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Exploring the impact of postgraduate preservice primary science education on students’ self-efficacy

Christina Maria Norris
Edith Cowan University

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Exploring the impact of postgraduate preservice primary science education on students’ self-efficacy

This thesis is presented for the degree of

Doctor of Philosophy

Christina Maria Norris

Edith Cowan University
School of Education
2017
As an educator of science since the late 1980’s, I have always believed in the need for solid scientific literacy. During my secondary science teaching career, in Australia and The Netherlands, I have had the pleasure to teach science from junior through to senior years. I was also given the opportunity to do relief teaching in primary schools, and unfortunately observed that at times, science ‘type’ activities were used to fill in time, have ‘fun’, without the relevant science being taught to improve science literacy. I have reflected that for each year level I have taught, each have their own intrinsic teaching challenges and pedagogical strategies required to ensure students are engaged, foster enjoyment and understanding of a subject that is seemingly laden with overwhelming amount of facts. Irrespective of what year level, I have always found that classes that were interactive, hands-on, open to inquiry and problem-based pedagogy assisted the students to learn about science.

During my time working with a group of talented and gifted primary students I was re-acquainted with Tournament of Minds, a problem solving challenge based tournament for teams of students in the fields of science and technology, engineering and mathematics, social sciences, language and literature. I became involved with the committee and am part of the ‘science technology’ and ‘engineering maths’ challenge writing committees and Co-Director of the Western Australian branch.

It was through an opportunity to teach preservice primary teachers in the area of science that an opportunity and encouragement was given to me to commence the research journey into the cycle of why secondary science students came into high school with gaps in their knowledge or held alternative conceptions. The completion of this doctoral study will mark the start of a journey into further research and teaching at the tertiary level where this work will make a difference to the future education of science in Australia. I look forward to this challenge.
NOTES ON STYLE

Throughout Chapters Five, Six and Seven, italicised text will be used to denote vignettes of data shared by research participants in the course of interviews, focus groups and feedback on surveys. The use of this will distinguish between participant voices and information quoted from the literature.

The Australian Curriculum, Assessment and Reporting Authority (ACARA) used to denote their areas of curriculum studies in italics, such as Australian Curriculum: Science. However, in the updated website, www.australiancurriculum.edu.au, this in no longer the case, and therefore this thesis will also not italicise the words instead will use Australian Curriculum: Science or AC: Science for consistency.

The Australian Academy of Science produce teaching resources for primary education called Primary Connections. These may also be referred to PrimaryConnections as one word, however for consistency this thesis will use Primary Connections as two words.
The effectiveness of science teaching in primary school is dependent upon teachers’ self-efficacy to teach science. Low self-efficacy has been linked to avoidance of teaching primary science; therefore, preservice teacher self-efficacy requires fostering to have graduates keen to teach primary science. Through an embedded mixed method intrinsic-case study, this research explored the impact of postgraduate preservice primary science education on students’ self-efficacy. This research examined the postgraduate students’ self-efficacy as the lens to determine the effectiveness of the design and pedagogical instruction of the unit and its tutors. Data sources included the use of pre/post surveys encompassing the Science Teaching Efficacy Belief Instrument (STEBI-B) (administered to 370 preservice teachers), pre/post focus group discussions by 35 preservice teachers, staff interviews, tutor self-reflections and researcher tutorial observations.

The study found preservice teachers’ science teaching self-efficacy was influenced through complex interactions including the design of the unit, tutor involvement, peer persuasion, home life, social media and a sense of entitlement. It was also found that as this was a post-graduate cohort, many students had fostered a positive disposition towards scientific literacy, due to life experiences. The analysis found that tutors’ unique style of teaching, explicit or implicit instructional techniques, their teaching background, science content and pedagogical content knowledge, the emotional climate set within their tutorials were found to influence preservice teachers’ science teaching self-efficacy. The research found there to be significant variances between tutors’ effect sizes from very small (Cohen’s $d = 0.11$) to medium-large (Cohen’s $d = 0.62$) for the constructs of personal science teaching efficacy and the science teaching outcome expectancy beliefs. The interactive design of the unit and assessment types were found, through focus groups, to be a positive factor affecting preservice teachers’ general self-efficacy. Investigation into the science learning backgrounds and type of science learners, found these factors additionally affected the science teaching self-efficacy constructs of preservice teachers. Preservice teachers also identified the use of social media as an additional factor of their general learning self-efficacy. Implications for the development of preservice teacher primary science
education programs, tutor professional development and future research are discussed in the thesis.
DECLARATION

I certify this thesis does not, to the best of my knowledge and belief:

i. Incorporate without acknowledgement any material previously submitted for a degree or diploma in any institution of higher education;

ii. Contain any material previously published or written by another person except where due reference is made in the text of this thesis; or

iii. Contain any defamatory material.

Signed and dated:

10th August 2017
ACKNOWLEDGEMENTS

I would like to acknowledge and thank my team of supervisors whose support and mentorship inspired me to commence and continue on the journey to achieve my Doctorate of Philosophy. Firstly, I wish to extend to my Principal Supervisor, Associate Professor Geoff Lummis my sincere thanks for the opportunity to research an issue that is integral to the success of science teaching in primary schools. Your continuing advice on academia and your unwavering support and belief that I could do it, even when at times I questioned myself. To my Associate Supervisor, Professor David McKinnon, thank you for your guidance, mentorship and teaching me the nuances of statistics for STEBI data analysis, it certainly is much appreciated. To my Associate Supervisor, Dr Julia Morris, thank you for the endless hours of attention to detail in my writing, your advice and unwavering support with pulling every component together and helping me make sense of it all.

Thank you to Dr Lena Danaia (Charles Sturt University) for your generous feedback and continued support on both my initial Master of Education research proposal and through the second phase of the doctoral proposal. Thank you to Professor Vaille Dawson (University of Western Australia) for your constructive feedback and support through the doctoral proposal stage of this research investigation.

To my dear Ken and Alek, I thank you both for your wonderful support in the endeavour to complete my thesis; your encouragement, love, understanding and motivation ensured that I did not become the ‘Queen of Procrastination’.

To all my family and friends who believed in me, particularly that going back to study wasn’t beyond me! Dr Gilly Smith, you inspired me to start this journey; I thank you for your continuing support and constructive feedback during the drafting of this thesis.

Finally, to the participants of the study, staff and students, thank you for your generous time to participate in the study, consequently providing me with a seemingly
overwhelming amount of rich data that could be analysed. You provided the backbone of this thesis.
### Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5E instructional Model</td>
<td>This science teaching model was developed by the BSCS and is comprised of five phases: engagement, exploration, explanation, elaboration and evaluation (Bybee, et al., 2006).</td>
</tr>
<tr>
<td>ACARA</td>
<td>Australian Curriculum, Assessment and Reporting Authority</td>
</tr>
<tr>
<td>AITSL</td>
<td>Australian Institute for Teaching and School Leadership Limited</td>
</tr>
<tr>
<td>ASTA</td>
<td>National Science Standards Committee from the Australian Science Teachers Association Incorporated and Monash University</td>
</tr>
<tr>
<td>BSCS</td>
<td>Biological Sciences Curriculum Study, a non-profit organisation based in Colorado Springs, USA.</td>
</tr>
<tr>
<td>Constructivism/constructivist</td>
<td>A learning theory that suggests that learners construct knowledge and meaning from their experiences (Skamp, 2012).</td>
</tr>
<tr>
<td>Curricular knowledge</td>
<td>Knowledge of different programs and corresponding material available to teach a given content (Shulman, 1986).</td>
</tr>
<tr>
<td>GDE-P</td>
<td>Graduate Diploma of Education (primary). A one-year postgraduate education program for preservice primary school teachers.</td>
</tr>
<tr>
<td>ICT</td>
<td>Information and communication technology</td>
</tr>
<tr>
<td>PCK</td>
<td>Pedagogical Content Knowledge used in the process of teaching (Kind, 2009) and is required to ensure appropriate theory and strategies are used to teach the subject content (Shulman, 1986).</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
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</tr>
<tr>
<td>PSTE</td>
<td>Personal Science Teaching Efficacy belief: This is the measure of an individuals’ self-belief in their own ability to teach science, as based on theory of self-efficacy by Bandura (1977) (as cited in Enochs &amp; Riggs, 1990).</td>
</tr>
<tr>
<td>TIMMS</td>
<td>Trends in International Mathematics and Science Study. This is administered to students in Year 4 and Year 8 providing comparative statistics from 57 participating countries (Martin, Mullis, Foy &amp; Hooper, 2016).</td>
</tr>
<tr>
<td>SCSA</td>
<td>School Curriculum and Standards Authority: Western Australian curriculum department</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>The construct that represents a person’s self-belief in their ability to produce the desired effect through their actions (Bandura, 1982).</td>
</tr>
<tr>
<td>STEM</td>
<td>Science, Technology, Engineering and Mathematics. An Australian Government strategic approach to restoring the focus back to STEM subjects in primary and secondary schooling to ensure Australia’s youth are ready for the future of the Australian economy (Australian Government Department of Education and Training [AGDET], 2015).</td>
</tr>
<tr>
<td>STOE</td>
<td>Science Teaching Outcome Expectancy: This is the measurable belief that an individual’s behaviour can result in a desirable outcome (Bandura, 1977); in this context the belief a teacher can influence their students’ outcome through effective teaching</td>
</tr>
</tbody>
</table>

Strategy
Refers to a pedagogical theory used to teach subject content.

Subject Content
Is subject specific content knowledge required to be taught and
Knowledge
essential to be understood to avoid alternative conceptions
(Shulman, 1986; Skamp, 2012).
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CHAPTER ONE
INTRODUCTION

The decline in Australia’s position in international science and mathematics standing motivates the investigation of the status and quality of science teaching in Australian schools, and subsequently, the adequacy and effectiveness of primary preservice teacher training. Concerns about the quality of primary science education have been raised in many countries, leading researchers to investigate preservice teacher education in an attempt to address these concerns (Appleton, 2003; Hackling, 2014; Velthuis, Fisser & Pieters, 2014). The aim of this study was to investigate the impact of unit design and tutors on a postgraduate primary science education unit, through the lens of the preservice teachers’ self-efficacy to teach primary science in the future.

The first chapter in this thesis will introduce the reader to the need for science education and the current status of science education in Australia and how Australia’s students compare to similar aged international students. It will also introduce the requirements for a teacher of science and the preparedness of teachers to teach primary science. These areas provide the basis upon which the significance of this research will be outlined, and inform the research questions explored in the study. A brief outline of the research methods will be given, which will be further discussed in the methods chapter. Finally, the organisation of the thesis is outlined to guide the reader throughout this thesis.

The need for science education

Hackling (2014) posits Australia is faced by significant challenges from social, economic and environmental factors, and as such, there is a need for well-educated and scientifically literate society. The need for science literacy is paramount to ensure young people in today’s society are able to make decisions about the world they live in (including sustainability) and for themselves, such as nutritional and medical requirements (Mullis & Martin, 2013). Rennie, Goodrum and Hackling (2001) suggest:

Scientically literate persons are interested in and understand the world around them, are sceptical and questioning of claims made by others about
scientific matters. They participate in the discourses of and about science, identify questions, investigate and draw evidence-based conclusions, and make informed decisions about the environment and their own health and well-being. (p. 494)

The benefit of science instruction helps provide a strong foundation of understanding science content, allowing students and citizens to become informed consumers of science and make sound decisions based on knowledge (Bell, Matkins & Gansneder, 2010). The aim of primary science teaching is to foster interest in science and develop pre-instructional conceptions in a learning pathway towards the intended science concepts to be learnt (Duit & Treagust, 2003), rather than perpetuating alternative or misconceptions of science understandings. Goodrum, Druhan and Abbs (2011) found a marked decrease in the number of year 12 students studying a science subject, from 90% in the early nineties to approximately 50% in 2011. The low enrolment in senior school science led them to advocate for greater engagement with science during the compulsory years of schooling. Logically, primary school years may be considered the most crucial time for capturing students’ interest in science (Fitzgerald, Dawson & Hackling, 2013).

**Status of primary science in Australia**

Australia’s primary school science status on an international scale is measured through the Trends in International Mathematics and Science Study (TIMMS), which are administered to 57 participating countries by the International Association for the Evaluation of Educational Achievement (IEA). This study allows for international comparative assessments to gain an insight into the effect of educational policies across varying countries (Martin, Mullis, Foy & Hooper, 2016). The 2015 study included student assessment, as well as parent and teacher questionnaires to provide further insight into the status of science education for students in Years 4 and 8 (Martin et al., 2016). Analysis of the 2015 TIMSS demonstrated that the Year 4 student performance had improved from the dramatic decline that had occurred from 1995 to the 2011, with the results showing 2015 as similar to 1995 results; Australia sitting in 25th position out of 47 countries (Martin et al., 2016; Thomson, Wernert, O’Grady & Rodrigues, 2017). The Year 8 results demonstrated little change from the 2011 results and were similar to the 1995 results with Australia at 17th place out of 39
countries (Martin et al., 2016; Thomson et al., 2017). Although results showed Australia was still above the international average, it remained well behind Asian neighbours, such as Singapore, Japan, Chinese Taipei and other countries including Kazakhstan, Russian Federation, Finland, Poland. The results were not significantly different to England, New Zealand, Germany and Korea (Martin et al., 2016; Thomson et al., 2017). As with the 2011 report, the performance stayed fairly stagnant in comparison to countries such as Singapore, Hong Kong SAR, Hungry and Morocco (Martin et al., 2016).

The Rennie et al. (2001) report continues to resonate there continues to be a significant gap between idealistic and actuality of teaching and learning science. Idealistically, ACARA (2014) requires depth in learning of science concepts and skills, however reports such as TIMMS by Martin et al. (2016) highlight this idealistic gap. Further insight into the study showed that 61% of Year 4 students had been taught all the TIMSS science topics before or during Year 4, whilst 59% of Year 8 students had been taught their relevant topics (Thomson et al., 2017). The amount of time allocated to the teaching of science (57 hours per year) was considerably less than mathematics (202 hours per year) in Year 4. The international average instruction time was 76 hours per year (in the United States of America [USA] it is 100 hours per year, and Singapore 85 hours per year), and only slightly less in Year 8 (126 hours per year science compared to 139 hours per year of mathematics) (Martin et al., 2016; Thomson et al., 2017).

In Australia, teachers teaching Year 4 science tended to be generalist primary teachers (77%) with no major specialisation in science. This is in comparison to other countries where 44% of Year 4 teachers of science were generalist primary educators (Martin et al., 2016; Thomson et al., 2017). It was also reported students who thought they were exposed to very engaging teaching in science declined markedly from 60% by Year 4 students to 35% of Year 8 students (Martin et al., 2016). From this it may be surmised that factors affecting Australia’s decline in the ranking of student performance may include reduced number of teachers with science specialist training, lower amounts of time spent teaching science. This in turn may lead to generalist teachers teaching science who may have low efficacy in teaching this area, which in
turn may lead to superficial teaching of science content or limited time spent on teaching science.

Although primary teachers who teach Year 4 students may be more enthusiastic in teaching science (Martin et al., 2016), the reduced number of hours of primary science teaching by non-specialist science teachers (Martin et al., 2016) may be due to levels of confidence or self-efficacy these generalist teachers may have, especially as the science content increases in the senior primary years. This concept will be further introduced later in this chapter.

Requirements for a teacher of science

The Australian Curriculum has been devised to set consistent and comparable standards across all Australian States and Territories to ensure all Australian children have the same improved learning outcomes (Australian Curriculum, Assessment and Reporting Authority (ACARA), 2015). In Australian schools, the teaching of science is strongly underpinned by the National Australian Curriculum as set out by ACARA. The Australian Curriculum: Science was endorsed by the council of Federal, State and Territory education ministers in December 2010 and it is expected its content descriptions are taught to all young people, with set achievement standards (ACARA, 2015). The broad aim of the Australian Curriculum: Science is to provide primary and secondary students with developing an:

understanding of important science concepts and processes, the practices used to develop scientific knowledge, of science’s contribution to our culture and society, and its applications in our lives. It provides an understanding of scientific inquiry methods, a foundation of knowledge across the disciplines of science, and develops an ability to communicate scientific understanding and use evidence to solve problems and make evidence-based decisions. The curriculum supports students to develop the scientific knowledge, understandings and skills to make informed decisions about local, national and global issues and to participate, if they so wish, in science-related careers. (ACARA, 2017, Learning Area Overview, Science section)
The Australian Curriculum is made up of seven general capabilities, specific subject content as well as three cross-curriculum priorities: Aboriginal and Torres Strait Islander histories and cultures; Asia and Australia’s engagement with Asia; and, sustainability (ACARA, 2015). The complexity of the curriculum increases as the science content is divided into three subsections comprising of Science Understanding, Science as a Human Endeavour and Science Inquiry Skills, which in turn are divided into specific scientific knowledge and processes (ACARA, 2015).

To ensure there are rigorous professional standards across all states and territories, the Australian Institute for Teaching and School Leadership Ltd (AITSL) was formed and funded by the Australian Government in 2010 (AITSL, 2011). For example, it is expected that Graduate teachers can demonstrate “Standard 2 – Know the content and how to teach it” (AITSL, 2011) in the relevant subject areas. Furthermore, to clarify how these standards may be met by teachers of science, members of the National Science Standards Committee from the Australian Science Teachers Association Inc. and Monash University (ASTA) have developed the national professional standards for highly accomplished teachers of science. They believe good teaching of science is complex and a skill that develops over many years (ASTA, 2002). The standards ASTA developed do not specify how science should be taught as this is based on school context and autonomy for a teacher to use their skills and judgements. Instead, these standards provide guidance for how a teacher of science can improve through development of critical aspects of practice, which are distinguishable from novice through to highly competent teachers (ASTA, 2002). ASTA (2002) highlights these differentiations for highly accomplished teachers of science by:

- possessing extensive knowledge of science content, science pedagogy and students;
- working with their students to achieve high quality science learning outcomes (through learning program design, setting effective and supportive science learning environments, engaging students, developing students’ confidence and ability to use scientific knowledge to make informed decisions); and
- possessing professional attributes that are reflective and analytical, are committed to improvements (of themselves and their students) and being
actively involved in their professional community (to improve quality and effectiveness of science education).

Shulman (1986) discusses knowledge in three categories: subject matter content knowledge, pedagogical knowledge and curricular knowledge. Subject matter content knowledge is specific to topics that are required to be taught. Therefore, it is essential the teacher understand why a topic is central to the discipline (Shulman, 1986). This is important so the topic can be discussed accurately, thus avoiding the risk of generating alternative conceptions (Skamp, 2012). Teachers must understand the variety of ways to organise the subject content and contextualise the theory with practice (Shulman, 1986). Shulman (1986) also posits teachers must not just understand something is so, but also why it is so. This would provide for a deep understanding of the content.

Understanding and depth of subject content knowledge has been found to affect the pedagogical choices a teacher will make (ASTA, 2002). Those with low confidence in content knowledge will tend to use didactic and ineffective methods of teaching science (Appleton & Kind, 2002). A teacher maybe very effective and use interactive pedagogical strategies in other curriculum areas yet may revert to traditional teaching methods in areas where they lack of confidence in the content (Appleton & Kind, 2002, ASTA, 2002).

Having only good subject content knowledge is insufficient to make a good teacher; there is also a need for a teacher to have effective teaching skills (Kind, 2009). Pedagogical knowledge is paramount to ensure appropriate strategies can be used to ensure students learn the content (Shulman, 1986; Skamp, 2012), as this is the knowledge used in the process of teaching (Kind, 2009). Pedagogical knowledge can be defined as the subject knowledge pertaining to its ‘teachability’; which includes teaching strategies such as powerful analogies, illustrations, examples, demonstrations and explanations to give alternative representations of subject content (Shulman, 1986).

Another strategy in building students’ knowledge is the use of the social constructivist theory, whereby learning focuses on concept development rather than passive
absorption of information (Skamp, 2012). This notion is based on the social development theory of Vygotsky and is complementary to Bandura’s work on social learning. Placing this in context, Vygotsky (1978) stated, “all higher order psychological processes and structures (such as science concepts) originate on the social plane” (p. 14). That is, “students encounter science concepts through the ‘[science] talk’ and ‘[science] writing’ of others . . . It is ‘social’ in that learning has social origins, but also because the scientific community advances knowledge through social conventions and contexts” (Skamp, 2012, p. 14). Essentially, pedagogical knowledge, and understanding of its application, is explicitly differentiated from other forms of knowledge.

Curricular knowledge is also important, as teachers need to understand there are curricular alternatives to teach similar content, including alternative texts, variety of information technology, demonstrations and audio-visual stimulation (Shulman, 1989). The teacher must also be able to relate the content of their subject in a cross curricular manner, and also relate how the content relates to prior and future learning of the same subject (Shulman, 1989). ACARA (2015) clearly sets out the required curriculum content through their scope and sequences of subject content knowledge (such as the science strands of biological, chemical, physical and Earth and space sciences), as well as a sequence of achievement levels that students should be attaining for each year level. An example of this is that by the end of Year 6, students should have learnt changes to materials can be reversible or irreversible, and are able to follow appropriate procedures to develop science investigations.

A few problems primary science education units and their tutors face, is that often the preservice teachers enter the course with inadequate science content knowledge, lack of confidence in science content or negative attitude towards science learning prior to even addressing the pedagogical content knowledge (Bleicher, 2009; Bleicher & Lindgren, 2005). Graduate teachers may be at risk of not meeting the AITSL standards if they feel they have not been able to master both the subject and pedagogical content knowledge (Lummis, Morris & Paolino, 2014). The impact results in universities graduating those strong in one subject’s pedagogical content knowledge (for example, in humanities) and not so in another (for example, in
science). The AITSL standards must be kept in mind when investigating the design and pedagogy of the postgraduate primary science education unit.

**Readiness to teach primary science**

The amount of knowledge required to teach science may be considerable and overwhelming for a generalist teacher, and therefore may be avoided altogether (Steele, Brew, Rees, & Ibrahim-Khan, 2012). Across the world, teachers face ongoing demands and challenges including increased workloads, time factors, societal changes, changes in policies and expectations (Fitzgerald & Schneider, 2013; Steele et al., 2012), along with the high stakes testing occurring in English language arts and mathematics (in US schools) may play an additional role in the marginalisation of science teaching (Roth, 2014). How teachers cope with these challenges and the self-belief of their capabilities will influence their commitment to their career and their students’ learning (Tschanen-Moran & Woolfolk-Hoy, 2001).

Research has found that student’s engagement with science tends to be developed by the age of 14 (Fitzgerald, Dawson & Hackling, 2013), along with positive attitudes and interest toward science (Tytler, 2014). Therefore, the role of the primary science teacher is pivotal to this development in their students through the use effective science teaching (Fitzgerald, Dawson & Hackling, 2013). Research has also well documented evidence for the reluctance of primary school teachers to teach science (Appleton, 2003; Appleton & Kindt, 2002; Fitzgerald, et al., 2013). Further factors have been cited in literature including limited science content knowledge, low confidence in teaching, low self-efficacy (Enochs & Riggs, 1990; Gibson & Dembo, 1984; Bleicher, 2007; Howitt, 2005; Skamp & Mueller, 2001); the need for specialist science equipment; time required for preparation; and, the complexity of the nature of science impact upon the willingness to teach primary science (Appleton, 2002; Tosun, 2000). These factors may result in primary students being exposed to sporadic or haphazard science education, which will affect their positive engagement and learning of science (Fitzgerald et al., 2013).

