing

Thank you again for participating. Do you have anything more that you wish to say?
Can you tell me about your experience of the interview?

Interview 3- October 2014

Interview Briefing

Thank you for your willingness to participate and be interviewed here. I am conducting a longitudinal study of the self-efficacy of pre-service teachers in teaching and learning about science, and I am interested in finding out your experience of teaching science during your final practical experience. It will take approximately 45 minutes and be audio recorded. Do you have any questions?

Suggested Interview Questions

1. Can you tell me about your experience of science when you completing your final practical experience?
2. Do you have any examples of science teaching and learning from your teaching that you would like to share and discuss? Please explain these.
3. Were you able to draw upon any of the ideas, skills or resources presented to you in ED 3221/4221 Primary Science?
4. How would you describe your mentor/ supervising teacher's perception of science and its role in the classroom?
5. How would you describe the importance of science in the curriculum in the class/school where you were on prac?
6. Could you describe in as much detail as possible any topics or strategies that were used in the class that you found interesting?
7. How would you describe your role in teaching science during this practical experience?
8. How did the students respond to science lessons in your class?
9. If you were able to complete this prac again, would you do anything differently in relation to the teaching of science?

10. How would you now rate your skills of teaching science to primary students?
11. Have your perceptions about teaching science in primary school changed in any way? If so, can you describe this in more detail?
12. Did you observe anything on your prac that impacted or impeded the teaching and learning program for science? If so, can you describe this?
13. Can you think of any factors that may impact on whether you can teach science effectively in your first year of employment?
14. In looking back over your university experience, is there anything that could be added or modified to the Early Childhood/ Primary degree in order to assist you to become an effective teacher of science? If so, can you describe this in more detail?
15. How would you describe your feelings about teaching science when you begin your first year of employment?

Interview Debriefing

Thank you again for participating. Do you have anything more that you wish to say? Can you tell me about your experience of the interview?

Interview 4- January 2016

Interview Briefing

Thank you for your willingness to participate and be interviewed here. I am conducting a longitudinal study of the self-efficacy of pre-service teachers in teaching and learning about science, and I am interested in finding out your experience of teaching science during your first year of employment. It will take approximately 45 minutes and be audio recorded. Do you have any questions?

Suggested Interview Questions

1. Can you tell me about your experience of your first year of teaching?
2. How would you describe your experience of teaching science this year?
3. Do you have any examples of science teaching and learning from your teaching that you would like to share and discuss? Please explain these.
4. How would you describe the importance of science in the curriculum in the class/school that you are working in?

5. Could you describe in as much detail as possible any topics or strategies that you have used in the class that you enjoyed or produced interesting results?
6. How have the students responded to science lessons in your class?
7. Do you feel motivated to teach science regularly with your class?
8. How would you describe your success in teaching science in your first year of teaching?
9. Have you experienced any challenges when teaching science?
10. How would you now rate your skills of teaching science to primary students?
11. Have you observed or experienced anything in your first year of teaching that has impacted or impeded the teaching and learning program for science? If so, can you describe this?
12. Have your perceptions about teaching science in primary school changed in any way? If so, can you describe this in more detail?
13. How would you describe your feelings about teaching science for the rest of the year?
14. In looking back over your university experience after 6 months of employment, is there anything that could be added or modified to the Early Childhood/ Primary degree in order to assist you to become a more effective teacher of science? If so, can you describe this in more detail?

Interview Debriefing

Thank you again for participating. Do you have anything more that you wish to say? Can you tell me about your experience of the interview?