Primary teachers are the first formal education influences on students’ attitude toward science, and any negative attitude from the teachers can easily be transferred to their students (Bergman & Morphew, 2015). Engagement is important in developing
attitudes and enhancing performance. For example, the 2015 TIMSS results showed disadvantaged students tended to report lower level of very engaging teaching, however when both disadvantaged and advantaged students did experience engaging teaching they performed significantly better than those who did not (Thomson, et al., 2017). This suggests positive attitudes displayed by teachers are also transferrable to their students. Teacher efficacy has been found to correlate to teacher effort, persistence during challenging situations, enthusiasm, attitude towards students, classroom management, professional commitment and attitude towards student outcomes and achievements (Tchannen-Moran, Woolfolk & Hoy, 1998).

The attitudes of the primary teachers and the science learning experiences may then form the attitudes of the preservice teachers entering the teacher education courses. Research has demonstrated that preservice teachers enter the courses with varying self-efficacy levels, which have been formed through prior experiences (Avery & Meyer, 2012; Cantrell, Young & Moore, 2003; Tosun, 2000). Research also indicates many primary teachers feel unprepared and uncomfortable teaching science (Bergman & Morphew, 2015; Howitt, 2007). Preservice teachers’ negative experiences with science may permeate their future classrooms and continue to perpetuate didactic approaches to teaching and learning of science (Avery & Meyer, 2012), or they may perpetuate poor attitudes towards science and an unwillingness or avoidance of teaching this subject area (Tosun, 2000). Effective teaching is important for science engagement by students where critical thinking is required to develop passion and interest in a field that is dynamic and continually changing (ASTA, 2002).

Teacher efficacy and preservice teacher efficacy have been, and continue to be important constructs in teacher education (Cantrell, Young & Moore, 2003). Bandura (1982) suggested self-efficacy is a construct that represents a person’s self-belief in their ability to produce the desired effect through their actions when faced with challenges. Self-efficacy can be similar to self-confidence, and therefore many studies may use the terms interchangeably (Appleton & Kindt, 2002; Rice & Roychoudhury, 2003; Settlage, 2000; Watters & Ginns, 2000). Lack of confidence or low self-efficacy can be formed through prior learning and may translate to future teaching, therefore this is a pivotal construct for preservice teacher education research. Self-
efficacy will be discussed in further detail in Chapter Two and Three, as this formed the lens through which this study was conducted.

The Significance of this Research

A considerable amount of research into primary teacher education has focused on investigating the self-efficacy of undergraduate preservice teachers (Gibson & Dembo, 1984; Mulholland & Dorman & Oggers, 2004, Rice & Roychoudhury, 2003; Watters & Ginns, 2000). For improved self-efficacy, many studies focused on the type of science education courses preservice teachers were experiencing, such as science content courses along science methodology courses or integrated science pedagogical and content courses (Bergman & Morphew, 2015; Cantrell et al., 2003; Menon & Sadler, 2016; Mulholland et al., 2004; Palmer, 2006; Watters & Ginns, 2000). Many of these studies found science education courses, that covered both subject content and pedagogical content, could have the potential of increasing participant self-efficacy through the use of various pedagogical approaches including inquiry, extensive hands-on activities, group investigations, incorporation of relevant primary classroom activities (Bleicher & Lingren, 2005; Hudson & Ginns, 2007; Menon & Sadler, 2016; Rice & Roychoudhury, 2003; Watters & Ginns, 2000). Other studies focused on the tutors’ interaction to set emotional climate (Bellocchi, Ritchie, Tobin, Sandhu & Sandhu, 2013; Cripps Clark & Groves, 2012) or preservice teachers’ identified tutor factors for facilitating self-efficacy changes as part of holistic approach to teaching and learning (Howitt, 2006), or how tutors’ behaviour may influence student learning (Chng, Yew & Schmidt, 2013) and the impact of modelling by tutors (Rice & Roychoudhury, 2003). Further in-depth studies, including investigating preservice teachers’ ‘type of learners’ were also investigated in relation to how their self-efficacies may be impacted by prior science learning experiences (Bleicher, 2007) or how having alternative science conceptions was linked to self-efficacy of preservice teachers (Schoon & Boone, 1998).

Researchers have found science educators must understand their preservice primary students and how they learn, and make deep conceptual changes in their attitude in and confidence towards science concepts to implement appropriate strategies that challenge understandings yet facilitate improved self-efficacy (Iii, Hand & Prain,
The effectiveness of a science teaching unit’s design has been found to be pivotal in influencing preservice teacher self-efficacy (Morell & Carroll, 2003); as preservice teachers need to develop a toolkit of instructional techniques, approaches and strategies to engage their own students in real-world science in a manner that is fun, exciting and relevant whilst managing their students’ behaviour (Swartz, 2009).

Petersen and Treagust (2014) discuss the importance for universities to understand what information preservice teachers use that will impact their personal beliefs and confidence, to develop appropriate development opportunities within the coursework and practical experiences to increase preservice teacher self-efficacy. Preservice teacher education appears to hold the key for changing practice towards the inclusion of education reform (Briscoe & Peters, 1997) and may be the most influential stage to target towards achieving effective primary science teaching practices (Appleton & Kindt, 1999; Watters & Ginns, 2000). Therefore, it is important for preservice teacher educators to develop primary science teachers’ efficacy to teach science, build their confidence and attitude towards science to evoke engagement, passion and interest in future generations.

Despite the vast research on primary science teacher education, in the Australian context there has been limited research into postgraduate preservice teacher self-efficacy. This research aims to fill the gap in literature by focussing on a primary science education unit within a one-year postgraduate education course. Additionally, as mentioned earlier, much of the research has focussed on specific areas of preservice teacher self-efficacy factors; therefore, this research aims to be a holistic investigation into the interplay and impact of science teaching course design and its tutors on postgraduate preservice teachers’ primary science teaching self-efficacy.

**Research Questions**

This research investigated the complexity of factors within a postgraduate preservice teacher primary science education unit. Preservice teachers’ primary science teaching self-efficacy is the lens through which the effectiveness of the unit’s design and tutors are measured. The following five research questions were investigated:
1. What are the preservice teachers’ science teaching efficacy beliefs pre and post intervention?
2. To what extent does a tutor’s teaching of the GDE-P Science unit’s science concepts impact preservice teachers’ self-efficacy constructs?
3. To what extent does the tutor’s modelling of GDE-P Science unit’s pedagogical content impact preservice teacher’s self-efficacy?
4. How did the preservice teachers perceive the design of the GDE-P Science unit influenced their self-efficacy in primary science teaching?
5. What perceived factors in the GDE-P Science unit did the preservice teachers believe would enhance their science and pedagogical content self-efficacy?

**Research Methods**

This intrinsic case study (Grandy, 2012; Stake, 2005) employed embedded mixed methods (Creswell & Plano Clark, 2011) to provide an in-depth investigation into the complexity of factors that influence preservice teachers’ self-efficacy in primary science education. The use of both quantitative and qualitative methods addressed the research questions using a pragmatic paradigm, whereby each method complements each other (Creswell & Plano Clark, 2011; Yin, 2010) to fully understand the complexity of self-efficacy.

The qualitative interpretivist-constructivist paradigm was employed to interpret participant vignette data and researcher observations. The quantitative post-positivist paradigm was used to acknowledge the complexity of the constructs that comprises self-efficacy through the use of a pre and post intervention administration of the science teaching efficacy beliefs instrument (STEBI-B). The embedded mixed method design allows for concurrent collection of qualitative and quantitative data from a number of sources, whereby neither method is considered more superior than the other (Creswell, 2014; Creswell & Plano Clark, 2011) in order to provide rich data for analysis.

Data were collected through pre and post intervention focus group discussions and surveys with preservice teacher participants. Vignette data from these participants provided an understanding of quantitative data results, along with rich discourse of
participant insight into the design of the unit and their respective tutors. Semi-structured interviews provided narratives by tutors that allowed for deep understanding of their unique teaching styles and strategies; those provided by the unit coordinators allowed for an understanding of the design of the unit and why certain subject content and pedagogical content were selected for their inclusion; and finally, the narrative from the laboratory technician provided an additional source of observational data from another point of view, along with the an insight into the budgetary demands on the design of the unit. The merging of data allowed for each form of findings to support each other for analysis and strengthen the study’s discussion and subsequent conclusions.

Organisation of this Thesis

This thesis has been organised into eight chapters. The first, or introduction chapter has presented the context and significance of the research study in relation to the need of in-depth study of factors present within a postgraduate preservice primary science education unit that may affect students’ self-efficacy to teach primary science in the future. Within this chapter the research questions and methodology have been outlined.

Chapter Two reviews significant literature in relation to the themes of this research. Within this chapter, the theory and constructs of self-efficacy have been examined. Furthermore, how these constructs may influence primary science teachers by in-service and preservice teachers. An overview is provided of the development history of an instrument to measure preservice teacher primary science teaching self-efficacy. This chapter also reviews literature in relation to preservice teacher education and the influence of design and tutelage of primary science units, and the interplay of these as factors of influencing self-efficacy.

Chapter Three outlines the theoretical and conceptual framework for the research. This chapter discusses the post-positivist paradigm in relation to quantitative research methods, the interpretivist-constructivist paradigm in relation to qualitative research methods, and finally the pragmatic paradigm that forms the basis for the use of mixed methods appropriate for this study. This chapter also provides a visual conceptual
framework to demonstrate the complexity of the theories and how they interrelate to inform the research design.

Chapter Four outlines significant literature for both the quantitative and qualitative research methods employed within this embedded mixed methods study. It also discusses the research context of the postgraduate primary science education unit, the pilot study and the research setting in which this research study was conducted. Furthermore, the data collection and analysis processes are also documented within this chapter.

Chapter Five presents research findings in relation to unit design and staff as factors of postgraduate preservice teachers’ self-efficacy. These data were collected using qualitative methods of semi-structured interviews and researcher’s observations.

Chapter Six presents research findings in relation to factors influencing preservice teachers’ self-efficacy from student data. These data were collected through the use of pre/post quantitative methods using the Science Teaching Efficacy Beliefs Instrument, measuring the preservice teachers’ two constructs of self-efficacy and qualitative methods using focus group discussions and vignette data from pre and post surveys.

Chapter Seven discusses the triangulation of findings from the previous two chapters, supported by significant literature, linking these to the research questions posed in Chapter One.

Chapter Eight summarises the conclusions from research findings, presents recommendations based on the conclusions and proposes further research directions built on the limitations of this study.

**Chapter summary**

This chapter has introduced this research study and its significance within the literature on preservice teachers’ primary science teaching self-efficacy. The need for effective primary science education has been presented in the context of Australia’s
current position in primary science education on an international scale. It also introduced the requirement teachers of science need in order to effectively teach primary science, along with a brief outline of what is required for students to learn in science under the Australian Curriculum (ACARA, 2015). Further to this, a brief outline was given in relation to the willingness and self-efficacy of primary school teachers and preservice teachers to teach primary science.

In order to demonstrate the significance of this research it was imperative a gap in literature was identified, which was shown through a brief outline of previous research. The significance of this research is its holistic investigation of a primary science education and the impact of unit design and tutors on postgraduate students’ self-efficacy. These aims informed the research questions that were posed, regarding the preservice teachers’ self-efficacies, and their perceptions of the influence of the design and the tutors on their self-efficacy. As the research was conducted within one science education unit and its cohort it was considered an intrinsic case study, using an embedded mixed methods approach in an attempt to garner a wide variety of rich data to allow for deep investigation into the interplay of factors impacting self-efficacy in this context.
CHAPTER TWO
LITERATURE REVIEW

Introduction

Chapter One introduced the context of a case study of a cohort of 277 Western
Australian Graduate Diploma of Education Primary (GDE-P) preservice teachers. The
importance of this research is linked to the comprehensive exploration of factors
associated with university tuition that may affect preservice teachers’ self-efficacy to
teach primary-science.

Chapter Two outlines the literature related to the themes of this study, which are:

- the theory of self-efficacy;
- constructs of science teaching self-efficacy;
- measurement of primary science teaching self-efficacy;
- self-efficacy of preservice teachers;
- preservice teacher education; and,
- the influence of university science education tutors on GDE-P preservice
  teachers’ self-efficacy.

The literature within these themes will provide a framework for the research and a
basis for discussion of the research findings.

Theory of self-efficacy

Commitment and identity of a teacher is based on their self-esteem, the values they
hold, motivation and self-actualisation (Cronje, 2011). These are closely intertwined
with a teacher’s attitude, commitment and confidence to deal with new situations that
may arise (Cronje, 2011). Preservice and graduate primary teachers are faced with a
multitude of new situations and content areas, and their self-efficacy to not only teach,
but to teach subject specific areas will be the motivational construct that directly
influences the outcomes in their classrooms (Bandura, 1977; Bergman & Morphew,
2015; Ginns, Tulip, Watters & Lucas, 1995; Predergast, Garvis & Keogh, 2001). In
the context of this study, self-efficacy to teach primary science has been considered an important construct in Australian teacher education.

Rotter (as cited in McKinnon & Lamberts, 2013) first developed the concept of self-efficacy in 1966, focusing on the belief individuals personally influence outcomes that affect them (internal locus of control) or external factors such as environment can influence outcomes (external locus of control). Bandura (1977) further developed the theory of self-efficacy grounded in the notion of Bandura’s (1971) social learning theory, which includes two factors of ‘efficacy expectation’ (an individual’s belief about their ability to achieve a desired outcome) and ‘outcome expectancy’ (the belief that a given behaviour will lead to a desired outcome) (Ginns et al., 1995; McKinnon & Lamberts, 2013). This theory is explored later in the chapter.

**Definition of self-efficacy**

Bandura (1977) posited self-efficacy as being an individual’s self-belief in their capabilities that can shape their actions (behaviour) to produce a desired outcome. Bandura describes self-efficacy as powerful incentives to persevere and act in a manner to exercise control over one’s own functioning to problem solve or achieve a personal goal during adverse conditions. These beliefs can affect levels of motivation, life choices, and resilience to adversity, quality of an individual’s actions, vulnerability to stress and depression. Bandura went on to suggest that given an appropriate environment, self-efficacy can be malleable and can be changed to affect the desired outcome. Therefore, self-efficacy is context specific (Morrell & Carroll, 2003; Pajares, 1996). Tschanzen-Moran et al. (1998) posit that as self-efficacy is contextual, and distinguished from other self-conceptions such as self-esteem; therefore it should be related to self-perception of competence and not the level of competence to perform a task.

Teachers’ self-efficacy beliefs are strong predictors of teacher behaviour (Bergman & Morphew, 2015; Tschanzen-Moran, Hoy, & Hoy, 1998). ‘Teacher self-efficacy’, grounded in Bandura’s (1977) social cognitive theory, refers to teachers’ belief in their ability to influence the outcomes of their students (Lakshmanan, Heath, Perlmutter & Elder, 2011; Tschanzen-Moran et al., 1998), whereas ‘teaching self-efficacy’ is an educator’s ability to teach and produce positive outcomes for their
students (McKinnon & Lamberts, 2013). Tschannen-Moran et al. (1998) define teacher self-efficacy as “the teacher’s belief in his or her capability to organise and execute courses of action required to successfully accomplish a specific teaching task in a particular context” (p. 233). Therefore, teacher efficacy may change with the various curriculum areas they may need to teach.

Research has shown teacher self-efficacy has been linked with student achievement, attitude towards students and classroom management approaches, student motivation and student self-efficacy (Mansfield & Woods-McConney, 2012). It was also found teachers with high self-efficacy were less critical of students’ errors and more supportive of struggling students to build their motivation and self-regulation (Gibson & Dembo, 1984). These teachers were also found to take risks and try new teaching methods (Mansfield & Woods-McConney, 2012).

According to Bandura (1977; 2012) when individuals are placed under constraints, they are less likely to act on their self-efficacy beliefs; therefore, regulating their level and distribution of effort in accordance to their expectations. These self-regulations may include motivation, performance levels, thought processes, change of emotional states or altering their environmental conditions (Bandura, 2012). Bandura (1977) went on to suggest the stronger the perceived self-efficacy, the more active the efforts of an individual, furthermore those who cease their coping efforts prematurely will retain their self-debilitating expectations and fears for a long time. Research has found that preservice primary teachers hold onto negative attitude and fear of science developed at an early time in their education experience (Avery & Myer, 2012; Blecher, 2007; Mulholland, Dorman & Odgers, 2004; Palmer, 2006a), which is in line with Bandura’s (1977) argument. Bandura (1977) suggests an individual’s self-belief also plays an integral part to realise a desired outcome (Lakshmanan et al., 2011), as a high perceived self-efficacy will allow a person to persist and be motivated to succeed.

Lasting changes to an individual’s self-efficacy and behaviour tend to be achieved through developing their capabilities by first using external induction procedures, such as being provided with mastery experiences, and then developing into self-directed mastery to strengthen their personal efficacy (Bandura, 1977). Individuals
with strong self-efficacy will continue to make vigorous and persistent effort and most likely to succeed, whereas, those with low self-efficacy will use minimal effort and give up or avoid the task altogether (Palmer, 2006b). It was also found many researchers interchange self-efficacy with self-confidence, as both are similar constructs (Appleton & Kindt, 2002; Palmer, 2006a; Rice & Roychoudhury, 2003; Watters & Ginns, 2000). Within this thesis these two constructs will be considered interchangeable when considering the research.

**Social cognitive theory**

As mentioned earlier, social cognitive theory is found to be an agent whereby an individual can deliberately influence their own functioning and the course of an event through their actions (Bandura, 2012). This theory is grounded in triadic reciprocal causation (Bandura, 1986), whereby an individual’s functioning is influenced by the three factors of behaviour, environmental events, and personal factors such as biological and cognitive events (Gibson & Dembo, 1984; Lakshmanan et al., 2011; Pajares, 2002), all of which function interdependently (Bandura, 2012). Based on these factors and in the context of this study, four sources may impact an individual’s self-efficacy:

- Performance accomplishments / Mastery experiences through:
  - Participant modelling
  - Self-instructed performance
  - Performance exposure
- Vicarious experiences through:
  - Symbolic modelling
  - Live modelling
- Verbal/social persuasion through:
  - Suggestion by peers
  - Self-instruction
  - Interpretive treatment
- Emotional arousal / Physiological and emotional cues through:
  - Attribution
  - Relaxation
  - Symbolic exposure
  - Symbolic desensitisation. (Bandura, 2012)
These will be discussed in terms of how they can influence preservice teacher self-efficacy throughout the remainder of this chapter.

Many people don’t live in social isolation and hence seek others to work together with to achieve set goals (Bandura, 2012). Therefore, the influences listed by Bandura are structured in a social context, whereby individuals can exercise ‘proxy agency’ by influencing others to act on their behalf as these may have the resources, knowledge and skills that can work together to achieve the desired outcomes (Bandura, 2012). The environmental factor may be imposed, selected or constructed; whereby an imposed environment will act upon a person whether they want it to or not (Bandura, 2012). Tschannen-Moran et al., (1998) assert an individual’s persistence and level of effort will influence their sense of self-efficacy, which in turn become part of the past and future sources of efficacy stabilising over time to become an enduring set of self-efficacy beliefs.

**Construct of science teaching self-efficacy**

Grounded in Bandura’s social cognitive theory, there are two dimensions that make up self-efficacy, outcome expectancy and efficacy expectation. In terms of teaching science, these constructs then become science teaching outcome expectancy (STOE) and personal science teaching efficacy (PSTE).

It could be surmised that STOE would reflect the amount that teachers believe they can control the environment, in effect, the extent that students can be taught; whereas the PSTE would reflect the teachers’ evaluation of their own ability to affect a positive change in their students (Cantrall, Young & Moore, 2003; Gibson & Dembo, 1984; Knaggs & Sondergeld, 2015; Tschannen-Moran, et al., 1998). Research has shown that both of these factors can operate independently (Bandura, 1977, 2012; Cantrall et al., 2003; Mulholland et al., 2004), as individuals can believe that for a certain outcome to be achieved, a particular course of action needs to be followed (Bandura, 1977). For example, some teachers believe they can have a positive effect on students’ learning; however, they lack personal ability to affect this on their students (Cantrall et al., 2003). Conversely, Cantrall et al. (2003) also found there
were teachers who believed, in general teachers have little influence on students but they themselves are an exception to this.

Gibson and Dembo (1984) explain that individuals who have a high level of both PSTE and STOE will respond actively and confidently to a situation, whereas those with low levels of both factors will give up readily if not receiving results. It could be predicted that teachers with high levels of PSTE and STOE would believe that students are influenced by effective teaching, are confident in their own ability to teach, and consequently would put in greater effort with increased academic focus into their classrooms than teachers with lower levels (Cantrall et al., 2003; Gibson & Dembo, 1984; Knaggs & Sondergeld, 2015; Mulholland, et al., 2004).

Preservice education research has found a lack of positive change in STOE scores, which suggested a lack of confidence in students believing that teachers do make a difference in science education (Bleicher, 2007; Mulholland, et al., 2004). Lakshmanan et al. (2011) posits, “positive outcome expectancy leads to an increase in the desired behaviour, and negative outcome expectancy causes a reduction in the behaviour” (p. 536). Tschannen-Moran et al. (1998) found that teachers with low STOE tended to be less effective teachers of science and less adventurous with teaching styles that would enhance student learning, such as cooperative activity work, instead using traditional textbook approaches.

As both factors of PSTE and STOE are integral to teaching primary science it is imperative that preservice education also addresses these through providing adequate experiences in line with Bandura’s (1977) sources of efficacy. Past research has shown the effect of providing these sources explicitly and will be discussed in the next section of the chapter.

**Mastery experiences**

Mastery experiences and the physiological arousal associated with the experiences are one of the most powerful sources to develop an individual’s belief in their capabilities (Bandura, 2012; Cantrell et al., 2003; Tschannen-Moran et al., 1998). Bandura (2012) believes that if individuals only experience quick and easy success then they will expect quick results and will get discouraged if challenged by setback and failure.
Resilient self-efficacy will require experiences that challenge an individual and place them in situations where they will learn to manage failure so that it becomes informative rather than demoralising (Bandura, 2012). This then builds a ‘library’ of skills, confidence and raises efficacy beliefs to inform future performances, based on similar experiences, whilst building intrinsic motivation to achieve a successful outcome (Bandura, 2012; Cantrell et al., 2003; Palmer, 2006; Tschannen-Moran et al., 1998). Bandura (2012) found individuals who had attained a standard of success, and had high level of self-efficacy, set higher new standards for themselves, and created further challenges with new motivating discrepancies to be mastered. Those with lower self-efficacy who believed they can achieve the set goal will persevere and increase their effort. Those with no trust in their self-efficacy to repeat what they had achieved, reduced their efforts and lowered their goals (Bandura, 2012).

Research has demonstrated preservice teachers come into primary science education courses with high level of anxiety, fear and intimidation of subject content due to their learning experiences during schooling (Avery & Meyer, 2012, Bleicher, 2007; Palmer, 2006a; Mulholland et al., 2004). Bandura’s (1977) social learning theory found that defensive behaviour and anxiety are co-effects of experiences. The understanding of subject content is a significant factor to preservice teacher self-efficacy (Palmer, 2006a). Lummis, Morris and Paolino (2014) found similar anxiety and fear in primary preservice teachers to teach primary arts; and other's research in mathematics (Buss, 2010; Thomson, di Francesca, Carrier & Lee, 2016).

Palmer (2006b) suggests mastery in understanding the science content would expect to increase self-efficacy for teaching science; and refers to this as cognitive content mastery. He argues cognitive content mastery is distinctly different to enactive mastery as it involves success in understanding, whereas enactive mastery is considered success in doing something (Palmer, 2006b). Cantrell et al. (2003) found mastery experiences through teaching science in primary classrooms or small group teaching, concurrent with their science methods course (how to teach primary science), was associated with an increase in their PSTE. The involvement in small group science teaching allowed preservice teachers to plan and implement whole class science lessons during their tertiary science methods course (Cantrell et al., 2003), further enhancing their cognitive content mastery along with the enactive mastery
Palmer (2006b) sums up cognitive pedagogical mastery for science teaching as “success in mastering an understanding of some motivating and effective techniques for teaching science could therefore be expected to make an important contribution towards developing their science teaching self-efficacy” (p. 339). Specific preservice GDE-P primary science education mastery experiences will be discussed later in the chapter.

Vicarious experiences

Bandura (1977) discussed how transitory experiences leave long-lasting cognitive impressions on individuals, and as such, much of human behaviour is derived from observation of modelling behaviours. During preservice teacher education, there is a limited amount of practicum where preservice teachers get to teach in a realistic setting, therefore, vicarious experiences are employed in on-campus units. These experiences portray the nature of the teaching task through watching others teach in the form of classroom observation or via other media sources (Palmer, 2006b; Rice & Roychoudhury, 2003; Tschannen-Moran et al., 1998). The observation of others who perform perceived threatening activities without negative repercussions could generate expectations in the observer’s aspirations and beliefs in their own capabilities (Bandura, 2012).

Observing successful teachers’ skilful and adept ways of working with subject content and students can increase the personal teaching self-efficacy of preservice teachers and encourage to believe they can also be successful teachers in similar situations (Bandura, 2012; Tschannen-Moran et al., 1998), and also to improve if they persist in their own efforts (Bandura, 2012). However, if a preservice teacher observes other teachers’ failure, their self-efficacy may further erode and not persist with teaching, unless their self-efficacy is such that they believe they have greater skills than the model (Bandura, 2012; Tschannen-Moran et al., 1998). Van Dinther, Dochy and Segers (2011) suggest vicarious experiences have a weaker effect on individual’s self-efficacy than mastery experiences and individuals who have lower self-efficacy will be more sensitive to observation of success or failure.

Research has found PSTE can be improved during preservice teacher education through modelling of a primary classroom setting where the tutor assumes the role of
the teacher and the preservice teacher assumes the role of the children whilst conducting hands-on activities (Palmer, 2006b; Rice & Roychoudhury, 2003). However, as this is not direct observation of a classroom it is not considered to truly reflect Bandura’s (1977) live modelling vicarious experiences. Palmer (2006b) suggests this would be referred to as simulated modelling. Palmer (2006b) also noted in the absence of mastery experiences, vicarious experiences were the most effective influence on science teaching self-efficacy.

**Verbal/Social persuasion**

Social persuasion is the third influence of an individual’s self-efficacy. Bandura (2012) mentioned that if individuals are persuaded by others to believe in their own abilities, they are more likely to persevere in adverse conditions; therefore, “resolve increases the chance of success” (p. 13).

Verbal persuasion may also take the form of evaluative feedback. When those who provide verbal persuasive communication and evaluative feedback are regarded, by the recipient, as realistic, reliable and knowledgeable, its effect on individuals is far greater (van Dinther et al., 2011). Positive feedback highlighting personal capabilities has been found to increase an individual’s sense of self-efficacy, whereas feedback focussing on shortcomings may deflate their self-efficacy (van Dinther et al., 2011).

Bandura (1977) suggests that efficacy expectations through this type of experience are likely to be weaker than those influenced through their own accomplishments as they do not provide authentic experiences for them; yet these influences are most readily available in a social setting. In preservice teacher education, tutorials, lectures and workshop discussions could also be considered verbal persuasion (Palmer, 2006b).

**Emotional arousal / Physical and emotional cues**

Self-belief in coping capabilities is considered an important factor in self-regulation of emotional states (Bandura, 2012). This will affect the quality of an individual’s emotional life and shapes their vulnerability to stress and depression (Bandura, 1977). Situations that may be stressful or taxing will elicit emotional arousal that may inform an individual’s personal competency (Bandura, 1977). Physiological arousal will inform an individual their level of anxiety and stress in a vulnerable situation; and in turn will produce a behaviour that will determine the level and direction of motivation.
for their actions (Bandura, 1977). For example: an individual who is susceptible to fear and anxiety arousal tends to become more preoccupied with their perceived inadequacy of performing a task rather than actually doing it (Bandura, 1977). Bandura (1977) suggests by having fear-provoking thoughts about ineptitude an individual could increase their levels of anxiety, which far exceeds the fear levels that may be experienced during an adverse situation. A positive mood may strengthen an individual’s self-efficacy whereby a negative mood my lower this (van Dinther et al., 2011). As individuals have the capacity to affect their thinking and feeling, those with high self-efficacy can use the physiological cue of tension as energising and enhance their performance; those with low self-efficacy may interpret the cue of tension as weakness (Panjares, 1997; van Dinther et al., 2011).

Research into emotional climates in educational settings has found emotions to be very important to be considered for students and teachers (Bellocchi, Ritchie, Tobin, Sandhy & Sandhu, 2013; Thomson et al., 2016). It was found that teachers’ emotional states were reflected in their pedagogical styles (Bellocchi et al., 2013; Thomson et al., 2016). Teachers with positive emotional states (displaying enthusiasm, humour, laughter) taught with greater student-focussed approaches (in dialogical interactions); whereas, those with negative emotional states (including anger, fear and anxiety) tended to use transmissive pedagogies (reliant on use of textbooks) using univocal interactions (Bellocchi et al., 2013; Hargreaves, 2000; Thomson et al., 2016). Teacher emotions set the emotional climate around them; and are therefore embedded and shown in interactions with others in building relationships (Bellocchi et al., 2013; Hargreaves, 2000). Logically this leads to consider the emotional climate a tertiary tutor develops in their tutorials will in turn also influence the preservice teachers’ self-efficacy in that context.

**Summary for science teaching self-efficacy**

People are motivated to perform an action if they believe it to have a favourable outcome (outcome expectation) and if they are confident the outcome will be successful (self-efficacy expectation) (Bandura, 1977, 2012; Bleicher, 2004; Cripps Clark & Groves, 2012). Placing this into context, the teaching of primary school science (i.e., Years 1-6 in Western Australia) is therefore, dependent on the teacher’s self-efficacy (Mulholland et al., 2004). Self-efficacy is a key motivational construct,
which influences professional behaviours that shape a teacher’s effectiveness in the classroom, and therefore affect student learning and achievement (Klassen, et al., 2009; Mulholland, et al., 2004; Pendergast, et al., 2011).

As stated earlier, efficacy beliefs develop early and are somewhat resistant to change (Bandura, 1977); however, efficacy is more malleable in preservice teachers as they have fewer mastery experiences (Tschanen-Moran et al., 1998). It therefore has implications for teacher education. Self-efficacy is contextual and teachers’ efficacy beliefs are dependent on the teaching situation (Riggs & Enochs, 1990). A specific instrument to measure science teaching self-efficacy beliefs was developed to investigate and predict science teaching behaviour (Ginns et al., 1995).

**Measuring primary science teaching self-efficacy**

The development of an instrument to measure science-teaching self-efficacy started with Rotter’s social learning theory (Tschanen-Moran & Hoy, 2001). The RAND (Research and Development) Corporation used Rotter’s two constructs of internal and external locus control to develop two questions to measure teacher self-efficacy within an extensive questionnaire (Tschanen-Moran et al. 1998; Tschanen-Moran & Woolfolk Hoy, 2001). In 1976, RAND researchers investigated teacher self-efficacy as the extent that a teacher believed they could control reinforcement of their actions, as an internal locus control, rather than external control by their environment (Tschanen-Moran & Woolfolk Hoy, 2001). To measure the teaching self-efficacy, teachers would indicate their agreement level of two questions; one which addressed the construct of the extent a teacher believed external factors (such as home environment) affected a student’s motivation and performance; the other question addressed the extent a teacher believed their ability to teach unmotivated or difficult students (Tschanen-Moran & Woolfolk Hoy, 2001; Tschanen-Moran et al., 1998). A teacher who expressed confidence in their teaching of difficult or unmotivated students believed their teaching activities were controlled by internal control (Tschanen-Moran & Woolfolk Hoy, 2001). The notion of general teaching efficacy was proven through research finding a significant relationship existed between a teacher’s self-efficacy belief and their students’ achievement (Dembo & Gibson, 1985; Tschanen-Moran & Woolfolk Hoy, 2001).
Further development of an instrument to measure teacher self-efficacy occurred using Bandura’s (1977) theory of self-efficacy. During the 1980’s research into self-efficacy by Ashton, Webb and Doda as well as Gibson and Dembo led to further knowledge of understanding teacher self-efficacy (Dembo & Gibson, 1985). Gibson and Dembo created a 30-item, 6-point Likert scale questionnaire, and yielded through a factor analysis Bandura’s constructs of outcome expectancy and sense of self-efficacy (Dembo & Gibson, 1985; Gibson & Dembo, 1984):

The first factor represented the belief that a teacher’s ability to bring about change is limited by factors external to the teacher, such as home environment, family background, and parental influence. The second factor represented a teacher’s sense of personal teaching efficacy or belief that she or he has the skills and abilities to bring about student learning (Dembo & Gibson, 1985, p. 174).

Gibson and Dembo (1984) considered personal teaching efficacy as a construct of an integration of an individual’s personal efficacy and their teaching efficacy.

As Bandura (1981) stated, individuals differ in their efficacy and efficacies are contextual to a situation. Enochs and Riggs (1990) extrapolated this definition and applied it to primary-science teaching as a context specific domain, investigating the behaviours, thought patterns and affective reactions in regard to teaching primary science. As primary teachers teach across a wide variety of subject areas, Enochs and Riggs (1990) considered these teachers would have varying efficacies between subject areas. Using Gibson and Dembo’s (1984) general teaching efficacy measurement instrument, Riggs (as cited in Enoch & Riggs, 1990) developed a science specific measurement instrument to assess science teacher self-efficacy and outcome expectancy beliefs of in-service primary teachers, named the Science Teaching Efficacy Belief Instrument Form A (STEBI A) (Enoch and Riggs, 1990). This instrument was a 25-item (13 positively written and 12 negatively written statements), on a 5-point Likert scale based on the two factors of Personal Science Teaching Efficacy Belief Scale (PSTE) and Science Teaching Outcome Expectancy.
Scale (STOE). This instrument was used by various researchers and found to be reliable and valid in both constructs.

A STEBI-A item example is:

3. Even if I try very hard, I do not teach science as well as I do most subjects.

This item is based on the Bandura’s (1981) premise that “people tend to avoid situations they believe exceed their capabilities, but they undertake and perform with assurance activities they judge themselves capable of handling” (p. 201).

The STEBI-A was modified to become STEBI-B (Enochs & Riggs, 1990), to be used in preservice teacher education. This underscores the research that claims self-efficacy can be enhanced through modelling, together with the successful mastery teaching experiences (Bandura, 1977). To be able to use this in preservice teacher science content and methodology units, the survey items were modified to become reworded in future tense. Taking the same item, the STEBI-B modifies it to:

3. Even if I try very hard, I will not teach science as well as I will most subjects.

Further research into in-service and preservice primary-science teaching self-efficacy using these instruments found the two factors of self-efficacy work independently from each other (Enochs and Riggs 1990; Gibson and Dembo 1984; Mulholland et al., 2004; Taştan Kirik, 2013; Tosun 2000). For example: a teacher with high PSTE may believe they can teach science effectively; however, may have a low STOE whereby they believe their teaching will may not have a great influence on student learning. Preservice teacher primary science teaching education courses may then become an intervention that can produce changes in their PSTE (Tosun, 2000), STOE (Ginns et al., 1995) or in both constructs (Bleicher, 2006). The monitoring and reacting to self-efficacy in preservice science teacher education have become a way teacher preparation programmes can evaluate the structure of their programs (Avery & Meyer, 2012; Tschannen-Moran & Woolfolk Hoy, 2001).
Some researchers have found that in the STEBI-B the construct of STOE may be problematic as preservice teachers have not taught in authentic classroom situations, and therefore they may measure external influences or external attributions to their future success or failure (Roberts & Henson, 2000; Tschannen-Moran et al., 1998). For example, this belief may be based on discussions with others, or by observing the teaching of a successful experienced teacher and then comparing themselves against these as standards.

Continued development of new self-efficacy instruments also includes the work of Shulman’s (1986) pedagogical knowledge efficacy as part of the constructs. The development of a Self-efficacy Teaching and Knowledge Instrument for Science Teachers (SETAKIST) was proposed by Roberts and Henson (2000), which would address both the methodological and theoretical problems of efficacy instruments within the field of science education.

Although varying forms of the STEBI have been developed, there has been continued international use (particularly throughout the USA, Turkey, Australia and The Netherlands) of the original STEBI-B (Enochs & Riggs, 1990) to investigate preservice teacher primary-science teaching self-efficacy. To allow for variance between languages the STEBI-B has been modified for use in countries such as The Netherlands (van Dinther et al., 2011; Velthuis, Fisser & Pieters, 2013) and Turkey (Taştan Kirik, 2013).

The self-efficacy of preservice teachers

Research into practising primary teachers has shown successful teachers tend to be highly efficacious, more willing to accept challenges and more committed to teaching science (Appleton & Kindt, 2002; Menon & Sadler, 2016; Riggs & Enochs, 1990). Teachers with high self-efficacy tend to be more likely to create student-centred environments incorporating hands-on inquiry based pedagogy (Menon & Sadler, 2016; Watters & Ginns, 2000). Teachers with low self-efficacy tended to rely on textbooks, limiting student creativity and problem solving to understand science concepts (Appleton & Kindt, 2002). These teachers tended to have weak commitment to the profession, custodial behaviour in the classroom and spend less time on
academic endeavours compared to teachers with higher self-efficacy (Gibson & Dembo, 1984; Mulholland et al., 2004; Woolfolk & Hoy, 1990). The low science teaching self-efficacy of these primary teachers has been attributed to the lack of their own understanding of science content along with insufficient experiences with successful science teaching (Bleicher, 2007). Further research has shown that PSTE and science attitudes are strongly correlated; however, a lack of relationship was found between STOE and science attitude (Settlage, 2000).

Research into self-efficacy of primary science preservice teachers has found many may have limited science learning exposure throughout their own schooling prior to commencing a teaching education course (Bleicher, 2004; McKinnon & Lamberts, 2013; Mulholland et al., 2004). Research has shown that lack of prior science knowledge by preservice teachers has been linked to low perceived self-efficacy to teach primary science (Menon & Sadler, 2016; Rice & Roychoudhury, 2003). As mentioned earlier in the chapter, self-efficacy is shaped early (Bandura, 1977), and this may have occurred during the secondary schooling years of preservice teachers. Preservice primary-science teachers may enter the course with a lower self-efficacy in science, as secondary students who had high self-efficacy in science tended to continue with science-based professions rather than entering primary teaching (Mulholland et al., 2004).

The continuing argument that preservice primary teachers are still entering their teacher training courses with many of them having a lack of confidence in both mathematics and science (Avery & Meyer, 2012; Mulholland et al., 2004), continues the need for increased engagement in subject and pedagogical content learning experiences that will increase their self-efficacy in these subjects. Avery and Meyer (2012) discussed that historically preservice teachers complained about the lack of hands-on methodology and they often described their science learning experiences using terms such as frustrating, stressful, tedious, boring, scary, impossible, and a waste of time (Tosun, 2000); leaving the course with feelings of dread, lacking confidence or being scared of science (Tosun, 2000). These negative experiences for a preservice teacher are often translated into their classrooms upon graduating, which continue the cycle of textbook approach to teaching science (Avery & Meyer, 2012). Lummis et al. (2014) posit that supportive learning environments are created where
Preservice teachers are supported to take learning risks. In turn teacher efficacy may be increased if preservice education provides both practical and knowledge skills which results in positive mastery experiences (Lummis et al., 2014).

As science is stereotypically seen as a male-dominated field, experience of females in school and society was thought be a factor of science teaching self-efficacy (Riggs, 1991; Steele, Brew, Rees & Ibrahim-Khan, 2012). Research found males had a higher level of self-efficacy belief for teaching of science than females; however, there was not a significant difference for outcome expectancy beliefs between each gender (Riggs, 1991; Steele et al., 2012; Tosun, 2000). It was found that the background experiences and education of the preservice teachers played a significant role in their self-efficacy rather than gender (Steele et al., 2012; Tosun, 2000). Tosun (2000) suggests preservice education must look at methods to link experiences with preservice teacher current and future learning of science.

Bleicher (2009) examined relationships between science content knowledge, the understanding of learning cycles and preservice teacher self-efficacy. In Bleicher’s study the context of the learning cycles (LC) refers to Karpel & Their’s (cited in Bleicher, 2009) three phases of exploration, invention and discovery LC. Bybee et al. (2006) phases of exploration, concept introduction, and concept application as well as the 5E LC model. Bleicher (2009) categorised the preservice teachers into four groups (fearful, disinterested, successful and enthusiastic science learners) according to their differing background characteristics in science interest and prior performances in science courses. The analysis revealed clear disparities between three of the groups; whereby fearful learners had less science content learning and knowledge of the learning cycle than disinterested and enthusiastic groups; disinterested learners had fewer science content knowledge than enthusiastic learners; the fearful science learners were less confident to learn science than the other categories; however, there was little distinguishing data between successful and enthusiastic learners (Bleicher, 2007). Bellochi et al., (2013) found social rules set by society in general; family and school influenced preservice teachers’ emotional displays. The emotional displays include codes of behaviour such as positive and negative emotions (e.g., happiness or aggression) (Bellochi et al., 2013). As emotion is a factor of self-efficacy Bandura
(1977) together with Bleicher (2009) support Tosun’s (2000) notion that background experiences are important factors in determining teaching self-efficacy.

The notion of entitlement is another area to be discussed in relation to preservice teachers’ self-efficacy, as entitlement may have an effect on individuals’ emotional being and the emotional climate they can assert at a tertiary institution (Fisk, 2010; Fullerton, 2013; Singleton-Jackson, Jackson & Reinhardt, 2010). Singleton et al. (2010) found students arrive at tertiary institutions expecting to have a voice as well as a significant degree of control over their university experiences. Researchers found students believe they are entitled to, and deserve, to receive certain benefits, treatments and services as they consider themselves as consumers or customers of the university (Fisk, 2010; Fullerton, 2013). Fullerton (2013) found many students believed professors should possess the attributes of effective teaching, along with setting clear expectations, fair treatment and possess empathy towards the students whose personal situation may impact their classroom performance; for example, special compensation for late work without penalty and the provision of all required materials for assessments.

Excessive entitlement is when an individual’s desire for a set outcome exceeds a socially normative value as based on their input (Fisk, 2010). Fisk (2010) asserts excessive entitlement is a pervasive and harmful social issue, whereby “individuals are increasingly subscribing to the belief they should get exactly what they want, when they want it — often times without regard for the well-being of others” (p. 102). Research has found no significant relationship academic entitlement and academic achievement; however, there was a negative relationship between academic entitlement and self-esteem (Singleton-Jackson, Jackson & Reinhardt, 2010). As individuals would prefer conditions of being over rewarded to satisfy their feelings of deservingness they may engage in the use acquisitive behaviours (Fisk, 2010), which may in turn affect their or others’ self-efficacy through social persuasion (Bandura, 1977).
Preservice primary teacher education

The continuing research into preservice primary-science education and preservice teacher self-efficacy on a global scale would indicate that the need for tertiary institutions to ensure reform and implement teaching strategies that can improve science teaching self-efficacy (Knaggs & Sondergeld, 2015; McKinnon & Lamberts, 2013). Similar trends with preservice teacher self-efficacy have emerged across the world, suggesting that the issue of self-efficacy to teach primary-science is not limited to Australia (i.e., elementary science education in the USA).

Taşтан Kirik (2013) posited that even if primary teachers possess scientific fact and knowledge it does not mean they can teach science effectively. Preservice teachers will need to be well versed in understanding students’ approach to science learning, possible alternative conceptions they may have, how to motivate students and how to create constructive learning environments (Taştan Kirik, 2013). Research has shown preservice teacher science-teaching self-efficacy is influenced by their conceptual understanding in science as well as their pedagogical knowledge on how to teach science (Taştan Kirik, 2013).

Research in Turkey (Taştan Kirik, 2013) outlined the need for tertiary institutions to be aware of the interplay of factors that may influence a preservice teacher’s self-efficacy including the need for science content education; and to design subject content and science teaching method courses accordingly to facilitate an improvement in preservice teaching efficacy. Research in the United Kingdom (UK) (Kind, 2009) found teachers lacked confidence to have student centred inquiry investigations in their classes, which echoed similar findings in the USA (Knaggs & Sondergeld, 2015), The Netherlands (Velthuis et al., 2015) and Australia (Palmer, 2006b). Palmer (2006b) reiterates that teachers who are under-prepared or with previous negative science experiences are more likely to avoid teaching science effectively or not at all. Knaggs and Sondergeld (2015) assert that preservice teacher training in the USA have not demonstrated a significant influence on science teaching self-efficacy in preservice teachers and reassert that previous calls for preservice teacher education reform are taken into account.
Design of preservice primary science teacher education courses

In Australia, many teacher education institutions have been investigating self-efficacy of preservice teachers and informing the design of courses (Bleicher, 2007; Mulholland et al., 2004; Palmer, 2006b; Teague & Corney, 2011). Mulholland, et al. (2004) assert preservice teachers must have access to high-quality subject that effect positive changes in self-efficacy even when teaching of children is not involved. Smolleck and Mongan (2011) agree preservice teachers must be given an opportunity to experience success as a learner of science in a ‘reform-oriented’ context; as well as experiencing first-hand how inquiry based science learning is placed within a primary classroom setting. Smolleck and Mongan (2011) posit that with successful science learning experiences the self-efficacy beliefs of preservice teachers will become a positive consequence to teaching science in an inquiry based manner in primary school. Bergman and Morpew (2015) assert there is little literature existing that provides clear guidelines for course development for preservice primary science teacher training. However, many researchers have found specific pedagogical strategies to be beneficial for improvement in science teaching self-efficacy in the tertiary setting.

Two areas of significance need to be addressed by preservice primary-science teacher education courses are the science content knowledge and pedagogical content knowledge, as the level of perceived confidence and preparedness affect self-efficacy (Kind, 2009; Palmer, 2006b).