Appendix 3

Example Transcript

August 2013 interview transcription

(I: Interviewer P: Sarah)

- I: Sarah, thank you for your willingness to participate and be interviewed here. I'm conducting a longitudinal study of the self-efficacy of the pre-service teachers in teaching and learning about science. I'm interested in finding out about some of the factors that might influence this, as well as your experiences of science on your third year practicum. It will take approximately 45 minutes and be audio recorded. Do you have any questions?
- P: Nope.
- I: Okay. What do you think it means to learn science effectively? What do you think an effective learner in science does?
- P: They're constantly like hands on interactive with what they're learning about and yeah, they're very inquisitive and they have that ability to be inquisitive. It's not just fed to them, like. They have to be able to ask questions and explore it for themselves and not just be spoon fed the answers and just go along with the flow. Like, there's no engagement. Yeah.
- I: What do you think the different roles the science learner might take in a classroom? What are some of the different things they'll do?
- P: I'm thinking primary science.
- I: No, good. That's fine.
- P: So, your director, your speaker and your manager. They're just your primary science roles obviously, and then like you can also have, now I can't think of the word. Yeah, that's it. I can't think of the word. I've gone blank.
- I: Could you tell me about your experiences of science when you were at primary or high school?
- P: From where I remember in primary school, it was all right, but high school was just terrible. The teacher, like, she did try and she was really nice and everything, but there was no enthusiasm behind it. It was just like that was what she had been given. She was the head of science, so it was just something for her. More recently, human bio, I took as a TE unit in high school.
- I: Yep.

- P: First year was good. Year 11 was really good, because the teacher was really good, and we did a lot of hands on stuff like dissections and lots of, we did a couple of excursions when they did like human body exhibits at the museum and stuff.
- I: Yep.
- P: And then she left, and we had another lady come in and she was also really good, but she was leaving too because she was pregnant, but she didn't have much control over the class. That's where it started to go a bit downhill, and then the last year, year 12 we had a lovely lady but she was foreign, so she was hard to understand and again, she was a pushover too, so there was no control, and it was just pretty much an hour to sit there and do bookwork. We did a couple of like experiments with Bunsen burners and flowers and stuff like that, and yeah the only good thing I remember from that unit was dissecting a rat in year 12, so. Other than that, it was pretty poor.
- I: So when you said primary school was good, what sort of things do you remember there?
- P: I remember we did a lot of outside stuff, and [0:03:26.7] we did a volcano unit.
- I: Yep.
- P: And the teacher actually like gave us the project. We had to make our own volcano at home, bring it in and we had to come up with different ways to make it explode, besides the bicarb one.
- I: Yeah.
- P: And yeah, she like crossed over into all this different, like we did an English thing about volcanoes, did an art, well kind of a TE part of it was making and then the art side of it as well. All of it, like everything was surrounded about the topic, so there was always questions being asked no matter what, and it was all relatable, like.
- I: Yep.
- P: We did one with balloons as well. I think it was a helium or gas one, or that might have been year eight.
- I: So when you said high school was terrible, what was it that made it terrible?
- P: There was just no follow up. Like, I really did find human bio like interesting. It was really good, but once the teacher that was engaging left, it was gone. Like, there was no, yeah, there was just no follow up. The teacher didn't seem to really care and when you generally wanted help, you couldn't get it because there was too many other factors going on in the classroom

where they had to tend to the needs of others, because I did go to a pretty rough high school, so there was a lot of trouble in the class.

I: So behaviour management sort of impacted on learning?

P: Yeah. And then, by the time it got to exam time, it was just hectic and yeah, you just couldn't retain information because you hadn't done it for the whole term.

I: Yeah. Could you, how do you think your own experiences match up with what you said about an effective science learner? Do you think your experiences have allowed you to become a successful science learner?

P: I think they did, and then it just stopped because I lost interest.

I: Yep.

P: And then once I started doing uni, I kind of felt a bit behind because I hadn't had the same experience, so when I went out on prac, I didn't think I was equipped because I didn't have the same kind of effective learning that I'd wanted, and didn't know if I could pass it on. Just be like one of those without making it sound so bleak, like one of those subjects I would have to teach and that.

I: Yep, yep. Do you have a memorable science experience from primary or high school that really just like, something you will never forget?

P: I was being a bit naughty. We were dissecting a cow heart and I got my finger stuck in the aorta, and I was just swinging this heart around on my finger and it flicked off and hit my friend in the face. Yeah.

I: So you remember it well for the social side.

P: Yeah, yeah, but then when we actually stopped stuffing around and cut it open, and then we watched a video on a heart transplant, that was pretty cool.