Shulman (1986) proposed three categories for teachers’ content knowledge. These included:

- Subject matter content knowledge;
- Subject matter pedagogical content knowledge; and
- Curricular knowledge.

Subject matter content knowledge is the knowledge of the subject being taught (Shulman, 1986), in this case science content knowledge as set by the relevant curriculum body. An individual’s science content knowledge is dependent on the degree science concepts and facts have been developed throughout the teaching course, and how it interacts with their prior science conceptual understanding, prior
science experiences and attitude towards learning science (Bleicher, 2009). Bell, Matkins and Gansneder (2011) found preservice teachers who experienced explicit instruction in science content and the nature of science were able to apply their understandings appropriately to novel situations; indicating there was an increase in confidence in their science understandings. Bleicher (2009) considers science content knowledge to be a complex network of facts, concept principles and their applicability to the science domain, which preservice teachers need to understand. Constructivist learning theory can be applied to emphasise core concepts and principles of science content knowledge to “address fundamental understanding of science rather than superficial terminology” (Bleicher, 2009, p. 295). Bleicher and Lindgren (2005) found preservice teachers who had better conceptual knowledge also had higher self-efficacy beliefs. Yet, they also found no significant difference between conceptual understanding and outcome expectancy, indicating that science pedagogical understanding is more important than the number of science content courses taught by affecting their science teaching efficacy belief rather than their outcome expectancy (Bleicher & Lindgren, 2005). Schoon and Boone (1998) researched alternative conceptions held by preservice primary teachers and found that holding certain alternative conceptions was associated with low self-efficacy; however, it did not reveal any notable relationship with the construct of outcome expectancy.

Pedagogical content knowledge is a tacit, latent knowledge that teachers use in the teaching process. It is considered knowledge that is unconsciously and pragmatically used by teachers to prepare or conduct lessons (Kind, 2009). This general pedagogical knowledge may transcend subject matter (Shulman, 1986). Shulman (1986) asserts that pedagogical content knowledge “also includes an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons” (p. 9). The understanding of the preconceptions or misconceptions leads back to the need for science content knowledge in teachers (Shulman, 1986). Both knowledge constructs to promote student learning are intertwined (Kind, 2009). As pedagogical content knowledge is not automatic this can be taught through science teaching courses which addresses both science understandings and pedagogy (Knaggs & Sondergeld, 2015). Making pedagogical content knowledge explicit in teacher education may help preservice
teachers adjust to teaching and improved self-efficacy through the use of reflective practices (Kind, 2009). For high quality science teaching to be understood, Kind (2009) believes what constitutes ‘effective’ pedagogy for teaching science is to ensure preservice training includes:

- making explicit what science teachers do during science teaching;
- indicate how teaching approaches relate to students’ learning; and,
- asserting that science content alone does not produce high quality science teachers.

Shulman’s (1986) third category of knowledge is curricular knowledge. Curriculum knowledge is considered to represent the complete range of programs designed to teach a particular subject (Shulman, 1986). Shulman explains the curriculum and its subject specific materials are the pedagogy from which a teacher can draw from to teach and assess students. In addition, he contends that teachers need to know and understand what curricular alternatives that are available for effective teaching (Shulman, 1986); therefore, advocating its inclusion in the design for teacher education courses. Settlage (2000) asserts preservice teachers required an understanding of the learning cycle as this was found to be predictable by outcome expectancy but not personal science teaching efficacy. Settlage (2000) outlined the learning cycle as active engagement of students investigating of a natural phenomenon, exploration of the phenomenon with the teacher as facilitator, discussion and sharing of observations, subsequently targeting a science concept which is then applied to additional new situations. His study indicated that preservice teachers believed they could affect the learning of students and that understanding the learning cycle is considered a viable teaching approach; therefore, contributing to preservice teachers’ self-efficacy (Settlage, 2000).

Research literature has revealed that many preservice primary-science teacher education courses have both science content units and science method courses (Ebrahim, 2012; Palmer, 2006). Morrell and Carroll (2003) found that preservice teachers with low science teaching self-efficacy might be slightly influenced in a positive manner through science content courses. Bergman and Morphew (2015) argue that course design must include a dual focus of both science content and instructional modelling (science method unit). Bergman and Morphew (2015) believe
that course planning and curriculum decisions should be informed using self-efficacy sources such as vicarious experience, enactive mastery, and social persuasion (Bandura, 1977; Palmer, 2006b). Bleicher and Lindgren (2005) posit there should be a focus on method course design to ensure adequate experiential learning or mastery experiences, and include opportunities for discussion and reflection.

As mentioned above, to influence science teaching self-efficacy the design of the preservice primary science teacher education courses must include mastery experiences, vicarious experiences and have a supportive learning environment (Cakiroglu, Aydin & Hoy, 2011; Lummis et al., 2014; Mulholland et al., 2004). Research has found general content specific training alone hasn’t improved science-teaching self-efficacy, whereas methods courses have shown varying results (Ebrahim, 2012; Ginns, Tulip & Watters, 1995). The variety of curriculum delivery among varying institutions globally would account for varied results in STOE and PSTE levels (Knaggs & Sondergeld, 2015). Research has shown that PSTE and STOE are attributed to the mastery and vicarious experiences within a methods course (Bleicher & Lindgren, 2005; Knaggs & Sondergeld, 2015; Morrell & Carroll, 2003; Tosun, 2000). Science methods courses and science content courses seem to increase the PSTE levels but how unit design of content and pedagogy can be used purposefully to improve both STOE and PSTE consistently continues to be an area for further research (Knaggs & Sondergeld, 2015; Lakshmanan et al., 2011).

Mastery experiences in preservice primary science teacher education design

Bloom (1984) defines mastery learning as a large group of students undergo conventional instruction paired with feedback and corrective procedures to allow students to master the subject content. Successful experiences with science can increase a teacher’s confidence and may translate into better science teaching practices (McKinnon & Lamberts, 2013). Researchers advocate the source of science teaching mastery experiences through teaching science to children is the most important factor to affect science-teaching self-efficacy (Cantrall et al., 2003; Ginns et al., 1995; Mulholland et al., 2004). Cantrall et al. (2003) also claimed that being a participant in extracurricular science activities would also influence science-teaching self-efficacy as an additional source of a mastery experience. Meaningful assessments to consolidate science content and pedagogical content knowledge will also benefit the preservice teachers’ self-efficacy (Gunning & Mensah, 2011). Other researchers
suggest the inclusion of ‘peer teaching’ and discussions will also provide opportunities for mastery experiences (Morrell & Carroll, 2003; Settlage, 2000), along with providing a setting for social verbal persuasion (Tschannen-Moran et al., 1998). Research has shown the extensive use of hands-on activities will enhance PSTE by providing effective instructional strategies (pedagogical mastery) and consolidate science content understandings (content mastery) (Palmer, 2006b).

The social approach of cooperative learning also fosters deep-learning experiences, whereby preservice teachers’ focus on conceptual and theoretical meaning and mastery of concepts (Campbell & Cabrera, 2014; Volkov & Volkov, 2015). The intention of deep learning experiences is for students to ‘tie together’ individual learning facts into a larger picture, giving a broader conceptual understanding of set course curriculum (Campbell & Cabrera, 2014). Research found deep learning approaches can foster positive emotions of excitement and exhilaration in learners, whereas surface approaches to assessments created negative emotions of boredom, anxiety or dread (Campbell & Cabrera, 2014). The provision of open-ended and authentic assessments, fostering deep learning, that could be used as future reference are therefore an important source of self-efficacy (Dawson, Forster & Reid, 2006). Research has shown surface approaches utilised during preservice teacher science teaching education courses, such as memorisation of course material or modelling of teaching methods by practicum supervisors, maybe problematic as preservice teachers may not be versed enough in the nuances of teaching (Gordon & Debus, 2002). Therefore, deep learning approach would in turn give preservice teachers a mastery experience of scientific knowledge as well as set a positive emotional cue, both of which are important dimensions of factors influencing self-efficacy (Bandura, 1977).

As mentioned earlier in the chapter, self-efficacy of teachers is also determined by the belief in their ability to teach unmotivated or difficult students (Dembo & Gibson, 1985; Soodak & Podell, 1996). Teachers with high self-efficacy will problem solve to work with these students, and those with low self-efficacy will attribute difficulty to student failure and not engage in innovative methods to deal with the difficulty (Dembo & Gibson 1985; Gibson & Dembo, 1984). Based on this premise Gordon and Debus (2002) assert that preservice primary science teacher education courses that
facilitate deep learning approaches are also facilitating students to gain problem solving capabilities that will sustain their PSTE in their classroom teaching.

**Vicarious experiences in preservice primary science teacher education design**

As Bandura (1977) mentioned, mastery experiences might not always be available and therefore vicarious experiences are considered another valuable source of self-efficacy. Teachers and preservice teachers have explicit and implicit beliefs about science, learning and teaching National Research Council (NRC), 2000); therefore, it is important they are able to engage in science learning experiences (similar to their students) to further develop their concept understanding (Avery & Meyer, 2012) and their beliefs. Research has shown that preservice teachers who have experienced simulated modelling may also increase their belief that same techniques may be effective in primary classrooms (Palmer, 2006b). Gunning and Mensah (2011) found peer discussions about teaching, hands-on activities, classroom videos and ‘microteaching’ opportunities as vicarious experiences also improved science teaching self-efficacy. Prior research has shown engagement preservice teachers in the learning cycle of planning, teaching and planning can increase their understanding and organisation of key science concepts (Schwarz, 2009). Observational engagement of effective and enthusiastic science teaching experiences also allows preservice teachers to build a repertoire of teaching techniques and increases confidence to engage in further discourse (Rice & Roychoudhury, 2003).

As research has shown, many preservice primary science teachers commence teacher training with low science efficacy and feeling underprepared with science content knowledge (Bleicher, 2009). Research has also demonstrated that children are not passive learners and hold deeply rooted conceptions and ideas they have constructed themselves through experience (Duit & Treagust, 2010). This notion may be similar to preservice teachers’ science content understanding; therefore, researchers advocate preservice primary science teacher courses include constructivism as one of the theories to promote hands-on experiential learning (Skamp, 2012; Skamp & Mueller, 2001a) as a simulation model of teaching (Bleicher, 2007) to change misconceptions in science understanding. Bleicher’s (2007) research found by engaging preservice teachers in a constructivist learning environment it allowed sufficient time for individuals to engage in exploring a scientific phenomenon followed by adequate time
to discuss and process their findings with peers. Preservice teachers need to engage in this type of pedagogical design as part of building their repertoire of knowledge and skills.

Research into effective science teaching has developed further science teaching models such as inquiry or problem based learning, learning approaches, cooperative learning and deep learning experiences (Avery & Meyer, 2012; Menon & Sadler, 2016; Smolleck & Mongan, 2011; Volkov & Volkov, 2015). Cooperative learning is based on Vygotsky’s premise that learning is a social activity (Steele et al., 2012). Together with a constructivist view of building conceptual understanding, the learning of science in a social context has been demonstrated as a useful science teaching strategy, whereby students together can construct their understanding of scientific concepts on the basis of experiences (Bleicher & Lindgren, 2005; Druit & Treagust, 1998; Skamp, 2012). Steele et al. (2012) found preservice teachers poorly interpreted the teaching of the inquiry based model and preferred a social constructivist approach to learning science. Smolleck and Mongan (2011) assert preservice teachers must experience learning science as inquiry first hand to understand how science learning occurs in primary schools. Successful experiences may provide increased levels of self-efficacy beliefs of preservice teachers and lead to usage of learning theories in primary classrooms (Enochs & Riggs, 1990; Palmer, 2006b; Skamp & Mueller, 2001b; Smolleck & Mongan, 2011). Palmer (2006b) reported that effective science instructional strategies such as role-playing were beneficial to preservice teachers’ self-efficacy as they could relate this to the primary classroom. Research into teaching strategies found that hands-on practical activities were fundamental to teaching science as they provide a motivational tool by making science enjoyable (Chng, Yew & Schmidt, 2015; Cripps Clark & Groves, 2012), along with providing significant shared experiences that promote conceptual changes (Cripps Clark & Groves, 2012). Research into informal science education, such as museums and science centres, have also been found to be beneficial to preservice teacher confidence as they highlight the relevance of science in everyday living (McKinnon & Lamberts, 2013). Bleicher and Lindgren (2005) advocate that activities that require reflection, discussion and experiential learning as part of a learning cycle will contribute to preservice teacher confidence to teach science. Bybee (2014) asserted preservice teachers require competencies of science content, practices and understand pedagogical implications
in order to be able to integrate curriculum, instruction and assessment in their teaching of primary science. Exposure to different theories, approaches and models have found to enable preservice teachers to develop further discourse in primary science teaching practices (Hudson & Ginns, 2007).

Recent research has shown that primary science teachers may still lack confidence to teach science, as on average 57 hours per year is spent teaching science in Year 4 Australian primary school classes, compared to Year 4 international average of 76 hours a year (Thomson, Wernert, O’Grady & Rodrigues, 2017). This research also indicated that within Australia 77 per cent of students had primary trained teachers without science specialisation and seven per cent that had science tuition from teachers with neither specialist science or primary education training (Thomson et al., 2017). Results of global trends in science and mathematical attitudes and knowledge by primary students highlighted the need for appropriate resources to be developed to support the teaching and learning of science (Rennie, Goodrum & Hackling, 2001). In Australia, the development of resources that were pedagogically based on Bybee’s (1997) learning cycle and aligned with the national curriculum, have been found to improve primary teacher confidence and self-efficacy to teach science (Hackling, 2014). Resourcing is considered important for teaching and learning of science in primary schools; however, preservice teachers need to build familiarity with these resources prior to graduation, as primary teachers have reported lack of time to engage in the resources (Fitzgerald & Schneider, 2013).

Research into the effectiveness of both specialised science teaching content courses and traditional science content courses has shown that one integrated specialised content course has a greater impact on preservice teachers’ science teaching self-efficacy; in comparison to having two separate courses (Menon & Sadler, 2016). Menon and Sadler (2016) found specialised content courses provided improved opportunities to engage both learning of science content with concurrent exposure to effect science teaching pedagogy. Some studies revealed that science teaching practicum could lead to a decrease in PSTE (Utley, Mosely & Bryant, 2005), yet other studies found significant increase in PSTE (Cantrall et al., 2003). Continuing support through the provision of encouragement to the preservice teacher during science teaching practicum also benefitted the self-efficacy beliefs (Velthuis et al., 2014).
Understanding the notion of self-efficacy being malleable, it is imperative that science teacher education should plan experiences that will improve the self-efficacy beliefs of preservice teachers, which in turn may promote success of primary science teaching and learning (Smolleck & Mongan, 2011).

**Influences of science teacher educators on preservice teachers’ self-efficacy**

Bandura (1977) asserts a triadic causal effect on self-efficacy. Although the focus of this study is the self-efficacy of preservice teachers, it is imperative to discuss the influence of the science teacher educators as a social persuasive and emotional source of self-efficacy (Bandura, 1977; Bellocchi et al., 2013; Cripps Clark & Groves, 2012). Using a systems perspective, the behaviour of individuals within a system influence each other; in this way, the behaviour of a teacher influences a student, which in turn influences the teacher again in a circular communication process (Fisher & Rickards, 1998).

Teachers of science are influenced by their own science experiences, which in turn influence their perception and understanding of science learning and teaching (Fitzgerald, Dawson & Hackling, 2013). A teacher’s beliefs about students, the science learning process, science teaching, curriculum development and nature of scientific knowledge become part of the fabric of being a teacher that ultimately influences their science teaching practices (Fitzgerald et al., 2013). These attitudes and self-efficacy beliefs are strengthened through classroom experiences, which continue to develop further efficacy beliefs (Fitzgerald et al., 2013; Tschannen-Moran et al., 1998). Extensive explicit and implicit learning experiences accompanied by intense and focussed practice in teaching science may lead to intuitive teaching occurring (Sadler-Smith, 2008). Many classroom teachers become preservice teacher educationalists, whereby their prior science teaching experiences and self-efficacy will influence their pedagogical and content knowledge in a tertiary setting.

The role of a science teacher educator is of paramount importance (Petersen & Treagust, 2014). Howitt (2007) posits the role of the teacher educator is central to
science teaching experiences through their responsibility to develop and deliver science-learning experiences and to provide authentic assessments. Bleicher (2009) found teacher educators’ modelling and use of innovative teaching strategies were beneficial to promote increased self-efficacy in preservice science teachers. Research conducted by Mansfield and Woods-McConney (2012) found emphasis was placed on the role of the teacher educators to facilitate network opportunities with other teachers of science; therefore, extending students’ science teaching experiences. The role of the science teacher educator is further extended by the need to facilitate a reality check of students’ self-efficacy with their actual capabilities (Poulou, 2007) in a manner that promotes positive or realistic aspects of science teaching performance (Petersen & Treagust, 2014).

Cripps Clark and Groves (2012) posit teacher identity is developed from multiple lived experiences and social cultural history they come from; therefore, separation of teachers’ emotions and identity as being one specific ‘type’ of teacher (whether it is a science teacher, primary teacher, science teacher educator) is not possible. Bellocchi et al. (2013) discuss how emotions shape the learning process of both the teacher educator and students, where the teacher educator must be able to ‘read’ their students’ individual and collective emotional arousal of a class. The ability to ‘read’ students and adjust their classes accordingly is an important factor of a teacher educator (Hargreaves, 2000). The interplay of teacher identity and emotion has found to be an indicator of readiness for teachers to incorporate practical activities in a lesson (Cripps Clark & Groves, 2012).

Teaching and learning are socially situated practices that are influenced by emotional experiences (Cripps Clark & Groves, 2012). Similar to teachers in a school classroom, a tertiary teacher educator will relate their pedagogical styles to emotions, as positive emotions will foster student-focussed approaches and negative emotions will foster teacher-focussed approaches (Belocchi et al., 2013). Teachers are found to be ‘emotional practitioners’ as they are able to make their classroom environments exciting or dull (Hargreaves, 2000). Hargreaves (2000) found that teachers were able to ‘manufacture’ or ‘mask’ their emotions by displaying enthusiastic behaviours, displaying patience with a frustrating student, or calm when confronted by anger. This emotional labour, or managing of moods is considered the highest form of
competence (Hargreaves, 2000). Grasha (1994) investigated teaching styles as they are viewed as “a pattern of needs, beliefs and behaviours” (p. 142) displayed in classrooms. These styles are multidimensional which affects the manner individuals present information, interact and mentor students and managed classrooms. The teacher styles that Grasha (1994) proposed were:

- ‘Expert’ teacher- teaching as a transmitter of information, which can be intimidating or not allowing critical thinking;
- ‘Formal’ teacher– sets and works by a set of standards and defines acceptable ways of performing, which can lead to rigidity and standardising the way to deal with students;
- ‘Personal model’ teacher – teachers ‘teach by example’, hands on nature and encouraging students to observe, which could lead to students feeling inadequate if they do not ‘measure up’;
- ‘Facilitator’ - there is an emphasis on personal interactions between teacher and student, guides students to explore options and suggest alternatives, which can lead to time inefficiency and making students uncomfortable if not used positively; and,
- ‘Delegator’ teacher – believes students work independently and is available on student needs basis, which may create anxiety in students who struggle with autonomy.

Grasha (1994) believed that teachers do not prescribe to only one style and often blend these to meet the outcomes set; therefore, creating integrated model of teaching and learning. Grasha’s (1994) research found when teachers combined the ‘expert’ and ‘formal’ styles it created cool emotional climates whereby students felt uncomfortable to interact with teachers; conversely, a blend of ‘delegator’/‘facilitator’/‘expert’ styles created warm emotional climates whereby teacher and students work together, share ideas and students felt comfortable to ask for assistance. As mentioned earlier setting a positive (warm) emotional climate can lead to successful interactions between teacher educators and preservice teachers (Bellocchi et al., 2013) which works towards increased self-efficacy (Bandura, 1977).

Howitt (2007) found the most valuable teacher educator characteristics to promote preservice teacher self-efficacy were enthusiasm, use of humour, passion for science,
and being approachable and friendly. Teacher educators who are seen to be caring, approachable and empathetic to students’ learning are socially congruent, as this plays part of developing a positive rapport with students (Chng, Yew & Schmidt, 2015). These tutors were found to create learning environments that promoted peer exchange of ideas and allowing for students to create new knowledge (Schmidt & Moust, 1995). Research has shown tutors who had appropriate content knowledge and the ability to express themselves to students in a manner easily understood, were found to be more effective in explaining concepts (Chng et al., 2015). These characteristics provide a positive emotional climate (Hargreaves, 2000) as well as acting as a role model for preservice teachers (Howitt, 2007), which influence self-efficacy beliefs.

For teacher educators to be effective they need to be well versed as “expert learners who can explicitly model their own learning strategies by asking meta-cognitive questions and focussing on the process of learning” (Learly, Walker, Shelton & Fitt, 2013, p. 43). They are to facilitate and support student learning (Leary et al., 2013); facilitate the locating and use of significant science teaching resources (Hackling, 2005); provide an environment that will promote a student’s level of intrinsic motivation and interest in a subject (Chng et al., 2015); and facilitate positive attitudes to promote student success in academic achievement (Taştan Kirik, 2013).

Chapter summary

Chapter Two presented important literature to underpin this study. It has drawn together the themes of the constructs of preservice teacher self-efficacy, the importance of tertiary teacher education training course design and the influence of the science teacher educator.

As preservice teacher self-efficacy is the central construct to this study, this chapter presented a position on how self-efficacy is constructed and influenced through triadic reciprocal causation (Bandura, 1977), whereby personal self-efficacy can be influenced through: mastery and vicarious experiences, social persuasion and emotional climates. In addition, the literature highlighted how self-efficacy is malleable and will continue to change with subsequent experiences and exposures. The literature exposed the importance for positive attitudes and confidence to be built
through well-designed preservice teachers’ education ensuring future teaching of primary science is impacted in a positive way. The literature reviewed informed the theoretical and conceptual frameworks that are outlined in Chapter Three.
CHAPTER THREE
THEORETICAL AND CONCEPTUAL FRAMEWORK

Introduction
Chapter Three introduces the theoretical and conceptual framework that formed the basis for this intrinsic case study. This study is an intrinsic case study (Creswell, 2014) as the study of GDE-P preservice science teachers and the specific design of a unit with their tutors were under investigation. The research was to investigate preservice teacher self-efficacy for teaching primary science through collecting anecdotal narratives from the preservice teachers, university staff and classroom observations along with measuring the latent trait of self-efficacy through a survey. Therefore, the researcher chose to employ a mixed methods design utilising both quantitative and qualitative data. This chapter will introduce theoretical perspectives of quantitative and qualitative paradigms, which provides a matrix whereby the embedded mixed method pragmatic paradigm is chosen to underpin this research.

A theoretical framework is one that provides a stance, structure, procedures and rules by which the research is positioned (Creswell & Plano Clark, 2011; Neuman, 2007). The conceptual framework provides a cohesive collection of interrelated concepts of pertinent themes associated with the research, along with providing a description of the relationship of key concepts and variables (Punch, 2000).

Choosing The Research Paradigm
According to Creswell and Plano Clark (2011), multiple paradigms could be used in mixed methods research, which are best aligned to the types of mixed methods designs used in the study. The philosophical assumptions, such as the epistemology behind the study, in mixed methods research are the set of beliefs that guides the inquiries (Creswell & Plano Clark, 2011). Within the educational perspective, the quantitative approaches are often associated with post-positivism, qualitative approaches are associated with constructivism and mixed method approaches with pragmatism (Creswell & Plano Clark, 2011). Each paradigm will be discussed to allow the reader to understand the pragmatic paradigm position taken by the researcher.
As mentioned earlier, the aim of this research was to measure the latent self-efficacy beliefs of preservice teachers, therefore, the researcher determined a quasi-experimental post-positivist paradigm was appropriate for the study. This paradigm is underpinned by Auguste Comte’s philosophy of positivism that dates to 1830-1842, where he believed truth came from facts that could be verified and therefore used cause and effect scientific methods (Newby, 2010) to study phenomena. This paradigm may be called ‘scientific’ or ‘positivism’ paradigm by some researchers (Mackenzie & Knipe, 2006; Payne & Payne, 2004; Pring, 2010; Shadish, Cook & Campbell, 2002).

The positivist paradigm has a scientific theoretical framework (as defined by Swanson, 2013), which is based on a single reality (Creswell & Plano Clark, 2011; Mertens, 2007; Pring, 2010) or critical realism (Mertens, 2007) whereby there is a tendency to reject or fail to reject a hypothesis. To assign this empirical framework to a social setting is difficult due to the large quantity of variables; therefore, it is not suited for social science research.

The post-positivist paradigm recognises the complexities of social research, accepting multiple perspectives and the subjective nature of research findings through the involvement of the researcher (Cohen, Marion & Morrison, 2011). This acknowledgement supports the use of quasi-experimental designs (Shadish et al., 2002) whereby the researcher can observe participants within their settings (Punch, 2009).

Cresswell and Plano Clark (2011) assert the post-positivist paradigm is based on:

- Cause and effect thinking;
- Narrowing and focusing on interrelated variables;
- Measurement and detailed observation of variables; and,
- Continual testing to refine theories.

Its epistemology may be objectivist, dualistic (Pring, 2010) or modified (Mertens, 2007), providing impartiality from the researcher’s perspective. The deductive
methodology is context free, predictive, controlled (as best as possible), manipulative and experimental (Pring, 2010) from a ‘top’ down (theory to hypothesis to data) approach (Creswell & Plano Clark, 2011).

Critical discourse of post-positivism has included: some interpretivists believing that human behaviours cannot have linear casual relationships as human behaviour is not stable nor uniform; some critical theorist believing it is providing generalised claims and sees the world without its complexities (Cohen, et al., 2007), some sociologists believing it to be superficial, value neutral with objectification of participants (Payne & Payne, 2004). Confirmation bias is another area of consideration, because a researcher might filter out potentially useful facts or information at a subconscious level to confirm their own established preconceptions. This confirmation bias can lead to statistical errors (Johnson & Christensen, 2014). However, the internal and external validity, reliability and objectivity of this paradigm give it strength to be used in research (Mertens, 2007; Mackenzie & Knipe, 2006), especially if counterbalanced using a mixed methods approach.

**Interpretivist-Constructivist Paradigm**

The humanistic quantitative approach to social research evolved after 1946 into many paradigm subsets including interpretative and constructivist paradigms (Cohen, 2011; Creswell, 2012; Payne & Payne, 2004; Pring, 2010) and phenomenology (Smith, 2013). During the 1960’s and 1970’s education research was influenced by the shift in social research as it was looking for answers using human behaviours and perceptions to give deep insight into why things happen as they do in a non-quantifiable manner (Newby, 2013). Freire’s study of human existence and Giroux’s studies led to existentialism and critical theory (Leonardo, 2004).

The theoretical underpinnings of constructivism are based on relativism and anti-foundationalism with multiple complex realities (Cohen, 2007; Pring, 2010). The epistemology tends to be constructivist, transactional and subjective values (Cohen et al., 2007). Therefore, constructivism is based on understanding or gaining meaning of a phenomenon through the subjective views of research participants, through social interaction or personal experiences (Creswell & Plano Clark, 2011) and the construction of ‘facts’ influenced by the data interpretation of the researcher (Pring,
The closeness of the researcher through personal interactions with the participants could lead to bias; however, it also benefits from an inductive method of data collection (Creswell & Plano Clark, 2011). The methodology is through building narrative and observation analyses on which conjectures and hypotheses are based, subsequently creating generalisations or theory (Newby, 2013) as it works from a ‘bottom-up’ perspective (broader themes leading to theory development) (Cresswell & Plano Clark, 2011).

This paradigm is contradictory to the post-positivist paradigm; therefore, many positivists question the subjectivity and methodological rigor of constructivism (Cohen et al, 2007). Johnson and Christensen (2014) note the drawbacks, include:

- The findings being unique, therefore the knowledge produced might not generalise to other contexts;
- Difficulty in testing hypotheses and theories with large number of participants; lengthy timeframe for data collection and analysis; and,
- This type of study may have lower credibility with some administrators and commissioners of programs.

Cohen, et al., (2011) discuss the notion of reality is constructed through subjective perceptions and as such participants are ‘free agents’ with their own interests, desire, life’s aims and the will to decide how they will act. Hence, the disclosure of information by participants may not guarantee replication in another context. The constructivist paradigm is complex and inductive in nature; therefore, a visual conceptual framework is required to give coherence to the research, its theoretical perspectives, strategy and design, and its outcomes (Leshem & Trafford, 2007; Newby, 2013).

**Pragmatic Paradigm**

According to Johnson, Onwuegbezie and Turner (2007) this paradigm emerged in the early 1950’s from a quasi-experimental background combining both the philosophical and methodological practices of the two dominant research paradigms. Further developments occurred during the 1980’s and 1990’s as a reaction to polarisation between quantitative and qualitative research. An intellectual movement focusing on synthesis occurred that led Johnson et al. (2007) to label this paradigm ‘mixed
methods research’. Education research reform began, which included discussions of triangulation for validity of this paradigm (Johnson, 2004). Creswell (2013) defines this as a pragmatic paradigm whereby researchers focus on the ‘what’ and ‘how’ of the research problem.

The pragmatic paradigm focuses on the consequences of the study, with research generally being problem-centred using multiple methods of data collection (Creswell & Plano Clark, 2011). The research question is at the centre of the study, leading to pragmatic paradigms as frameworks for mixed methods researchers (Mackenzie & Knipe, 2014). Denscombe (2008) posits that pragmatism is the most appropriate paradigm for mixed methods research, with Johnson (2009) summing up the definition of mixed methods as research that “provides a philosophy and set of approaches or possibilities for merging insights from diverse perspectives; its working goal is to provide pragmatic, ethical solutions to local and societal problems” (p. 449). Therefore, the pragmatic approach may combine deductive and inductive thinking, whilst mixing both quantitative and qualitative methods (Creswell & Plano Clark, 2011).

The interplay of two dominant paradigms in mixed methods research makes this research an area of strong criticism. Positive critique would include this research provides a more in-depth study and increases generalisability of results (Johnson & Christensen, 2014). Negative criticism comes from critics strongly aligned with one style of paradigm who cannot see the value in mixing both (Newby, 2013) forming a ‘false dualism’ (Pring, 2010). Other criticisms stem those as mentioned above, including that mixing the paradigms has not clearly been defined nor interpreting conflicting results or how to qualitatively analyse quantitative data (Johnson & Christensen, 2014). However, Johnson et al. (2004) assert this is the third powerful paradigm that will often provide the most informative, complete, balanced and useful research results. The mixed methods approach has also been criticised if a pragmatic philosophy is applied whereby the researcher uses a ‘what-works’ approach (Denzin, 2012), threatening the validity of study’s findings (Lipcomb, 2008). Pragmatism is not the only philosophical paradigm that is compatible with the evaluation of mixed methods (Mertens, 2013); however, Greene (2009) posits that such an evaluation is “not really about epistemology, defensible methodology, or warranted claims to
know, even though framed as such. Instead, represents political principles and tactics to attain them” (p. 156).

Creswell and Plano Clark (2011) believe a mixed methods study can use multiple paradigms as they best relate to the type of mixed method designs; also the guiding assumptions of the paradigms shape how researchers construct their procedures. For example, a study may commence with a quantitative survey instrument, under a post-positivist paradigm; the next phase becomes the use of focus groups or interviews to explain the outcomes of the survey, under a interpretivist-constructivist paradigm; therefore, shifting between paradigms. When both quantitative and qualitative data are collected in the same phase an overall pragmatic paradigm can be adopted (Cohen et al., 2007; Creswell & Plano Clark, 2011).

As such this researcher adopted the stance of engaging the pragmatic paradigm for the mixed methods research of investigating the GDE-P science unit design and tutor impact using the lens of preservice teacher self-efficacy, as both qualitative and quantitative data were collected in an embedded design. The use of this methodology will allow transferability of findings between the two paradigms to answer the research questions in depth. Further discussion of the mixed methods used for the research will be discussed in Chapter Four.

The Conceptual Framework
The conceptual framework visually demonstrates the complexities and relationships of the main theories that support and inform the research design (Leonardo, 2004; Punch, 2009). The conceptual framework for this research (Figure 1) outlines the relationships between Bandura’s (1977) self-efficacy theory, preservice teachers’ self-efficacy belief constructs, and the influence of preservice teacher education programs including the influences of university primary science education tutors. This conceptual framework will also form the basis for data collection. It will use an embedded mixed methods design, and will be discussed in Chapter Four.

The literature indicated self-efficacy is a notion that is constructed from two latent factors of outcome expectancy and personal efficacy beliefs (Bandura, 1977; Bandura, 2012). Self-efficacy is a notion explained through Bandura’s (1977) social
cognitive theory that outlines three reciprocating factors affecting it. These factors are personal factors, behavioural factors and environmental factors, and as such these are central to the conceptual framework as seen in Figure 1. Sources that affect these factors are: vicarious and mastery experiences; verbal or social persuasions; and physiological factors, including emotional arousal (Bandura, 1977; Tschannen-Moran et al., 1998). The self-efficacy of an individual is context specific, and therefore, may be evident under different circumstances (Bleicher, 2007; Tschannen-Moran et al., 1998). In the context of this study, the preservice teachers’ experiences in primary science teaching was the focus.

Research on primary preservice teacher self-efficacy has shown these students come into the science education units with varying levels of science content knowledge and science learning experiences, and this affects their self-efficacy through their emotional arousal (such as anxiety) (Bleicher, 2007; Howitt, 2005; Lederman & Lederman, 2015; Mullholland et al., 2004). Therefore, the importance of the design and tutelage of primary science education is paramount in the influence on preservice teacher self-efficacy to affect a positive outcome of increased self-efficacy to teach primary science after graduating.

The literature suggests that preservice teacher education should provide mastery experiences such as teaching practicum and vicarious experiences in the absence of physically teaching primary students (Palmer, 2006; Rice & Roychoudhury, 2003). The success of these experiences will influence the preservice teachers’ self-efficacy as a consequence of environmental and behavioural factors, as seen in Figure 1. Tutors are a source of setting the emotional climate of an individual’s learning environment and the source of verbal persuasion (Bellocchi et al., 2013; Thomson et al., 2016); which also affect preservice teacher self-efficacy. The social constructivist design of the tutorials also provides another setting for other environmental factors, including peers. These may add to the social persuasion of this factor, yet also may become a target for behavioural factors such as having ‘proxy agency’ influence instilled upon them; interlinking together with personal factors. The researcher sees the use of the interpretivist-constructivist paradigm to understand the impact of these influences through the subjective nature of anecdotal information on surveys and focus group discussions, as the most appropriate paradigm.
As mentioned earlier, the literature has shown that preservice teachers enter teacher education training with a variety of backgrounds, experiences, knowledge and self-efficacies (Bleicher, 2007; Howitt, 2005; Lederman & Lederman, 2015; Mullholland et al., 2004). As self-efficacy is shaped by prior experiences (Tschannen-Moran et al., 198) it is imperative these are identified at the commencement of the unit. The experiences during the primary science education unit also affect the self-efficacy of preservice teachers to teach primary-science; therefore, the self-efficacy needs further measurement at the completion of the unit to detect any changes. In this instance, the post-positivist paradigm was best suited to investigate the latent constructs of science teaching outcome expectancy and personal science teaching efficacy beliefs.

The following conceptual framework, Figure 1, formed the basis for data collection using an embedded mixed methods design, which will be discussed in Chapter Four.
Figure 1. The Conceptual Framework for Influences Exerted on Preservice Teacher Self-Efficacy Through Primary Science Education Experience
Chapter Summary

Chapter Three outlined the theoretical conceptual framework that underpins this research. The rationale for the use of the pragmatic paradigm was outlined through the exploration of the ontology, epistemology, axiology of the post-positivist, and interpretivist-constructivist paradigms. The post-positivist paradigm is well situated for quantitative research methods to measure the latent traits of self-efficacy through the use of a self-efficacy belief instrument. The researcher could also adopt the interpretivist-constructivist paradigm for the qualitative methods to explore the subjective participant input for influences affecting the primary-science education students’ self-efficacy. As both of the research methods are occurring concurrently the researcher felt best positioned to adopt the pragmatic paradigm for mixed method research; therefore, allowing the post-positivist and interpretivist-constructivist paradigms to complement the depth and breadth of the investigation.

The conceptual framework for this research was presented visually to represent the extent of the research concepts and theories that are underpinned by significant literature. Chapter Four will outline a literature review of the quantitative, qualitative and mixed methods that are utilised for this research. Chapter Four will also include a methodological framework outlining the concurrent and consecutive timeline of data collection.
CHAPTER FOUR
RESEARCH METHODS AND PROCESSES

Introduction

Chapter three presented the theoretical and conceptual framework for this study with the pragmatic paradigm discussed to form the basis for the research methods employed. Therefore, this chapter will discuss the mixed methods approach used to conduct the research, outlining both the qualitative and quantitative methods.

Due to the nature of the research questions, this research study employed an embedded mixed methods approach. The research questions required a measurement of preservice teachers’ self-efficacy and the tutors’ role in development of self-efficacy, as well as further explanation through the researcher’s observations and narratives from the tutors and the preservice teachers. This was in order to ensure triangulation of data (Yin, 2003) for factors that may affect preservice teachers’ self-efficacy. Subsequently, a detailed description of each method and its strength and limitations will be discussed in relation to the research questions posed.

Mixed Methods Approach

As mentioned in Chapter Three, mixed methods research is a relatively new approach. Creswell and Plano Clark’s (2011) definition has developed to include both a methods and philosophical orientation based on its core characteristics. Creswell and Plano Clark (2011) describe these characteristics as the rigorous collection and analysis of both quantitative and qualitative data without necessarily giving priority to either method in terms of what the research requires. It involves the linking, integration or embedding of the two forms of data which may be collected concurrently or sequentially within a single study, whilst being framed within “philosophical world views and theoretical lenses” (Creswell & Plano Clark, 2011, p. 5). Yin (2010) posits that mixed methods will allow the researcher to obtain sufficiently rich data “addressing a set of research questions that deliberately requires complementary qualitative and quantitative evidence and methods” (p. 291) to better understand the context for events that are being investigated.
According to Creswell and Plano Clark (2011) “mixed methods research provides strengths that offset the weaknesses of both quantitative and qualitative research” (p. 12). The methods may vary and may be qualitative dominant, equal status (pure mixed) or quantitative dominant (Johnson et al, 2007). Quantitative data may not give an explanatory voice to the participants, yet provides an unbiased view and the ability to analyse trends and frequencies; qualitative data will allow participants to express their feelings and explanations to get a deeper understanding of the study’s complexity, yet the researcher’s interpretations may introduce biases; therefore, the combination of each of their strengths will outweigh their weaknesses (Creswell & Plano Clark, 2011). Another advantage is that triangulation of both quantitative and qualitative data increases the concurrent validity of the complexity of social sciences research and allows for deeper analysis through data comparisons (Cohen, Manion & Morrison, 2011; Creswell, 2014; Yin, 2010).

Mixed methods research aims to combine the strengths of quantitative and qualitative methods, the strengths and limitations of each will be discussed to outline the rationale for using mixed methods in this study. Within these discussions validity, reliability, and ethics will be outlined, as these are important concepts in all research (Merriam, 2009). In general, the validity of a study can be defined as “one that has properly collected and interpreted its data, so that the conclusions accurately reflect and represent the real world (or laboratory) that was studied” (Yin, 2010, p. 78), with reliability being defined as the ability to replicate research findings (Merriam, 2009). However, validity and reliability have different meanings and ways to be dealt with in quantitative and qualitative research (e.g., quantitative internal validity is termed credibility in qualitative research; external validity as transferability or even reliability in quantitative as dependability in qualitative) (Cohen, et al., 2011), and therefore these topics will be addressed separately within each of the research paradigms.

**Quantitative Methods**

Quantitative methods study actual phenomena (Payne & Payne, 2004) to derive numerical evidence as measurable outcomes (Newby, 2014). It makes many assumptions on data collection and analysis leading to a conclusive answer to the
question posed along with a set of recommendations and judgement based on numerical value (Newby, 2014; Pring, 2004).

As mentioned in Chapter Three, there has been critical discourse about the use of quantitative methods in social sciences and applied research, however, the strength of this research approach is its internal and external validity, reliability and objectivity (Mertens, 2007). Quantitative methods seek regularities in human lives, assigning numerical values to human attributes, attitudes or demographics as frequencies or rate, whose associations with each other can be explored through mathematical statistical analysis (Cohen, 2013; Creswell & Plano Clark, 2011; Payne & Payne, 2004). These are obtained through researcher-introduced stimuli and systematically measured through means such as questionnaires (Creswell & Plano Clark, 2011; Payne & Payne, 2004).

Human attributes or traits are often abstract concepts and as such cannot be easily observed with the naked eye or directly measured, and therefore are termed as latent variables (Muijs, 2004). Hence, self-efficacy is considered as a latent variable. To measure these concepts indirectly an instrument whereby every question becomes a ‘manifest variable’ is developed (Muijs, 2004). These manifest variables become measurable (Muijs, 2004) in the form of a questionnaire with specific, narrow questions and with the intent to generalise from the results (Creswell, 2014). The design of the instrument is crucial for its validity (Creswell, 2014; Muijs, 2004). Bandura (2012) considers a “Likert-type scale [is] appropriate for phenomena that have positive and negative valences, such as attitudes, opinions, and likes and dislikes” (p. 16). The items would be rated against an interval scale ranging from 1 (strongly disagree) through a neutral midpoint of 3 (neither agree nor disagree) to 5 (strongly agree) (Bandura, 2012; Creswell, 2014) in order to elicit the latent information. However, for quantitative findings to be considered valid, reliability testing is also required (Creswell, 2004).

Quantitative reliability can be defined that “scores received from participants are consistent and stable over time” (Creswell & Plano Clark, 2011, p. 211). Cohen et al. (2013) extends the definition to include reliability as equivalence, and Muijs (2004) includes statistical measurement whereby reliability is measured as the extent that the
scores are free from measurement error. Reliability of the instrument requires stability over a similar sample and time between the test and retest (Cohen et al., 2011; Creswell, 2014; Creswell & Plano Clark, 2011; Muijs, 2004). The instrument could be administered to similar groups undergoing the same intervention (Cohen et al., 2011). The time between the test and retest should be such that change to situational factors is minimised, so participants do not remember the first test or so the participants become too interested to start researching the topic themselves (Cohen et al., 2011; Creswell, 2014; Muijs, 2004). Testing of reliability is to ensure that participant’s scores have remained consistent and stable given the time between the pre and posttests (Creswell & Plano Clark, 2011). This reliability can be tested with correlation coefficients using Pearson statistic or a t-test, where the statistical significance is 0.05 or higher (Cohen et al., 2011; Muijs, 2004). Internal consistency is a measure of reliability where the instrument has more than one item (Cohen et al., 2011; Creswell, 2014; Muijs, 2004). It determines the homogeneity of the items to measure a single construct through the responses given by the same participant on both the test and retest (Creswell, 2014; Muijs, 2004). Cronbach’s coefficient alpha is a measure of an instrument’s internal consistency of scores (Cohen et al., 2011; Creswell, 2014; Muijs, 2004) with a score over 0.70 before it could be internally consistent for social sciences research (Muijs, 2004).

With the use of questionnaires, the validity means data scores are “meaningful indicators of the construct being measured” (Creswell & Plano Clark, 2011, p. 210) whereby standards are sourced externally from the researcher and participants, such as statistical analysis and experts in the field (Creswell & Plano Clark, 2011). The validity of quantitative methods is divided into three aspects of content validity, criterion validity and construct validity (Creswell & Plano Clark, 2011; Muijs, 2004). Content validity pertains to whether the questions measure the latent concept, such as self-efficacy (Creswell & Plano Clark, 2011; Muijs, 2004). Criterion related validity allows for comparisons of findings with theory or instruments in other research (Creswell & Plano Clark, 2011; Cohen et al., 2013; Muijs, 2004). Finally, construct validity is considered to be more complex (Muijs, 2004) and it pertains to internal validity, in ensuring that the items measure the intended latent concepts (Cohen et al., 2011; Creswell & Plano Clark, 2011; Muijs, 2004). The use of factor analysis if more
than one construct is present in the concept is a useful tool to determine validity (Muijs, 2004).

**Qualitative methods**

Qualitative research is most commonly utilised in studies of behaviour, words and images, as the evidence on which hypotheses could be formulated and conclusions developed uses an inductive and emergent manner (Creswell, 2014; Newby, 2014). Its epistemology sits within an interpretivist and constructivist paradigm where researcher and participants work together to discover findings (Cohen et al., 2011; Creswell, 2014; Newby, 2014; Pring, 2004). The advantage of qualitative research is “to understand how people experience their lives as a means of providing rich and deep insights into why things happen as they do” (Newby, 2014, p. 95) in a realistic non-contrived environment. As qualitative research is a broad area of inquiry, one definition cannot encompass all its complexities (Yin, 2010). Yin (2010) defines qualitative research based five features of this approach as:

- Studying the meaning of people’s lives, under real-world conditions;
- Representing the views and perspectives of the participants in a study;
- Covering the contextual conditions within which people live;
- Contributing insights into existing or emerging concepts that may help to explain human social behaviour; and
- Striving to use multiple sources of evidence rather than relying on a single source alone. (pp. 7-8)

Critics argue creations and construction of transactional and subjective ‘facts’ are influenced by the values of the researcher, however researchers with similar values may, through the process of negotiation, reach a consensus which leads to the validity of the research and its findings (Creswell, 2014; Pring, 2004). Others feel the findings cannot be generalised as they are in context, value laden and contain ideographic knowledge based on the respect of individuals (Creswell, 2014; Cohen et al., 2011; Merriam, 2009).

To ensure quality and integrity the researcher must manage subjectivity, credibility, transferability, dependability, consistency and confirmability (Cohen et al., 2013). Although the terms may be different these are like the quantitative research terms
validity and reliability (Newby, 2014); for example, terms such as credibility is related to internal validity and transferability to external validity (Cohen et al., 2011; Newby, 2014; Yin, 2010). Yin (2010) defines a “valid study is one that has properly collected and interpreted its data, so that the conclusions accurately reflect and represent the real world (or laboratory) that was studied” (p. 78).