I: Yeah. So you actually remember it was a good learning experience?

P: Yeah.

I: Yep. Can you tell me what you think are the most important factors that impacted on your learning of science at primary or high school?

P: Definitely the teacher.

I: Yep.

P: Because we, you change teachers mostly every year in high school. So, when I had a different teacher engaging with the content, that, my participation would change, would go up or down and my interest would peak. I think,

like we've had in class talking about topics that engage the students like learning about flowers and their anatomy didn't interest me at all, so I switched off completely. But, then when it got to the stuff like the human body and like world science, then like biological sciences, then yeah.

I: It was something that actually really engaged you?

P: Yeah, because there was a lot, there wasn't just one thing that you had to do. There was many factors to it, and you could just go on and on and on for days about it, so.

I: Yep. When you, your experiences of science teachers you've spoken about that you've had, so quite a variety. As a result of all this, how would you describe your overall feelings about science?

P: Mixed.

I: Yep.

P: My prac teacher actually changed it for me, because he was the head of science, and Brian was brilliant. Like so much passion for the sciences and always trying to get the kids involved and every science experiment we did was hands on. There was no, I mean they did do a lot of write up, but they did so many experiments, I just lost count how many they were doing, and it was all related to one topic, like we did climate and oil spills, so they had to do an experiment where they had a piece of grass. They had to cut the grass and pour different chemicals on it and then keep pouring it on there, and test it and stuff like that.

So he made me feel a bit more confident in teaching science when I did do the science lessons, but other than that, I don't yeah. I'm a bit unsure about it still.

I: Yeah. What do you think would have been the most significant factors that have impacted on your feelings towards science?

P: Again, the teacher.

I: So your school experience?

P: Yeah.

I: Would be the most significant?

P: Yeah, because they've just carried, stuck with me for so long, because it's been so bad.

I: Yep. Did you complete the unit environmental science and technology?

P: Yep, with Rae.

I: Could you tell about your experience of this unit?

P: It was first year.

I: It was your first year?

P: Yeah. It was all right. She, but the content was good and it was useful, and Rae was, like she was very passionate about what she was talking about. I think being in the first year, and that was my first real contact with science since I left school, I was a bit unsure about it, so yeah.

I: So you probably didn't get much out of it as you could if it had been later?

P: Not as much as I would have wanted to, and I'm pretty sure I took it in second semester as well, so going out on to prac, I didn't get to use any of it.

I: No, it wasn't selected.

P: No, which is a shame because it was really relatable to what I did in second year prac, so.

I: Yep, yep. Have you experienced any changes in your feelings about science from primary to high school and now university? If you sort of had to like describe that, what would you say?

P: Good, bad, good.

I: Yeah. So, you feel like it's been a bit of a.

P: Yeah, so it's definitely gone up and down.

I: Yep.

P: And it did peak a bit in high school again, and then just dropped and then came back up once I started doing science again in uni.

I: Yep. Can you tell me about your experiences of science when completing your practical experience? Was that the most, the good experience that you're talking about, was that your most recent prac?

P: Yeah, this is third year prac. Yeah.

I: Yep.

P: Yeah. I was so thankful that I had him as my teacher, because he was just so knowledgeable about everything to do with the science aspect.

I: Yep.

- P: And, you know, just didn't want to leave any, like we had a couple of ESL kids and I had an autistic kid, and I wouldn't necessarily call him disabled, but he was.
- I: Developmental things?
- P: Yeah, yeah. It was very low self-esteem. Didn't have very many social skills, and his whole goal was to not leave any of them out, and in one experiment that I did with him, we actually put them all in the one group and they were the best group. They worked so hard, they did the experiment correct. Like the autistic kid, there was one part of the experiment where we had to pour an oil mixture of gravy and vegetable oil on top of this water, and he poured it so perfectly that there was just like this film and everything that they dipped in there to weigh the oil change in it, it was just perfect, and they were all just so like, it was just great.
- I: What about in comparison to your second year prac? Did you see science being taught then?
- P: Not as much.
- I: No.
- P: My second year teacher, it was more, they were doing the human body and they pretty much watched a video on their website for kids, and then wrote about it.
- I: So there wasn't a huge amount of learning going on there.
- P: No, there wasn't a lot of experiments, I don't think I saw one experiment done at all in the ten weeks.
- I: Yeah, yep.
- P: It was mainly just, yeah write up or turn this into a cartoon strip.
- I: Yep. So using more literacy based strategies perhaps.
- P: Yeah, and that class didn't need the literacy, but there was just, yeah there was no hands on at all, and it was kind of, it was done at the very end of the day on a Wednesday, so the kids were tired.
- I: Yeah.
- P: So it was kind of just to fill in.
- I: Yeah. How would you describe your mentor or supervising teachers' perception of science and its role in the classroom, of your most recent prac?
- P: His was very high.

- I: Yep.
- P: Especially because at the school I was at, they had the Head of Education come out.
- I: [name suggested]
- P: No, the guy. The Minister for Education.
- I: Oh, okay.
- P: He came out because they were launching a new program with CITEC, so he was coordinating the whole thing, so he didn't want to just hand over or introduce this program into the school without testing out with the kids first, so him and two of the PAC classes that was at the school, they all took experiments out of the book and tested it, and collaborated. There was a lot of collaborative learning going on, and yeah, the whole idea of the program was to get them all engaged. All the kids, and that's what they were. They were all engaged, so.
- I: So he obviously rated its importance in the curriculum?
- P: Oh yeah, and we did science maybe three times a week.
- I: Yep, okay. Therefore would you be able to make a judgment on the importance of science in the curriculum of the whole school?
- P: The whole school was behind it. I had the principal and the deputies come out a number of times into the classroom when it was being taught to watch how it was getting done.
- I: Yep.
- P: Because the schools are all in that cross-over period with the Australian curriculum and stuff like that. They wanted to make sure like that it was getting taught properly and they had all the teachers doing, I wish I'd brought it with me, they had term planners and that broke down what they had to teach out of the curriculum and then the principal would come around and check and make sure it was getting taught, and getting taught correctly.
- I: Wow.
- P: And that was for every subject. It wasn't just science. So, they, yeah.
- I: So they were really doing a follow up and that sort of thing to make sure they were doing it.
- P: Yeah, yeah and checking all the assessments that they were getting done on science as well, making sure that all the kids were getting a fair go and coming up and watching them. Making sure everyone was engaged.

- I: Oh, that's wonderful.
- P: Yeah.
- I: Could you describe in as much detail as possible any topics or strategies that were used in the class that you really found interesting?
- P: In regards to teaching science?
- I: Yeah.
- P: They did use the primary science.
- I: The primary connections?
- P: Yeah, the primary connections, yeah. I used the director, speaker, manager cards a couple of times and he had the explanation of what they were up around the classroom in numerous places.
- I: Yeah.
- P: They also had a couple of, he had quite a few sites, posters on strategies like, "What do you think, how do you feel, what does it look like, what does it smell like". All that kind of stuff around the class. Lots of group work, small groups. I think there was no more than four if we could help it.
- I: Yep.
- P: Everyone had their role over and had their place.
- I: And you did the topic of oil slicks? Like that sounds so fascinating.
- P: Yeah. I can't remember what, it was. Yeah, oil slicks and then they did a Pacific garbage patch and how they had to create and they had to think about how they could create a machine to clean up the rubbish in the ocean. So they were drawing these massive pictures of, one kid had a vacuum. It looked like an elephant. It had a vacuum like thing coming out the side, and then this big scoop on the back and then inside it was a big like, it just broke everything down, it was crushing things, and yeah.
- I: How do the students respond to science lessons in your class?
- P: I distinctly remember them begging to do one of the experiments because it was laying around in the back. They had to keep the experiments inside in the classroom, so that was the first thing they would see in the morning. So it was like, "When are we doing science today, when are we doing science today. Can we go and check on our experiments, can we do it". So, I think he'd engrained into them early that science is important and they really like, he always, this was a very chatty class anyway. They liked to talk so, they

were always asking questions and he was always letting them answer them so.