Reliability is the extent to which research findings can be replicated (Cohen et al., 2011; Newby, 2014; Yin, 2010) and yield the same results. In social sciences reliability is difficult to manage as human behaviour is not static and experiences will vary between participants, along with ensuring that the results are consistent with the collected data (Merriam, 2009). It is therefore suggested that rather than using the term and definition of reliability, it would be more precise to use dependability and consistency (Merriam, 2009). This is interpreted as making sure the set of data and results make sense, and are consistent and dependable, rather than being concerned about if the results are replicable by others (Merriam, 2009).

For research to be considered credible Yin (2010) suggest there to be three objectives including:

- Research procedures and data to be transparent whereby the research is accessible to others for review which may lead to criticism, support or refinement;
- Methodologic means to follow and orderly set of research procedures avoiding unexplained bias or deliberate distortion of the research which leads to be able to cross check the procedures and data; and
- The research being based on explicit evidence where participants’ voice and context of the study is expressed.

Strategies that can be used to combat threats to credibility, transferability, consistency and dependability are varied and may include immersion of the researcher on-site, self-reflections, triangulation of data, checking interpretations with individuals interviewed or observed, auditing and discussions with peers to comment on emerging findings (Cohen et al., 2011; Creswell, 2014; Creswell & Plano Clark, 2011; Denzin, 2012; Merriam, 2009; Newby, 2014; Yin, 2010).
It is imperative that researchers are adequately engaged in the process of data collection in order to ensure saturation of information to gain an in-depth understanding of the context of study and its participants (Merriam, 2009; Yin, 2010). The rich data need to provide extensive contextual descriptions so readers may determine if their situations match that which is being reported on, hence facilitating transferability (Merriam, 2009; Yin, 2010).

Newby (2014) warns the researcher must be aware of their influence between researcher and subject, as a neutral relationship based on mutual recognition of professionalism could develop into a more social relationship that may introduce bias or influence the participants’ behaviour (when being observed) or responses (such as in focus groups or interviews). The researcher must engage in critical self-reflection regarding any assumptions, views, biases, own professional and theoretical experiences and position with the study, which may affect the investigation (Merriam, 2009; Newby, 2014; Yin, 2010). In addition to the researcher’s self-reflection, the participants or peers could undertake member checking to ensure the data and tentative interpretations are credible and dependable (Merriam, 2009; Yin, 2010).

Triangulation is when multiple sources of data or methods are employed to confirm, disconfirm or converge findings (Cohen et al., 2011; Creswell & Plano Clark, 2011; Denzin, 2012; Merriam, 2009). This could be achieved using qualitative interview or observational data to further explain the statistical findings obtained through quantitative methods; or through the use of multiple groups of participants undergoing similar interventions; and checking findings against other literature available (Creswell, 2014; Denzin, 2012; Yin, 2010).

To ensure maximum variation or diversity, sampling needs adequate numbers of participants to ensure there is enough data to reach saturation of information, allowing for a greater range of use of findings by other researchers (Merriam, 2009).

Finally, the data may need verification from an independent person using an audit trail (Cohen et al., 2011; Merriam, 2009). An audit trail is a detailed account of the methods, procedures and decision points throughout the research period and how the findings were derived from the data (Merriam, 2009).
The extent to which the data can be transferred to other research (external validity) is constantly under debate (Merriam, 2009). Even though qualitative research cannot be widely generalised, qualitative findings can still reveal important contextual information.

**Mixed Methods Designs**

As the research question is at the centre of the study, it is appropriate to apply the transformative and pragmatic paradigms (Mackenzie & Knipe, 2014). There is no philosophical loyalty to any of the aforementioned approaches (Creswell, 2014). Using the strength of both quantitative and qualitative approaches, the methods may vary and may be qualitative dominant, equal status (pure mixed) or quantitative dominant (Creswell & Plano Clark, 2011; Newby, 2014; Yin, 2010). There are different designs of mixed methods including explanatory, exploratory, triangulation (convergent), embedded, transformative and multiphase designs (Creswell, 2014; Creswell & Plano Clark, 2011).

In explanatory and exploratory designs, the findings from one method inform the follow up from a secondary method, with often the primary method being emphasised (Creswell, 2014; Creswell & Plano Clark, 2011). For example, in the explanatory design the quantitative data are first collected and analysed and the expanded on or supported with qualitative data whereas the exploratory design first collects qualitative data to inform the quantitative data collection method (Creswell, 2014; Creswell & Plano Clark, 2011). The final data are then interpreted (Creswell, 2014). The transformative design is similar in that quantitative data are collected and analysed and then followed up with qualitative data collection and analysis for a final interpretation (Creswell, 2014).

Triangulation (convergent) and embedded designs use parallel or concurrent data collection from both quantitative and qualitative methods. These support each other through merging data in analysis or embedding the findings of one type of data into the other to strengthen the study (Creswell, 2014).
This research used a concurrent embedded design with both qualitative and quantitative data within a traditional design, such as anecdotal questions embedded with a quantitative instrument (Creswell & Plano Clark, 2011). The qualitative and quantitative data are analysed and interpreted together before a conclusion is drawn (Yin, 2010).

The embedded design was appropriate for this study as the research questions required different types of data to address the overall purpose of investigating different factors in the preservice teachers’ self-efficacy, such as the role of the tutors and unit design. It allowed for the concurrent collection of qualitative and quantitative data from the tutors, preservice teachers, unit coordinator and researcher’s observations. In addition to this, neither method was considered more superior to the other and allowed for an interpretive approach appropriate to each research question (Creswell, 2014; Creswell & Plano Clark, 2011). This design allowed the quantitative data to inform recruitment for specific focus groups and interviews. It also allowed for the examination of the intervention process through observation, which informed further questions for follow-up focus group discussions and interviews, as well as for the questionnaire participants to explain their reasoning for selection of answers. Brady and O’Regan’s (2009) concurrent embedded design linked their qualitative data to their quantitative data for their case study participants and developed an integrated analysis of mentoring relationships at the individual participant level. In this research study, the rich data provided a clearer understanding of how varying factors affected individual’s self-efficacy as measured on the quantitative questionnaire.

The nature of the embedded concurrent study addresses each quantitative and qualitative credibility, reliability, validity, dependability and consistency measures for each paradigm rather than through a framework situated within the mixed method paradigm. Further information in relation to this will be provided later in the chapter.

A design framework of the mixed methods is very important to visually demonstrate the complexity of how the philosophical assumptions and methodology of both paradigms are used to suit the research question (Leonardo, 2004). Figure 2 outlines the research design for this study.
Research Context

Background

This research was conducted on Graduate Diploma of Education Primary (GDE-P) preservice teachers in the area of science, at an Australian University. The GDE-P science unit is an integral unit in this course and historically had curriculum changes occurring to reflect the changing trends in the national focus of education, requirements of the standards required by the Australian Institute for Teaching and School Leadership, as well as the University’s requirements.

It is important to understand the unit’s current design to further understand how this context may have a bearing on preservice teacher’s self-efficacy. Many studies (e.g., Cripps Clark & Groves, 2012; Ebrahim, 2012; Mulholland et al., 2004) have been based upon multiple years in the Bachelor of Education or Masters of Education/Teaching courses, whereas the GDE-P course for this study is uncommon as a one year course, and hence the need for research in this area.
The GDE-P Science unit consists of 30 teaching hours (as three hour tutorials) over a 10 week program based on a collaborative and constructivist instructional model (Bybee et al., 2006). In addition to the unit delivering science content knowledge, its goals included enhancing preservice teachers’ inquiry skills through the modelling of collaborative inquiry-based pedagogical strategies such as using problem solving skills, developing an appreciation of the nature of science through exposure to the 5E learning cycle: engage, explore, explain, elaborate and evaluate (Bybee, 1997; Menon & Sadler, 2016). This style of instruction uses a constructivist approach to learning, and has been found to result in the cultivation of more positive attitudes to science by school-aged students (Bybee et al., 2006). A constructivist learning environment allows students to become engaged in exploring science concepts in a collaborative manner; having time to observe and experience the phenomenon and then process the learning together with their peers (Bybee et al., 2006; Hany & McArthur, 2002). The 5E instructional model has been adopted by the Australian Academy of Science, through the support of the Australian Government Department of Education. The Australian Academy of Science used the model to develop programs of primary science, Primary Connections to assist primary school teachers to gain science teaching confidence and competence (Australian Academy of Science [AAS], 2016). These programs are directly linked with the Australian Curriculum, Assessment and Reporting Authority (ACARA) Australian Curriculum: Science. The use of this instructional model within the GDE-P preservice teacher science unit may form the basis for positive modelling of pedagogical strategies and provision of a platform for possible increased confidence before preservice teachers are required to teach science in the primary classroom.

The design of the primary science unit was inclusive of Vygotsky’s social constructivist learning theory (Leach & Scott, 2002), whereby modelling teaching strategies would assist to shape the preservice teachers’ own pedagogy for future teaching. In this manner, preservice teachers could experience the aspects of learning and knowledge construction in a dynamic and transformative process (Duit & Treagust, 2003; Leach & Scott, 2002). Further building of content knowledge was through mastery experiences such as learning about and experiencing science through teamwork, inquiry experiences and peer-to-peer instruction. Student participation in
tutorials throughout the term was vital for student success and subsequently an influencing factor on self-efficacy.

Unit Design/Learning Experiences
Bandura (2012) discusses the “triadic reciprocal determination in the causal model of social cognitive theory” (p. 12) whereby an individual’s function can be shaped through personal, behavioural and environmental determinants. Self-efficacy, being a constituent of these influences, will also be shape their future behaviours (Bandura, 2012). The environment is important as it may be imposed from an external source (Bandura, 2012). In this research case the external source is the unit design. The interactivity and inquiry-based nature of the primary science unit may have an impact on both the personal and behavioural determinants of a preservice teacher, and subsequently, influenced their self-efficacy to teach primary science.

Mastery learning experience
Bloom (1984) defines mastery learning as a large group of students undergo conventional instruction paired with feedback and corrective procedures to allow students to ‘master’ the subject content. He defines tutoring as small groups (one to three) of students with a tutor together with formative assessments with feedback and corrective procedures (Bloom, 1984). Mastery learning and tutoring have been found to have a one to two sigma effect on the students undergoing a learning process (Bloom, 1984). The sigma effect is demonstrated by the shift of standard deviation from the group that has had an intervention, compared to the standard deviation of a control group (Bloom, 1984). Bloom (1984) posits that a one sigma effect equates to the average student being above 84% after an intervention, and that a two-sigma effect is at 98% above the students who do not receive an intervention. These interventions were in the form of mastery learning and tutoring respectively. The benefits demonstrated by Bloom have been used in the GDE-P science unit, which allows for small group work and peer teaching to become a factor for self-efficacy.

Teamwork learning experience
Further study of teamwork benefits by Volkov and Volkov (2014) has shown that teamwork will develop skills to assist with the creation of effective lifelong learners who can compete within the workforce. Effective teamwork is a deep learning
approach, which develops student connectedness through working towards a common
goal for the production of an outcome (Ohl & Cates; 2006; Scott-Ladd & Chan, 2008;
Volkov & Volkov, 2014). The deep approach to learning and mastery of subject
content and pedagogical content at a tertiary level is expected to create high levels of
motivation within the students to further learn what is necessary (Volkov & Volkov,
2014).

In contrast, a transactional superficial approach to learning experiences has been
found to lead to student boredom, dread and anxiety to learn (Campell & Cabrera,
2014). Entwistle (cited in Volkov & Volkov, 2014) recommends that a deep learning
approach be developed through assessment tasks at the university education level.
Volkov and Volkov (2014) discuss the effect of student’s perception of teamwork
process. If a group is successful in “achieving a required result rather than in
achieving deep learning of the subject matter” (p. 265), a student who is deep learner
may avoid teamwork in future learning experiences or workforce if they consider this
type of collaborative work is not beneficial to them.

Assessment strategy
The inclusion of a portfolio assessment point as part of the design was intended to
encourage attendance as well as providing ongoing assessment related directly to the
students’ learning experiences. This strategy has been found to increase engagement
by students (Teague & Corney, 2011). Teague and Corney (2011) also found there is
a strong relationship between high attendance and results, whereby greater
germination in learning experiences has an increase in assessment results. The
increase in assessment results is thought to increase self-efficacy through gaining
confidence in mastery learning.

Technology learning experience
Use of technology has been included in the unit design through asking students to
produce a visual portfolio of activities and creating ‘stop motion’ animation of
scientific concepts. Lavinge and Mouza (2012) state a focus on technologies can have
capacity to influence outcomes and processes of student learning experiences.
Technologies allow students to visualise abstract concepts, construct dynamic
representations, collaborate with other students, engage in active self-reflection of
learning, as well as creating of useful resources for future use (Lavinge & Mouza,
The use of technologies supports learning to understand and provide a tool for deep understanding of concepts (Lavinge & Mouza, 2012). Dawson et al., (2006) found demonstrating information and communication technology (ICT) resources and pedagogies would lead to increased confidence for future use of ICT in the classroom in students who may have technology anxiety through limited technology literacy. The chosen design and pedagogical strategies used in learning experiences, in turn, would have an impact on preservice teachers’ self-efficacy in the context of the GDE-P science unit and subsequent flow on effect to preservice teachers to use these strategies in their future teaching.

Need for review of design and subsequent research
At the end of 2014, the University’s Institute of Education Research financed a thorough evaluation of the 2014 GDE-P Science unit. This evaluation was commenced due to concerns with declining student attendance (59%) throughout the semester (Lummis, Norris & Slater, 2015). The evaluation was conducted and presented to the School of Education who provided additional financial support to refresh the 2015 unit as detailed below. The 2014 review demonstrated a number of students were unable to attend classes due to family or work commitments (Lummis, et al., 2015); therefore, additional weekend classes were added to accommodate these students. This also allowed for increased attendance by those affected by work or family constraints during weekdays. During 2015, the GDE-P Science unit accommodated approximately 350 students across two campuses with six tutors across all locations.

Another amendment to the unit was the increased cohesion of pedagogical content knowledge (PCK) across the 10-week duration through the integration of UNECO’s three pillars of sustainability, which also supported the Australian Curriculum’s cross curriculum priority of sustainability (ACARA, 2015). Amendments also included the nature of the assessments, which encouraged increased weekly attendance so they could maintain a portfolio of science activities.

Prior to the commencement of the unit, a professional development day was held for all tutors involved in this unit. This was funded through the assistance of the University’s Institute for Education Research, to ensure all tutors were familiar with
the new 2015 unit plan, including some changes in weekly content and use of explicit pedagogical strategies. This was to ensure all students were given the same information and similar strategies, yet still allowing for individual tutor’s styles of teaching. Although specific science content is limited, the self-efficacy of preservice teachers was to be enhanced through the science tutors modelling pedagogical strategies that can be used to teach science, within a constructivist-learning environment.

As this unit was undergoing an evolutionary change, there was some initial resistance by staff who had been involved in teaching the unit for a long time. The evolutionary development of the unit may continue to provide additional discourse of possible confrontation as those with long term teaching into the unit may not fully support the design changes that have been made, however, the modifications to the unit were made in an effort to enhance preservice teacher self-efficacy to teach primary science.

The changes made to the unit provided the basis for the initial pilot study to investigate factors that may affect preservice teachers’ self-efficacy to teach primary science. The subsequent follow-up Doctoral study with a second GDE-P cohort was to ensure the pilot study data were reliable and valid.

**Pilot Study**

The pilot study provided a platform to investigate possible factors that may affect the GDE-P science preservice teachers’ self-efficacy. In the pilot study, the methods and instruments for both quantitative and qualitative approaches were trialled, with the analysis giving an indication of further factors to be investigated. All appropriate ethics clearance was received and adhered to. Further details will be outlined later in the chapter.

A constructivist theoretical framework was used to support the mixed methods approach, as it engages the researcher’s and students’ shared experiences to explore common understandings of self-efficacy and science teaching within the sample (Lummis et al., 2014).
The pilot research employed an explanatory mixed methods approach, in which the quantitative data were collected prior to the qualitative (Creswell & Plano-Clark, 2011). The secondary data, in this case the qualitative interview data, were used to “support or augment the primary [quantitative] data” (Creswell & Plano-Clark, 2011, p. 220). The quantitative method employed was through an online Qualtrics questionnaire at the commencement, middle and end of the unit. The online questionnaires remained open for two weeks after the class during which the questionnaire was conducted, allowing for those who were not able to attend class to complete the questionnaire in their own time. Having three data collection points throughout the study enabled tracking of any changes in attitude throughout the length of the unit. The intention of the questionnaire was to elicit demographic data on commencement of the GDE-P course, prior science experiences, as well as determining preservice teachers’ self-efficacy to teach primary science. The qualitative data were collected through small focus groups, which were used to assist in further explaining latent results received in the questionnaire, and therefore, supported the complexity of the research (Creswell, 2014). The focus groups were conducted in the final week of the semester, either before or after the final tutorial, also to maximise participation.

Purposeful sampling was used in the pilot study to select participants for the research, as all participants were from the same cohort of students enrolled in the GDE-P science unit under investigation. This meets the criteria of purposeful sampling as defined by Creswell and Plano-Clark (2011). Further discussion on sampling for the thesis’ research will be demonstrated later in the chapter.

As previously mentioned, all students were invited to participate in the study. The total number of students in the cohort was 350 of which 35 (10% of the cohort) self-selected to participate in the focus group discussions held at the end of the semester. These students were prepared to share their experiences in such a forum, and provided anecdotal information in a more in-depth manner. As the questionnaire was conducted on multiple occasions, the number of participants varied throughout the semester. Table1 demonstrates those participating in the online questionnaire.
Table 1. Number of respondents participating in the online questionnaire

<table>
<thead>
<tr>
<th>Questionnaire administration</th>
<th>N</th>
<th>% Cohort represented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre test</td>
<td>165</td>
<td>47</td>
</tr>
<tr>
<td>Mid test</td>
<td>77</td>
<td>22</td>
</tr>
<tr>
<td>Post test</td>
<td>66</td>
<td>19</td>
</tr>
<tr>
<td>All three tests above</td>
<td>39</td>
<td>11</td>
</tr>
<tr>
<td>Pre and Post tests only</td>
<td>56</td>
<td>17</td>
</tr>
</tbody>
</table>

*Note* Total number of students in cohort = 350.

**Limitations**

The decline in participation rate was of concern, despite tutor encouragement, notices on the unit’s learning management system site and reminder emails to participate. Questionnaires were administered on three occasions throughout a very short period of time, 10 weeks. The questionnaire link was left available to GDE-P preservice teachers for two weeks after each invitation to allow for maximum participation. However, this meant that a questionnaire would need to be completed every three to four weeks. The timing of these also tended to coincide with submission timeline for assessments. The third questionnaire included both short answer questions and questions in a Likert scale, therefore becoming lengthy. This questionnaire length was reduced to decrease the amount of time required to complete it. Some of the statements within the quantitative instrument could also be considered to be ambiguous or inclusive of negation. This may have confused respondents and created misinterpretation of a statement.

It could also be surmised that reasons for this decline may have been attributed to student stress with course pressures such as: coinciding with assignments due in, student fatigue, nature of questionnaires being online, constant reminders, or in fact with a change in self-efficacy beliefs. Nulty (2008) found response rate was affected by barrage of reminders, and the need for students to respond to multiple course questionnaires created irritation and therefore lowered response rate. Whereas questionnaires administered face-to-face had the high response rate, it was also found that repeat emails to students, staff and provision of an incentive also provided high
response rates of 47% (Nulty, 2008). The changes made for the questionnaire and its administration for this doctoral study will be discussed later in the chapter. Throughout the pilot study the author of this thesis was a tutor of one of the participating science tutorials, as well as the researcher. As the researcher’s role was not defined as a participant-observer role (Creswell, 2014) it could be considered as a conflict of interest due to the possibility of influencing preservice teachers’ responses on the questionnaire as their tutor. To alleviate this in the doctoral study, the researcher declined a tutor position in the unit, and therefore, was only a researcher of the phenomenon and had the role of a participant-observer, participating only during the various tutorials at three points throughout the semester. This immersion rendered the author accessible to collect authentic observations of the participant’s (both student and tutor) realities from an insider’s point of view (Yin, 2010).

Pilot conclusion
The pilot study results demonstrated that experience and learning of subject content knowledge is as important as experiencing and learning variety of pedagogical strategies to improve preservice teachers’ self-efficacy to teach science. Students benefitted from the interactive hands-on approach and social constructivist style to learn scientific concepts, scientific inquiry skills, and were equipped with the knowledge of appropriate scientific resources to further their learning whilst practicing teaching. The results of the pilot study demonstrated a large effect size was achievable in the 2015 structure of GDE-P Science unit through the unit design and more informed tutors. As a result of the pilot research, the level of interaction of tutor and unit design continued to be investigated this thesis’ research as factors of preservice teachers’ self-efficacy to teach primary science. A number of changes were also made to the methods and instruments for the doctoral study, to allow valid and convenient data collection.

The Thesis’ Research Setting
Sample Selection and Sample Size
Preservice teacher participants for this study were selected using a purposive sampling. This allows for diverse individuals to be chosen who hold a range of different perspectives (Creswell & Plano-Clark, 2011), due to their varying
undergraduate degrees, life experience backgrounds, and self-efficacies whilst meeting the needs of the research (Cohen et al., 2011; Creswell, 2014). These participants allow for focus on a specific case, such as this research into GDE-P preservice teachers’ self-efficacy to teach primary science, and may generate theory specific to this case based on their in-depth information (Cohen et al., 2011).

Respondents for the quantitative instrument were self-selecting (due to voluntary participation) within the initial sample, which included all preservice teachers enrolled in the GDE-P Science unit for 2016. Homogenous sampling is defined as the selection of participants who have similar traits or characteristics (Creswell, 2014). Therefore, it could also be considered the participants in the different tutorials could also be considered as homogenous sampling as they are experiencing various methods of instruction from different tutors within the same unit design. From those that completed the initial questionnaire, again homogenous sampling was performed to extract groups of individuals that had similar initial self-efficacy scores across all tutorials for focus group discussions. A summary of participant groups for each tutor is listed in Table 2 below.

Table 2. The number of pre and post intervention questionnaire participants per tutor

<table>
<thead>
<tr>
<th>Tutor</th>
<th>Pre intervention</th>
<th>Post intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>19</td>
</tr>
<tr>
<td>2</td>
<td>91</td>
<td>88</td>
</tr>
<tr>
<td>3</td>
<td>44</td>
<td>39</td>
</tr>
<tr>
<td>4</td>
<td>43</td>
<td>33</td>
</tr>
<tr>
<td>5</td>
<td>73</td>
<td>61</td>
</tr>
<tr>
<td>6</td>
<td>44</td>
<td>33</td>
</tr>
<tr>
<td>TOTAL</td>
<td>370</td>
<td>278</td>
</tr>
</tbody>
</table>

*Note* Tutors are identified numerically to provide anonymity.

As mentioned above, preservice teachers with similar questionnaire scores in tutorials with the same tutor, were invited to participate in focus groups at various times throughout a week. Not all who were invited attended the relevant group sessions, instead chose to participate in a self-selected time slot pre or post tutorial. These timeslots were made available to ensure maximum participation of preservice
teachers. Numbers of preservice teacher participants for the focus group discussions pre and post intervention were 63 and 61 respectively. These focus groups were over a number of sessions with a minimum number of two and maximum of 10 participants within a group, with the same participants pre and post intervention.

Tutors of the unit were selected as participants using convenience sampling (Yin, 2010), and were invited to provide their teaching backgrounds and philosophies, as well as perceptions of their tutorials. These participants are readily available sources of data and can provide information specific to the research questions (Cohen et al., 2013). Yin (2010) warns these sources may produce an unwanted degree of bias; however, this type of sampling was appropriate for this case study to gain extra information about the unit and their influence on self-efficacy development.

Two further sources were selected as participants through convenience sampling. For information in relation to unit’s history, design and management, it was valuable to also interview the Unit Coordinator. It became evident from observations that another possible source of information was the Laboratory Technician, as her role was to support the unit design, tutors and preservice teachers. Her insights were considered valuable and hence were included in the study.

The following table provides a summary of all participants for the various data sources.

Table 3. Total number of participants for various data sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Pre intervention</th>
<th>Post intervention</th>
<th>Throughout intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Coordinator Interview</td>
<td>NA</td>
<td>NA</td>
<td>1</td>
</tr>
<tr>
<td>Laboratory Technician Interview</td>
<td>NA</td>
<td>NA</td>
<td>1</td>
</tr>
<tr>
<td>Tutor Interview</td>
<td>NA</td>
<td>NA</td>
<td>7</td>
</tr>
<tr>
<td>Preservice teacher Questionnaire</td>
<td>370</td>
<td>278</td>
<td></td>
</tr>
<tr>
<td>Preservice teacher Focus Groups</td>
<td>63</td>
<td>61</td>
<td></td>
</tr>
</tbody>
</table>
Ethics

In any human or social research, a researcher seeks a deep understanding of a phenomenon that will include human interaction (Creswell, 2014). There is an ethical dimension to this research that involves ethical conduct, which is an ethos that should permeate throughout the research approach (National Health and Medical Research Council (NHMRC), 2015). It is legislated human research will only be conducted after ethics confirmation (NHMRC, 2015). Patton (2002) (cited in Creswell, 2014) identifies some guidelines for ethical practices such as:

- **Informed consent**
  - This principle comes from the participant’s right for freedom and self-determination (Cohen et al., 2011). Whereby informed consent is the procedures individuals use to choose whether to participate after being fully informed of the study’s facts and weighing up the pros and cons as pertaining to themselves (Cohen et al., 2011). It is imperative the researcher does not engage in deception in relation to the study’s purpose (Creswell, 2014).

- **Reciprocity**
  - As incentives to participate researchers may offer a small reward in return for participants in depth information and experiences (Creswell, 2014).

- **Assessment of Risk**
  - Risk is the potential for harm, discomfort or inconvenience and should be identified and aimed to be low (NHMRC, 2015).

- **Confidentiality**
  - Researchers need to protect the study location and participants’ anonymity through the use of numbers or pseudonyms in the process of analysing and reporting data (Creswell, 2014) to avoid possible identification.

- **Data Access and Ownership**
  - Participants should be given the opportunity to access data directly pertaining to themselves, and can opt out at any stage without explanation (Cohen et al., 2011). Data storage needs to be secured and de-identified to protect participant’s privacy.
Prior to commencing the research, approval was obtained from the University’s Human Ethics Research Committee (HREC). The ethics application clearly articulated the way in which data and anonymity/confidentiality of respondents would be dealt with complete integrity. It also outlined the possible risks and benefits to participants. All potential participants, preservice teachers in the GDE-P science unit, the unit’s tutors and laboratory technician were provided with information about the research (Appendix A letter to student participants, Appendix B letter to tutor participants, Appendix C letter to laboratory technician participant) and all were invited to participate through face-to-face and email forums. Informed Consent documents approved by the HREC were issued to all participants (Appendix D for student participants, Appendix E for tutor participants and Appendix F for laboratory technician participant) and were advised of their right to withdraw from the research at any time without penalty. As the Unit Coordinator was also a tutor, this participant provided consent via the tutor documentation.

Privacy and confidentiality was maintained through the provision of pseudonyms assigned to specific tutorial groups. This allowed the researcher to identify which responses were appropriate in relation to a specific tutor for targeted analysis of individual tutor impact as a factor on the participant’s self-efficacy. Participants within these tutorials could randomly select from a list of pseudonyms provided. Data for the hard copy (paper copy of pre and post intervention questionnaires) included participant pseudonyms as well as student numbers and surname to ensure the ‘pretest’ and ‘posttest’ data could be kept together for data input. Subsequent soft copy (data entered into SPSS, NVivo or transcription documents for analysis) used the pseudonyms and therefore reduced the possibility for identification of an individual participant. All documentation such as consent forms and hard copy data were kept locked in the researcher’s secure workspace at the University. All soft copy data were kept on the researcher’s password protected personal computer. Any data was only made available to the researcher and supervisors for analysis; however, were also made available to a participant if requested to verify information from a semi-structured interview. During focus group discussions and semi-structured interviews, participants only used their pseudonyms as identification for transcription and subsequent analysis. Focus group discussions and interview audio files were transcribed by a University approved external agent. A confidentiality work order was
signed prior to commencement of transcription services in order to protect the confidentiality of the participants.

Quantitative Methods in Context

The phenomenon of preservice teachers’ self-efficacy has been widely researched around the world in many fields of education. The development of an instrument to conceptualise this construct was based on Bandura’s (1977, 1986) cognitive social learning theory (Gibson & Dembo, 1984; Soodak & Podell, 1996; Tschannen-Moran & Woolfolk Hoy, 2001; Woolfolk & Hoy, 1990). Bandura (1977) describes an individual’s self-efficacy is made up of two factors, personal efficacy and outcome expectancy. Personal efficacy can be described as a teacher’s belief in their ability to perform, and outcome expectancy as the teacher’s belief the students’ outcome were attributed to their actions (Soodak & Podell, 1996). The Rand Corporation was the first to introduce teacher efficacy evaluations in both primary and secondary education by producing a two 5-point Likert scale questionnaire (Gibson & Dembo, 1984; Woolfolk & Hoy, 1990). To further measure teacher efficacy and provide a construct validation, Gibson and Dembo (1984) produced a 30-item Teacher Efficacy Scale (Gibson & Dembo, 1984; Soodak & Podell, 1996; Tschannen-Moran & Woolfolk Hoy, 2001; Woolfolk & Hoy, 1990). A factor analysis on this scale yielded support for Bandura’s two factors of self-efficacy (Gibson & Dembo, 1984). These studies concluded that the Teacher Efficacy Scale is multidimensional and has at least two factors that are clearly distinguishable (Gibson & Dembo, 1984). This was supported by similar research performed by Ashton and Webb in 1986 (cited in Woolfolk & Hoy, 1990). Soodak and Podell (1996) modified Gibson & Dembo’s instrument and through factor analysis yielded three factors of personal efficacy, outcome efficacy and teaching efficacy (described as a teacher’s belief about the influence of external factors, such as their own background and experiences, as impacts on their teaching) (Soodak & Podell, 1996).

Based on the above development of a teaching efficacy instrument, Enoch and Riggs (1990) developed a valid and reliable instrument to measure the construct of teacher self-efficacy to teach science. These two factors are Personal Science Teaching Efficacy belief (PSTE) and Science Teaching Outcome Expectancy belief (STOE) (Enoch & Riggs, 1990). Together these factors were thought to be able to elicit
information from the preservice teachers’ self-confidence, belief and attitudes towards their own ability to teach primary science, as well as understanding what an effect a teacher can have on the primary student’s learning (Enoch & Riggs, 1990). This instrument was labelled the Science Teaching Efficacy Belief Instrument (STEBI). To investigate the effectiveness primary preservice training science programs, this instrument was modified for preservice teachers as a 23-item scale form B; therefore, called STEBI-B, which measured the beliefs of preservice teachers in future tense (Enoch & Riggs, 1990). An example of this is: “Even if I try very hard, I will not teach science as well as I will most subjects” (Enoch & Riggs, 1990, p. 5).

A modified 30-item STEBI-B has been widely used by other researchers of Bachelor of Education primary preservice teacher self-efficacy to teach science (Ginns et al., 1995; McKinnon & Lamberts, 2013; Mulholland et al., 2004) and found to be a valid and reliable instrument under their circumstances. Their research occurred in units that were longer in length, and over multiple years, such as a four-year Bachelor of Education (Primary) degree. The results were measured on an interval Likert style scale that consists of a set of statements rated against a scale of five units (Likert, 1932; Newby, 2014). Where score range of one equalling ‘strongly disagree’ to five as ‘strongly agree’ against each statement. The Likert scale is considered an interval scale as the responses are theoretically of equal weighting (Creswell, 2014). As the modified STEBI-B has been validated to investigate the construct of self-efficacy, this research also used the same instrument in its investigation.

As this research used an embedded research design, the instrument was further modified with the addition of qualitative questions relating to the preservice primary teachers’ prior experiences (demographic information relating to their own school science experiences) in the pretest (Appendix G) and anecdotal questions about their experience in the tutorials for the posttest (Appendix H). These questions were considered important to include to provide as much in-depth information by each participant as possible factors for their beliefs, attitudes and self-efficacy scores. The qualitative questionnaire was kept as short as possible, based on the pilot feedback and because questionnaires need to limit the number of questions directly related to any contextual condition as the degrees of freedom need to be carefully managed to analyse the responses to a set of questionnaire questions (Yin, 2010).
**Instrument Dissemination**

Preservice teachers in each tutorial, who consented to participate, were presented with a hard copy of the questionnaires and given tutorial time to complete these. These were returned directly back to the researcher at the city campus, and internally mailed back from a regional campus.

**Coding and Data Analysis**

Responses from pretest and posttest questionnaires were entered into, and analysed, using Statistical Package for the Social Sciences (SPSS) version 23 software. As the instrument measured two factors of self-efficacy, Science Teaching Outcome Expectancy (STOE) and Personal Science Teaching Efficacy (PSTE), these were analysed and reported on independently. Chapter Six (Student Findings) will include the analysis and findings for the quantitative data.

Within the modified STEBI-B instrument, 10 items related to the STOE factor with questions such as:

Q1. When a primary school pupil does better than usual in science, it is often because the primary teacher exerted a little extra effort.

The STOE items were numbers: 1, 4, 7, 9, 11, 13-16.

The remaining 20 items related to the PSTE factor with questions such as:

Q2. I will continually find better ways to teach primary school science.

The PSTE items were numbers: 2, 3, 5, 6, 8, 12, 17-30.

There were 10 items that required to be reversed scored due to their negative wording prior to analysis. These included items such as:

Q6. I will not be very effective in monitoring science experiments in the primary school.

These items were numbers: 3, 6,10, 13, 17, 19, 20, 21, 23, 24, 26, 29.
Validity testing

Content validity, as justified within the literature review, is embedded within the instrument (Creswell & Plano Clark, 2011). Criterion-related validity has been justified through literature whereby the STEBI-B has been modified to include the use in an Arts (ATEBI) study (Morris, Lummis, McKinnon & Heyworth, 2017) and in mathematics studies as a MTEBI (Bursal & Paznokas, 2006; Enochs, Smith & Huinker, 2000; Utley et al., 2005). Construct validity is where the instrument measures its intended constructs of science teaching self-efficacy, that is the science teaching outcomes expectancy and personal science teaching efficacy belief. This has been shown through Rasch analysis by various studies including Boone, Townsend & Staver (2011), confirmatory factor analysis in other studies included by Roberts & Henson (2000) and validated in many studies including the seminal works of Enochs & Riggs (1989; 1990).

Reliability testing

The instrument was tested for internal consistency using the Cronbach alpha values for both subscales of STOE and PSTE, and items reduced for maximum reliability. Using the principle of parsimony, both scales (STOE and PSTE) were subsequently reduced to 8 items. The STOE items used were numbers: 1, 4, 7, 9, 11,14, 15, 16 and PSTE items used were numbers: 3, 17, 18, 19, 21,22, 27 and 29. As each item had lowest possible score of one (where 1 = strongly disagree) and highest possible score of five (where 5 = strongly agree), these scores were added to give an overall PSTE and STOE score, with the maximum score as 40. Whilst determining the reliability, Tukey’s test of additivity was also instigated to assess if the factor variables were additively related to the expected value of the response variable. It was found that although the Cronbach alpha scores for STOE and PSTE were acceptable (0.73 and .84 respectively), the Tukey’s test of additivity was problematic (2.16 and 1.49 respectively). Tukey’s test has one degree of freedom under the null hypothesis (Tukey, 1949), therefore scores should be as close to one as possible; subsequently pretest and posttest items underwent a mathematical transformation to render them comparable prior to any further analysis. The reliability of the transformed STOE and PSTE subscales were found to be Cronbach alpha = .75 and .90 respectively with Tukey’s test of additivity scores as .88 and .77 respectively.
Frequencies and Means

Descriptive statistics were used to report frequencies and means significant to both STOE and PSTE subscales as well as coded contextual information to provide statistical relationships between self-efficacy and other possible factors including the different tutors and use of participant demographics. Such means or frequencies were further investigated by comparisons of vignettes as part of the embedded research design. Further analysis of the data was performed using Cohen’s $d$ Effect Size, t-test, Multiple Analysis of Variance (MANOVA) and Regression analyses to determine further relationships amongst variables with use of comparative pre and post intervention data.

Qualitative Methods in Context

In qualitative research, the phenomenon investigated is at the centre of the investigation and for it to be understood in depth; multiple rich narratives of data are described in detail (Creswell, 2014; MacMillan & Wergin, 2010). Although the construct under investigation is the preservice teachers’ self-efficacy to teach primary science, to assist in contextualisation of this, additional sources of rich data were also used. These sources included:

- Anecdotal and background information on the preservice teacher questionnaires;
- Preservice teacher focus group discussions;
- Semi-structured interviews with
  - the developer of the unit, the Unit Coordinator;
  - support to the unit’s day to day administration, the Laboratory Technician; and,
  - tutors delivering the unit’s objectives and content.
- Pedagogical self-reflection check sheet provided to the tutors; and,
- Researcher’s non-participatory observations during tutorials to provide an alternate point of view.

Qualitative method embedded in Quantitative method

As mentioned in the Quantitative Methods section, the embedded research design also provided a means for collecting qualitative data concurrently within the questionnaire.
These data included background information about the preservice teacher participant; for example, prior science experience may be a factor for their science teaching self-efficacy. It also provided a means for preservice teacher participants to give vignette feedback on the unit design and tutors anonymously without the need to participate in focus groups or interviews. Research has shown that anonymity and confidentiality aids the response rate (Newby, 2014).

**Interviews**

Interviews could be one-on-one interviews or group interviews (Creswell, 2014). In this research interviews were conducted in a one-on-one manner with the Unit Coordinator, tutors and the Laboratory Technician. In contrast to everyday conversation, an interview has a specific purpose, question-based and responses should be as explicit and detailed as possible (Cohen et al., 2011). The interview is a planned event and constructed specific to the goals of the research, with a set of guidelines for conducting interviews (Cohen et al., 2011).

Types of interviews differ from structured to non-structured. In non-structured interviews the researcher uses a conversational mode. They do not have a questionnaire, and instead have a mental framework of study questions that may differ according to the context and participant (Yin, 2010). Secondly, the researcher does not adopt a uniform demeanour for each interview conducted (Yin, 2010). Conversely, in a structured interview the researcher uses a set of questions uniform to each participant and acts in the same manner each time (Yin, 2010).

This researcher used an audio recorded semi-structured interview method, whereby a set number of open ended questions were provided, to ensure the interview remained focused; yet allowed the participants to express their own understandings and attitudes in a conversational manner and slightly deviate away if required within the broad framework of the questions. These questions are in Appendix I. The interview with the Unit Coordinator was non-structured with broad points of discussion provided to allow for a free flow of dialogue between the Unit Coordinator and the researcher.
There are some disadvantages to individual interviews as they are time consuming for both interviewer and respondent, may be open to interviewer bias or interviewee fatigue may appear making the interview more difficult, and anonymity must be ensured (Cohen et al., 2011). To reduce the requirement for long interviews and reduce interviewee fatigue, tutor interviews were conducted in two sessions, whereby in the first session they provided their teaching backgrounds and teaching philosophies. The subsequent session gave the tutor an opportunity to provide reflective insights and attitudes about the unit and their practices employed throughout the semester. The interview for both the Unit Coordinator and Laboratory Technician were conducted in one session. To ensure anonymity all participants provided a pseudonym at the start of their interviews.

**Focus Groups**

Ogubameru (2003) defines a focus group as “a group discussion that gathers together people from similar backgrounds or experiences to discuss a specific topic of interest to the researcher” (p. 1). Focus group discussions are designed to collect a shared understanding from a number of individuals (Creswell, 2014; Yin, 2010) providing insights into participants’ opinions, perceptions and attitudes (Ogubameru, 2003). There is a benefit that the interaction between participants will release more data due to the free flowing nature of discussion (Newby, 2014). The rationale for using this method is to gain efficiency with a larger sample size in a shorter period of time, and may allow participants to feel a sense of readiness to express themselves, as part of a group rather than in a one-on-one situation (Yin, 2010). Focus group dynamics need to be carefully managed to avoid a strong participant to dominant the discussion (Creswell, 2014; Newby, 2014; Yin, 2010).

Newby (2014) describes three main forms of focus groups, these include:

- **Group interviews**, which is the process of collecting data from each participant answering the same questions (Creswell, 2014). Group interviews have shown that individuals influence each other, and therefore may shift their personal viewpoints throughout the discussion (Ogubameru, 2003).

- **Group discussions**, which is the process of eliciting data from a series of questions that are offered to the group to answer. The benefit is a much rich data as answers will be beyond just a quick response as the topic is discussed.
• Exploration of individual views in a group context. This will lead to an understanding of stability of participant viewpoints.
• A combination of some of the above.

This researcher ensured a set of protocols regarding the group discussion was set out at the commencement of the session. These included ensuring prompts were used to allow all participant to voice their opinion and an opportunity was given for a private interview if a participant felt they would like to add further information. As with interviews it was important to ensure that the discussions were not time consuming, and therefore the focus questions were administered at two times throughout the semester. These were near the commencement and completion of the unit. The focus questions are available in Appendix J. These topics of discussion were in relation to the participants’ own science learning background prior to attending the unit, their expectations of the unit, and then subsequently their evaluation of their own learning/self-efficacy and feedback on the unit. This provided further in-depth evidence to support the responses given for individual self-efficacy data and was used as a direct source of triangulation of data as a means to strengthen research credibility.

Focus group data was audio recorded and subsequently transcribed. All participants were reminded they were able to receive a copy of the transcript for checking accuracy and amend or add to the content if they chose to.

Tutor self-reflection checklist
The tutors were provided a check-sheet for weekly self-reflection of pedagogical strategies that were used during the tutorials. These provided another source of data that were triangulated with data to measure the effectiveness of tutor modelling as a factor of preservice teachers’ self-efficacy to teach science. This document can be found as Appendix K.

Observations
The researcher assumed the role of a non-participatory observer (Creswell, 2014). Observations are an invaluable way of collecting data as the researcher is looking at the situation with another standpoint (Yin, 2010). This becomes a valued primary source of data, not influenced by the participants of the study (Creswell, 2014; Yin, 2010). Observations may include written documents, photographs or descriptions of
feelings as a means of collecting data (Yin, 2010). Yin (2010) describes the researcher as a research instrument, even though the observer may use mechanical instruments to collect data.

The researcher observed the tutorials of tutors who consented, and produced field notes based on the tutors’ check sheet as a means of triangulating the data tutors would provide in relation to their pedagogical and teaching strategies. The observations took place three times throughout the semester at various times of the day or lengths within one tutorial. Each tutor was observed in weeks two, six and nine, for a period of approximately 45 minutes to 1 hour in length. One observation round was specifically planned to also observe the preservice students presenting their first assessment to a group. This provided an opportunity for the researcher to get an in-depth look at how individual students were coping with the science content knowledge. It also provided the researcher photographic evidence of the projects produced, which were used as part of the analysis. Although the researcher was not an active participant within the tutorials, the preservice teacher would offer further anecdotal data, which were subsequently recorded in the field notes.

All field notes directly relating to the tutor were made available for the tutor to check for accuracy or use as a form of self-reflection on their teaching strategies.

**Coding and Analysing of Data**

According to Cohen et al. (2011) coding is the process of disassembling and reassembling data to elicit new understandings that explores differences and similarities across cases. Qualitative data can be approached and coded in different ways using manual or computer software. The researcher utilised NVivo software to analyse the qualitative data and code in a manner to allow for triangulation of data with all sources. It further allows individual participant’s narrative to be linked with the quantitative questionnaire scores for that participant, and further analyse factors leading to their self-efficacy. This method is similar to that used by Brady and O’Regan’s (2009) concurrent embedded research.

**Credibility and Dependability**

To determine credibility and dependability of this research, the researcher addressed the following areas:
• Self-reflection
  o Notes were taken throughout the research and coding, which formed the basis of active self-reflection and subjectivity on the topic.
• Triangulation of data
  o A number of different sources of data were utilised including statistical data, focus group discussion, semi-structured interview data and observational data.
• Sampling size
  o Preservice teachers from all tutorials were approached and invited to participate in the research. A range of focus group timeslots was made available to allow for maximum participation.
• Data verification
  o Through critical discussions and verification of data collected with research supervisors.
• Audit trails
  o Through the use of planning notes and memorandums throughout the research period which were readily available to the researcher. These included both audio and transcriptions of focus group discussions, interviews, hard copies of questionnaires as well as handwritten notes kept in a manner to make them readily located if need be. Student data was kept chronologically and alphabetically for easy identification.

**Chapter Summary**
Chapter Four outlined the mixed methods and procedures used for the research. Mixed methods, quantitative methods and qualitative methods were individually discussed and a case put forward for the use of a concurrent embedded research design to answer the research questions. The quantitative method measured the construct of preservice teachers’ self-efficacy to teach primary science and tutors’ influence on this construct. The qualitative methods investigated the factors that may affect the self-efficacy scores and provided a means to verify quantitative data. The findings of the analysed data, through the use of mixed methods will be discussed in Chapters Five and Six.
CHAPTER FIVE
RESEARCH FINDINGS
UNIT DESIGN AND STAFF

Introduction

Chapter Four presented the justification for a mixed methods design to collect data relevant to answer the research questions. As mentioned in the previous chapter, a pilot study was conducted and it was found that the unit design and the academic staff teaching the tutorials were two factors that may affect preservice teachers’ self-efficacy to teach primary science. Further to this, through researcher’s own observations, it also became apparent that another possible factor may be the interaction of the Laboratory Technician (LT) with preservice teachers in various capacities.

The research findings have been segregated into two chapters with Chapter Five including findings through qualitative methods providing data as vignettes from consenting staff (Unit Coordinator, tutors and Laboratory Technician) and researcher’s observations. Chapter Six will include the preservice teachers’ questionnaires and focus group discussion data. Each chapter is of equal importance and allows for triangulation of all data for analysis. The chapters have been segregated to allow for ease of navigating the data and for ease of reading. To protect tutor identity, throughout the chapters, tutors will be assigned the acronyms T1-7. Any vignettes will be stylised with italics to emphasise the participants’ voices. For the benefit of the reader, in this chapter ‘preservice teacher’ will be replaced with ‘student’ as this is their role within the unit.