I: Yeah, yeah. And your role in teaching science during this practical experience? What was that?

P: I pretty much followed his plan that he had for that program, so I did do a couple of the lessons and then I did a lot of procedure, like how to write the procedures properly and stuff like that with them as well, and that ran over into English lessons, and making sure they were getting the structure right. And then we did a couple of question, them asking me questions kind of thing.

I: Yes.

P: About the topic they were doing, so and then in one they had to, they were talking about the BP oil spill, so I was on the computer showing them photos of the animals that were affected, and they were just sitting there just in shock, so I was more there for shock factor in some ways as well.

I: Yeah, yeah, but it sounds like quite a collaborative effort between you and your mentor teacher.

P: Yeah, he didn't want to leave me out.

I: No.

P: I don't want to be left out. I wanted to be as involved as I could, so.

I: That's brilliant. If you taught science, which you have, how consistent is what you said earlier about how we learn science, so you spoke about lots of characteristics of effective learning of science with how you think about learning when you're actually teaching it. Do you think they're compatible?

P: Yes.

I: Yep.

P: I'm not sure if I think about it too much as I'm doing it. Like, I know I still forget some things. In one of the lessons, I don't think I actually let them get as hands on as they should have gotten, only because it just took so long with the write up and everything that we just ran out of time. I think also there was one day where I just, I hit a brick wall, so my enthusiasm had just dropped and I could see it in the kids as well. They were just bored out of their brains, so I think, yeah definitely the whole teacher influence affects it, and the fact that they'd done this topic, there was still so much to learn but they felt like they were repeating themselves a little bit, and I felt like that too.

- I: Yeah, yep. So you could pick up when you were sort of not allowing them to ask questions and move on. Instead, you were sort of caught in the back.
- P: Yeah, and if you'd met the kids you would understand, like they were very inquisitive, but also liked to question every single thing that came out of your mouth, so. There was points where you just had to say, "No, no we have to move on now".
- I: Yeah. Yep.
- P: As much as I want to sit here with you for another two hours and talk about what you want to know, I can't.
- I: Yeah, yeah. So they sound quite eager, but it could also get out of hand.
- P: Definitely. Yep, definitely.
- I: Yeah. How would you describe your feelings about completing your practical experience and returning to uni?
- P: Now?
- I: Yes.
- P: I didn't want to come back. I wanted to stay at school.
- I: Yep.
- P: Just because the school was just fantastic and they pretty much, without tooting my horn, the deputy pretty much said if I walked into the school tomorrow, I could get a job. So that just gave me like the whole confidence, I don't want to go back to uni, I can do this.
- I: Yeah, yep.
- P: Definitely a shock how much work I did on prac coming back into uni and it still feels like I haven't done a lot. Yeah, just, I've had, I've been very lucky with all my prac experiences, but this one was just something else, so I didn't want to come back.
- I: You wanted to keep going. Yep.
- P: Yeah. I haven't had a chance to go back to the school yet, either so kind of, I just, I know if I go back I will be like I don't want to go back to uni again.
- I: Yep. You need time to sort of catch up with everything.
- P: Yep.

I: Sarah, thank you so much for assisting with this study. Do you have anything more that you'd like to say?

[end of recording]

Appendix 4

Science Teaching Efficacy Belief Instrument- Form B (STEBI-B)

Figure C

STEBI FORM B (Final Instrument)

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.

SA - STRONGLY AGREE
A - AGREE
UN - UNCERTAIN
D - DISAGREE
SD - STRONGLY DISAGREE

- | | |
|---|--------------|
| 1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort. | SA A UN D SD |
| 2. I will continually find better ways to teach science. | SA A UN D SD |
| 3. Even if I try very hard, I will not teach science as well as I will most subjects. | SA A UN D SD |
| 4. When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach. | SA A UN D SD |
| 5. I know the steps necessary to teach science concepts effectively. | SA A UN D SD |
| 6. I will not be very effective in monitoring science experiments. | SA A UN D SD |
| 7. If students are underachieving in science, it is most likely due to ineffective science teaching. | SA A UN D SD |
| 8. I will generally teach science ineffectively. | SA A UN D SD |
| 9. The inadequacy of a student's science background can be overcome by good teaching. | SA A UN D SD |
| 10. The low science achievement of some students cannot generally be blamed on their teachers. | SA A UN D SD |
| 11. When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher. | SA A UN D SD |
| 12. I understand science concepts well enough to be effective in teaching elementary science. | SA A UN D SD |
| 13. Increased effort in science teaching produces little change in some students' science achievement. | SA A UN D SD |

14. The teacher is generally responsible for the achievement of students in science. SA A UN D SD
15. Students' achievement in science is directly related to their teacher's effectiveness in science teaching. SA A UN D SD
16. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher. SA A UN D SD
17. I will find it difficult to explain to students why science experiments work. SA A UN D SD
18. I will typically be able to answer students' science questions. SA A UN D SD
19. I wonder if I will have the necessary skills to teach science. SA A UN D SD
20. Given a choice, I will not invite the principal to evaluate my science teaching. SA A UN D SD
21. When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand it better. SA A UN D SD
22. When teaching science, I will usually welcome student questions. SA A UN D SD
23. I do not know what to do to turn students on to science. SA A UN D SD

Appendix 5

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License Number	4385040336939
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Licensed Content Title	Further Development of an Elementary Science Teaching Efficacy Belief Instrument: A Preservice Elementary Scale
Licensed Content Author	Larry G. Enochs,Iris M. Riggs
Licensed Content Date	Mar 17, 2010
Licensed Content Pages	13
Type of use	Dissertation/Thesis
Requestor type	University/Academic
Format	Electronic
Portion	Text extract
Number of Pages	2
Will you be translating?	No
Title of your thesis / dissertation	A Longitudinal Study of Preservice Teachers and their Efficacy Beliefs about Teaching and Learning Science.
Expected completion date	Jul 2018
Expected size (number of pages)	253
Attachment	DCFACCEB-5C7C-4649-A132-7E449DE2F22E.jpeg
Publisher Tax ID	EU826007151
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Appendix 6

Information Sheet- STEBI-B



**Curtin University of Technology
Science and Mathematics Education Centre**

PARTICIPANT INFORMATION SHEET

**Project- A Longitudinal Study of Preservice Teachers and their Beliefs about
Teaching and Learning Science**

My name is Jacinta Petersen and I am a staff member with the School of Education at The University of Notre Dame. I am currently completing a piece of research for my Doctor of Science Education at Curtin University of Technology. I am also the unit coordinator for ED 3221/4221 Primary Science.

Purpose of Research

I am investigating how preservice teacher's self-efficacy in teaching science is influenced by coursework and practical experience, and how this impacts on teachers as they begin their first year of teaching.

Your Role

I am interested in finding out how individual students perceive their own self-efficacy in teaching science. I will ask you to complete a questionnaire called the 'Science Teaching Efficacy Belief Instrument' (STEBI-B) during class time on 2 occasions. I am hoping that most of the cohort of 3rd year early childhood and primary students will be involved in this. This questionnaire will take approximately 10 minutes to complete and there are no 'right' or 'wrong' answers.

Consent to Participate

Your involvement in the research is entirely voluntary. You have the right to withdraw at any stage without it affecting your rights or responsibility. You can withdraw by simply contacting me at any point during the study. Please also be aware that your consent to participate will in no way influence your grade for the unit ED 3221/4221 Primary Science. When you have signed the consent form I will assume that you have agreed to participate and allow me to use your data in this research.

Confidentiality

The information you provide will be kept separate from your personal details, and only my supervisor and myself will have access to this. The results of the questionnaire will be presented as 'whole group' findings. In adherence to university policy, the questionnaires will be kept in a locked cabinet for at least five years, before a decision is made as to whether they should be destroyed.

Information Produced During the Study

Participants in this research will be notified of any significant new findings that develop during the course of the research. A summary of the results of the research will be made available to all participants at the conclusion of the study.

Further Information

This research will be carried out in accordance with the National Statement on Ethical Conduct Involving Humans and has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee [HREC] (Approval Number SMEC-92-11). The contact phone number for the Curtin HREC are 08 9266 9223 and the email address is hrec@curtin.edu.au. If you would like further information about the study, please feel free to contact me on 0412 019 474 or by email Jacinta.petersen@nd.edu.au. Alternatively, you can contact my supervisor on 08 9266 7924 or d.f.treagust@curtin.edu.au.

Thank you very much for your involvement in this research. Your participation is greatly appreciated.

Appendix 7

Information Sheet- Interviews



**Curtin University of Technology
Science and Mathematics Education Centre**

PARTICIPANT INFORMATION SHEET

**Project- A Longitudinal Study of Preservice Teachers and their Beliefs about
Teaching and Learning Science**

My name is Jacinta Petersen and I am a part-time staff member with the School of Education at The University of Notre Dame. I am currently completing a piece of research for my Doctor of Philosophy at Curtin University of Technology. I am also the unit coordinator for ED 3221/4221 Primary Science.

Purpose of Research

I am investigating how preservice teacher's self-efficacy in teaching science is influenced by coursework and practical experience, and how this impacts on teachers as they begin their first year of teaching.

Your Role

I am interested in finding out how individuals perceive their own self-efficacy in teaching science and how course work and practical experience influence this. I wish to interview you at 4 different points in your final years of university and in your first year of teaching. Each interview will take approximately 45 minutes and it can be done at a time and location that is convenient for you. These interviews will be audio recorded to assist in the transcribing process. I would also like to examine any science planning documents and documents you produce when teaching science. It may be confronting to talk to me as the unit coordinator, but I emphasise that I am interested in finding out your honest feelings and perception of teaching and learning about science. Please also be aware that your consent to participate will in no way influence your grade for the unit ED 3221/4221 Primary Science.

Consent to Participate

Your involvement in the research is entirely voluntary. You have the right to withdraw at any stage without it affecting your rights or responsibility. You can withdraw by simply contacting me at any point during the study. When you have signed the consent form I will assume that you have agreed to participate and allow me to use your data in this research.

Confidentiality

The information you provide will be kept separate from your personal details, and only my supervisor and myself will have access to this. The interview transcripts

will not have your name on it or any other identifying information on it. In presenting findings from this study, pseudonyms can be used to protect your identity if desired. In adherence to university policy, the interview transcripts will be kept in a locked cabinet for at least five years, before a decision is made as to whether they should be destroyed.

Information Produced During the Study

Participants in this research will be notified of any significant new findings that develop during the course of the research. A summary of the results of the research will be made available to all participants at the conclusion of the study.

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Thank you very much for your involvement in this research. Your participation is greatly appreciated.

Appendix 8

Consent Form- STEBI-B



**Curtin University of Technology
Science and Mathematics Education Centre**

CONSENT FORM- QUESTIONNAIRE

**Project- A Longitudinal Study of Preservice Teachers and their Beliefs about
Teaching and Learning Science**

I _____ have read the
information on the attached letter.

Any questions I have asked have been answered to my satisfaction. I agree to
participate in this research but understand that I can change my mind or stop at any
time.

I understand that all information provided is treated as confidential.

I agree that research gathered for this study may be published provided names or any
other information that may identify me is not used.

Name _____ Signature _____

Date _____

Investigator _____ Signature _____

Appendix 9

Consent Form- Interviews



**Curtin University of Technology
Science and Mathematics Education Centre**

CONSENT FORM- INTERVIEWS

I _____ have read the information on the attached letter.

Any questions I have asked have been answered to my satisfaction. I agree to participate in this research but understand that I can change my mind or stop at any time.

I understand that all information provided is treated as confidential.

I agree that research gathered for this study may be published provided names or any other information that may identify me is not used.

Name _____ Signature _____

Date _____

Investigator _____ Signature _____