Current Unit Design Background

As mentioned in Chapter 4, unit design was determined as a factor of self-efficacy; therefore, the Unit Coordinator (UC) was interviewed extensively in relation to various factors that influence the unit’s design. Tutor and preservice teacher interactions during tutorials and their perceptions of the unit will be provided later in Chapter Five and Chapter Six.
The UC’s role is to be responsible for ensuring the integrity, relevance and currency of the unit. The UC is accountable for both the documentation and planning of the unit, as well as its delivery by staff. The UC’s organisation of the unit has a direct impact on the teaching and learning outcomes for students.

The GDE-P science unit is taught at two campuses, one metropolitan and one regional campus of the University. There were two tutorials at the regional campus and 14 tutorials at the metropolitan campus. The regional tutorials had smaller groups of less than 20 students while the metropolitan campus tutorials had 25 students on average. Currently the GDE-P science unit runs as a three hour, 10-week intensive course; therefore, a total of 30 hours contact time. The researcher found through observations and tutor feedback that although the timetable is set for three hours, it is in fact closer to two and a half hours as most tutors have a 15 minute break in the middle of session, and then finish 15 minutes earlier to allow for changeover of academic staff into the tutorial rooms. Therefore, total contact time is closer to 25 hours. The UC explained that reducing time was as per university policy, as “According to the Student Guild and others, they have 15 minutes off after every hour”.

Within the structure set at University level, the UC designed the unit to also take into account the students’ educational background. According to the UC:

Students coming in are a fifth year level, they're Post Grad, they're not BEd. Primary [Bachelor of Education Primary]. They're not four years of growing up in this. They've already got degrees. They've got industry experience, and we're trying to get people to come in at that level, the unit has to be [at a] critical thinking level. One of the tensions you're always going to face is soon as when you ask for people to think, and critically reflect, it takes more time, and it takes more effort.

The UC explained the underlying pedagogical strategy of the unit is based on the “social constructivist model” of teaching. This model provides kinaesthetic learning, tactile learning, whereby the unit’s students carry out physical hands-on activities, rather than sitting in a lecture. Students are socially involved in the learning experience and able to construct their own understanding through their own
experience, rather than transmission from a lecturer or tutor. The UC expressed “that it's ensuring that critical thinking, problem solving, is at the forefront of the design of this unit”. The other design area is to provide modelling of pedagogical and teaching strategies alongside the science content relevant to the primary science context as per ACARA and lead to competencies required for the Professional Standards of Teaching as outlined by AITSL (2015).

The unit plan provided a brief weekly description (schedule of work) of the science topics along with the pedagogical/teaching strategies that will be covered. Additional online resources that students require, such as PowerPoint slides, additional science information and worksheets supported these weekly descriptions. Time was allocated, in the relevant weeks, for assignment explanation and group discussions in relation to their cooperative learning in the assessments. The UC allowed the tutors to “slightly interpret” the PowerPoint presentations and amend them to what their classes and their style required. The UC’s own teaching philosophy is demonstrated through comments such as:

*I’ve got diversity of staff, which is healthy. They’ve got rich experiences. We do not want everybody to have the same. Social constructivism is based on having different perspectives and having science knowledge and all the rest of it.*

The tutoring team the UC selected were based on their science content knowledge and teaching pedagogical content knowledge “. . . because you need the content knowledge . . . also you're teaching adults, you're not teaching primary school kids”; therefore, there are tutors with varying teaching experience, both secondary science teachers and primary science teachers to cater for the variation of students attending the tutorials. The teaching staff demographics will be further explored later in the chapter.

To be able to administer the materials for the day–to-day running of the tutorials, support was required from the Laboratory Technician. During this research period there were 14 tutorials run over a period of three days on a weekly basis. On occasions three tutorials were timetabled concurrently; therefore, intensive on the
Laboratory Technician to provide required resources simultaneously. The UC explained that the unit design must be such that resources are within budget and possible to be disseminated across the tutorials. Therefore, “constructing your curriculum and the hands-on material is budgetary and time constraints” (UC). The Laboratory Technician provided further discussion around this issue, explained later in this chapter. Tutorials were made available at various times of the days to allow for students to participate and attend. For example, those students who had families or worked full time, were able to attend tutorials available at 5:30pm on weekdays or alternatively on Saturdays. These classes were well attended.

The design of the unit includes two points of assessment. The first assessment was a STEM (Science Technology Engineering Mathematics) focused investigation worth 40%. The second assessment was a portfolio comprised of eight primary science activities that have been experienced throughout the course length, which is worth 60%. A review conducted in 2014 (Lummis, Norris, & Slater, 2014) found that students were able to successfully complete the unit with partial or non-attendance to tutorials. The UC found that “people could pass this unit by not turning up, the way it was structured, which demolished the whole idea of the philosophy [social constructivist learning]”. This area was addressed through the change in design of the assessments in 2016.

Assessment One – STEM Investigation

This investigation was conducted in pairs and designed to enhance STEM investigation skills that would support primary science teaching. The timeframe for this assessment was six weeks to completion. The perceptions and experiences of this assessment by the staff and students will be discussed later See Appendix N, which outlines the requirements for the STEM Investigation. This assessment is clearly scaffolded to assist preservice teachers in the development of their investigation.

The researcher observed the students presenting their Assessment 1, both orally and visually. The researcher’s perceptions are based on her professional science teaching and mentoring background. Photographs (with student permission) were taken of varying STEM investigations’ presentations. It was evident from the researcher’s point of view that all students had worked well on their investigations to ensure that
the physical aspect of the project (the working model) was presented. It was also evident that their own science understandings were displayed through their models and posters. The following photographs (Figures 3 - 6) demonstrate the students’ understanding and various standards of production of presentations demonstrating their science concept and science skills understandings. The researcher found that those with a stronger understanding of the science appeared to be more confident in their delivery of their project and more complex in the way the investigation had been conducted. Conversely, those that seemed to have lower levels of science understanding seemed less confident in their presentation, and often referred back to written notes or their project partner for confirmation of their scientific information. The researcher also found the level of poster presentations varied from simplistic to more complex. This also included the level of information presented in relation to how the investigation was performed, how it would fit within the curriculum and the science of the concept under investigation.
Figure 3. STEM investigation of meteorites creating craters

These photographs represent various levels of presentations produced by the preservice teachers in the science understanding area of Earth and space sciences. Figure 3a demonstrates a workable model of the investigation and a complex presentation of required results and explanation of the project relevant to teaching in primary school. Figure 3b demonstrates a simplistic poster presentation with a brief explanation of the investigation and its results. Figure 3c demonstrates a presentation of a very brief explanation of the project, the equipment used and results of the investigation.
Photographs taken by C. Norris
Figure 4. STEM investigation of water rockets

These photographs represent various levels of presentations produced by the preservice teachers in the science understanding area of physical science. Figure 4a demonstrates a computer produced presentation with a brief explanation of the science concepts, the equipment used, methods and results of the investigation. Figure 4b demonstrates a basic workable model of the investigation and an outline of the investigation with its results only. Figure 4c demonstrates a visually stimulating poster presentation with an explanation of the required science concepts of the investigation, its results and equipment used. Photographs taken by C. Norris.
Figure 5. STEM investigation of 'Mouse Trap' vehicle

These photographs represent various levels of working models produced by the preservice teachers. Figure 5a demonstrates a workable model of the investigation using repurposed items. Figure 5b demonstrates a good understanding of scientific process knowledge through the demonstration of various variables for the investigation. Photographs taken by C. Norris

Figure 6. STEM investigation of 'Battery Operated' vehicle

These photographs represent various levels of working models Figure 6a demonstrates a simplistic workable model of the investigation using repurposed items (excluding batteries). Figure 6b demonstrates a variety of understandings of scientific content knowledge through the variation of either producing a moveable vehicle through operating a drive shaft to the ‘wheels’ or to a fan for forward motion. Photographs taken by C. Norris
**Assessment Two – Portfolio of Eight Primary Science Activities**

The UC explained the design for assessment two had changed following an attendance and assessment review two years previously. For this assessment students were expected to outline various activities from ACARA’s four science strands (biological, chemical, physical, Earth and space sciences). One activity per tutorial week (up to eight weeks) was to be selected as part of the portfolio, which would also increase attendance rate.

The researcher did observe that students who attended were engaged and involved in the activities, taking photographs as a record for assessment two. The researcher could not numerically assess the level of science content and pedagogical knowledge the students obtained through observation. The final assessment marks were made available for the students who participated in the research, which are available at the end of this chapter and Chapter Six, which may reflect a relationship between assessment results and self-efficacy.

**Unit Resources**

The unit was rich in resources available to the students. The Unit curriculum was written with the ACARA science curriculum as its basis. Therefore, ACARA scope and sequence of the primary science understandings, science inquiry skills and how science is used as a human endeavour were referred to on a weekly basis, in context with the activities and content discussed in the tutorial. The Federal Government funded primary science resource, Primary Connections, was used extensively for both the activities and science content knowledge required by the students. This resource was developed through thorough pedagogical and primary science content research, and therefore considered suitable for this unit. Additional resources included the hands on activities, online suitable websites, and other written materials were made available throughout the course.

**Design Concern**

The UC had some areas of concern about the current and future design of the unit. These included budgetary constraints for the large number of tutorials that are run. There were two fulltime staff employed in this unit, with the remainder being casual or sessional academics. The UC explained this also assists with keeping the costs down; however, the concern here is the lack of collegiality and availability for tutors.
to get together to discuss areas of unit concern, such as assessment marking. The quantity of communication across emails may increase miscommunication, which in turn affects staff understanding and therefore threatens unit content consistency across the tutorials. It was also noted that many of the sessional tutors were involved in other university teaching/research or teaching outside of the science unit, which added to communication complexity, such as assessment turnaround time and other delays.

In the past an alternative structure to the unit has been proposed, which is to have the three-hour tutorials replaced by one mass lecture with shorter tutorials. Again this provides an area of concern to the UC. The UC stated this would affect “the Saturday people, most people with jobs will not turn up because it won’t fit in with all these complicated work and family related things”. Another alternative under consideration is to have online tutorials, which would reduce the number of sessional academics required; however, this concern was verbalised through the following anecdote:

\[
\text{. . . humans are socially designed to interact with each other and share ideas.} \\
\text{. . . you cannot do social constructivist and hands on kinaesthetic intelligent, develop the stuff which we want to model, it's incompatible . . . it's geared by the economics rather than the research informed knowledge that has been developed over a long time that the best science is basically model, it's talking, sharing, and scaffolding, and all the things that we know.}
\]

This will be discussed, together with further findings and literature, in Chapter Seven.

**Design Summary**

The UC has designed the unit by:

\[
\text{. . . trying to educate the science content and pedagogy at the same time for adults who've got a deficit. If I do not put them through and challenge their learning . . . I'm actually designing it to up skill their pedagogy, and lots of content, that is at a lower secondary level . . . ensuring that critical thinking, problem solving, this is at the forefront of the design of this unit.}
\]
The unit is designed as a social constructivist, kinaesthetic, collaborative pedagogical unit, with science content at a secondary level.

**Tutor Impact**

As mentioned in the Literature Review, research has shown tutors have an influence on preservice teachers’ self-efficacy. Hence, the following section explores the pedagogical and teaching styles of the Unit’s tutors to determine the level and type of impact they may have on the students in their tutorials.

**Tutor Demographics**

Seven tutors taught across the science unit. Only two tutors had a fulltime position at the University, with the remainder being sessional academics. One of the fulltime positions is that of the UC, who taught one tutorial. It is important to note that one tutor (Tutor 4) withdrew from the research and therefore their direct interview, tutorial observation and self-reflection check sheet was destroyed, according to ethical procedure. Therefore, data are discussed for six tutors in this section. Through preservice teacher feedback and focus group discussions, indirect source of data on the tutor 4 will be available for comparison with other tutors in the next chapter. Table 4 below provides an overview summary of the tutor background to demonstrate their diversity.
Table 4. Tutor demographics in relation to teaching background.

<table>
<thead>
<tr>
<th>Tutor</th>
<th>Teacher training background</th>
<th>Teaching background</th>
<th>Number of years tertiary teaching</th>
<th>Employment status at University</th>
<th>Science area of interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Primary</td>
<td>Primary, some secondary The Arts, tertiary Arts and science</td>
<td>30+</td>
<td>Full time Lecturer</td>
<td>Philosophy of science Sustainability</td>
</tr>
<tr>
<td>2</td>
<td>Secondary</td>
<td>Secondary science (15 years) some primary</td>
<td>15</td>
<td>Sessional academic</td>
<td>General junior science, senior human biology</td>
</tr>
<tr>
<td>3</td>
<td>Primary Secondary</td>
<td>Primary - teaching (8 years) Secondary – Director of leadership students (7 years)</td>
<td>2</td>
<td>Sessional Academic</td>
<td>Sports science, biology</td>
</tr>
<tr>
<td>5</td>
<td>Primary</td>
<td>Science specialist primary yrs1-7</td>
<td>16</td>
<td>Sessional academic</td>
<td>Biology</td>
</tr>
<tr>
<td>6</td>
<td>Primary</td>
<td>30+ years primary teaching, some secondary</td>
<td>10</td>
<td>Sessional academic</td>
<td>All science areas, innovative teaching of science</td>
</tr>
<tr>
<td>7</td>
<td>Secondary</td>
<td>Secondary (5 years full time); science curriculum consultant</td>
<td>3</td>
<td>Sessional academic</td>
<td>Human biology</td>
</tr>
</tbody>
</table>

4 All data removed from tutor findings.
The science backgrounds of the tutors vary, with the majority having background strength in biology. Two tutors had a background in biology and chemistry; one had technology and physical geology interests; and one had physics, chemistry and sustainability interests. In all cases, their passion for science was clearly evident with some stemming back from their own secondary school experiences, and comments such as “I loved science, I loved physics the most, and chemistry . . . I studied engineering for nearly a year and then I went to teachers’ college” (T1); “I had a teacher in year seven that instilled in me a love of nature, and I have always been involved in plants, animals, and it sort of stemmed from there” (T6); “I loved science, so I did chemistry, I did biology, I did human biology, I had a really strong interest in science all the way up to year 12” (T2).

As students were questioned about their secondary school learning experiences, the researcher also enquired about this area with the tutors, as this may have impacted them in a similar way. The comment made by T6, above, would indicate that a teacher ignited their passion for science. Another tutor, T7, mentioned that:

My experience with high school science was varied, and mixed, and I certainly didn’t feel confident, in science, at high school, until I was probably, you know, in year 11, 12, and then became interested in human biology, and realised that I was actually quite good in that area of science. So, my interest in science didn’t develop until I was well into secondary education ... some of the chemistry, physics, teachers were men, they were male, and they were more willing . . . to nurture the male students, the boys, that showed an obvious interest . . . I think, had I had a chemistry and physics teacher, that took some interest, was willing to . . . tutor you a little, then I probably would have gone into the sciences, you know, more fully.

Yet another tutor, T5 mentioned the following:

I had two really interesting science teachers. One was in year 9 and one was in year 11, and they were exciting, they provided lots of hands on experiences, they didn’t teach from the text, they incorporated the text, we had the web of
life in high school. Some of the other teachers were just teaching . . . chalk and talk.

One tutor, T3 discussed that although she had a very good science learning experience in secondary school, she also had “very good lecturers at university, in the first few years, that I was studying, and the teaching quality was such, that I found I became more engaged, rather than less engaged”, demonstrating that the passion for learning science can be increased with the injection of quality tertiary learning experiences.

Along with the variety of science backgrounds, the tutors were also diverse in their teaching backgrounds. One tutor “was an art specialist, I was doing the sciences, I was teaching sport, I was playing the piano at assemblies, and in the 1980s, I was in head office writing curriculum material” (T1).

T2 was high school trained where:

... high school biological science is my major, and maths is my minor. So I taught in high schools for, like, 15 years . . . and then primary school, I haven’t had any primary school training, as such, but have done the Primary Connections [Federal Government Primary science resource] and worked with primary schools and the high schools.

Other tutors such as T5 have a teaching background in primary school teaching as a science specialist; however, fell into this role because “I did not think I was going to be ending up in the science field, but as I got into schools, and saw that science wasn’t being taught, I put my hand up to be the science specialist”. T7 on the other hand was a secondary school senior human biology teacher who:

... outgrew teaching fairly quickly . . . got into the curriculum side of things more than anything else . . . curriculum framework, was . . . new for everybody, and I took an interest in that, and developed my skills in the area of curriculum. And within my first couple of years, I did pretty well . . . I was presenting at conferences.
T6 had a very diverse teaching background in the primary sector in both regional and metropolitan regions. With his passion for science and his enthusiasm for embedding the love of science and knowledge into primary students, T6 won awards for science teaching. Whilst tutoring at the University, T6 is concurrently working as a science specialist teacher at a metropolitan primary school.

The above is indicative of the diversity of the tutors teaching the GDE-P science unit, and as a team, these individuals can influence the preservice teachers’ self-efficacy to teach primary science. The researcher observed that all tutors have strong general knowledge of the four science strands, but with some observed bias towards their area of expertise and interest. As they vary in their own science background, they are supportive of each other to assist with science strands where there may be less confidence in their in-depth content knowledge. These supportive strategies are discussed in the next section.

**Teaching Pedagogy and Strategies**

Tutors were asked to complete a reflective diagnostic instrument, checklist (Appendix K), in relation to the pedagogical and teaching strategies they employed during the tutorials. In the second questionnaire (Appendix H), preservice teachers were also asked to complete a section about their observations of pedagogical and/or teaching strategies they had observed during their tutorials. This information, together with researcher observation, can be triangulated with the data provided by tutors to determine strategies that have been most effective to preservice teachers’ pedagogical content knowledge. The triangulation of data will be discussed in Chapter Seven.

The pedagogical styles and teaching strategies used were dependent on the activities, science content and pedagogical focus the weekly tutorials. These will be discussed individually as they appear on the diagnostic instrument (Appendix K). Each of the styles were discussed with the tutors in a professional development session prior to commencing the unit and below are the shared understandings of each style in the context of this study.

*Transmission/lecture style*

All of the tutors reflected on the use of using transmission/lecture style method in short bursts throughout each tutorial. These occasions were to ensure that the correct
science concepts were consolidated, to introduce pedagogical concepts (such as the constructivist model) or information related to activities.

*Discovery/student centred approach*

Each of the tutors also used the Discovery/Student centred approach in each tutorial, citing examples such as “hands-on activities . . . allowing students to decide on researchable questions for investigations” (T5) and “. . . follow the 5E model. To engage and capture interest using the Prediction-Observation-Explanation strategy” (T7).

*Flipped Classroom model*

To a lesser degree (two tutors) the Flipped Classroom model was used, with T1 citing the use of students as a tutor when their expertise was greater than that of the tutor. ‘Expert’ students are possible as a GDE student as these have degrees and industry experience in a given field. An example of this was the use of a student who was a geologist, who was engaged to further explain geological concepts during a tutorial session.

*Experiential learning*

Experiential learning occurred in every tutorial as the design of the unit was to incorporate hands-on kinaesthetic activities. This strategy is also reflected in current classrooms as T6 explains:

> I think the way the hands-on activities are structured each week, obviously there is a hands-on activity that students would use in the classroom, but it's also the collaboration, the collaborative work within groups, and that's what's expected of students in the classroom today . . . hands-on, the creative part, also integrating science, technology, engineering, and maths, so the students can actually see the links in other learning areas as well.

T5 mentioned that she:

> ... often guided [the experience] through questioning. The students were encouraged to discuss their finding and relate to real life experiences. Reflection of the experience was done at the conclusion of the lessons.
Use of technology

The amount of technology use was dependent upon tutorial content. During every tutorial there was a weekly PowerPoint presentation used to guide the learning experience. Some tutors only used this as an overview guide and did not refer to these very often throughout the tutorial. As mentioned earlier, the UC gave scope to the tutors to amend the PowerPoint presentation slightly as required for their purposes. Given this, some tutors mentioned they did amend the presentation to include the week’s expected outcomes, including “objectives which include teaching strategies and any activities that we did each week” (T3); or add in extra relevant videos (“Icky Icky Insects” YouTube clip) and websites of interest. Other technology that was used was both basic stereomicroscopes as well as a single ocular electronic microscope that was linked to an application on an iPad and therefore the use of multimedia. The researcher also noted that students were encouraged to use their Smartphones as part of recording activities for their assessment. The researcher did note that tutors were unable to plan for the use of interactive whiteboards, as these were not operational in the tutorial rooms.

Brainstorming

Brainstorming was a strategy that all tutors utilised during the tutorials. This strategy was used as pair-share technique in small groups as well as whole group brainstorming prior to and at the conclusion of activities. This technique was used to elicit prior knowledge from the students that could be built on throughout the tutorial, then consolidation of learning at the end of the activity or tutorial reflecting the social constructivist style of teaching.

Collaborative learning

The researcher observed all tutors using group work as a collaborative learning tool. In addition to this, the tutors employed a primary school group learning strategy of designating students with specific roles such as Manager, Director, Speaker or Recorder. These techniques were used to model teaching strategies that could be used once the preservice teachers graduate.

Questioning

All tutors used a variety of questioning techniques during each tutorial; however, the level and complexity of the questions varied. Tutors would commence the classes
with reflective questioning, employing knowledge or recall inquiries, at a superficial level, to determine whether students could remember prior learning or facts. These questions were often followed up with comprehension and application questions, where students would demonstrate understanding or able to apply their learning to a new situation posed. Analysis, synthesis and evaluation type questions were utilised when discussing the activities that students had participated in. Most tutors used open-ended questioning techniques eliciting various answers and endeavouring to include as many students as possible in the discussion.

The researcher observed one tutor using the funnel question technique whereby a broad topic was introduced and using students’ understanding to construct together the understanding of a specific concept and reach a decision to answer a question. This question was whether a spider is an insect, whereby the tutor questioned and constructed on the board a tree of knowledge starting at defining the difference between plants and animals; funnelling this down to differences between insects and arachnids through further questioning.

As constructivist learning is based in part on extracting information from participants some tutors deliberately also used probing or trigger questioning techniques. The researcher observed that in tutorials where the tutor used a variety of questioning techniques, the students were far more engaged and actively participating in answering the questions. The researcher noted that although the tutors were using the questioning techniques well, they were not always explicit in explaining the questioning techniques they were using so that the students could note these as teaching strategies that could be used once they graduated.

**Modelling**

There are topics within science that are abstract, and therefore, more difficult to understand. In these instances, models were used to simulate the abstract concepts. For example, the concepts of the phases of the Moon, day and night, seasons and eclipses were modelled using polystyrene balls, a torch and the student to model how these are created. Modelling ensured that a concrete method was used to help students to understand the concepts. The researcher noted that in some cases the student was part of the model and their participation seemed to assist them in developing
conceptual understanding. Other simulations included a game to represent the rock cycle and a toilet roll time line of events that have occurred on Earth (time line commenced as scientific research determined) making abstract concepts concrete. These activities were part of the design of the unit, and therefore, only used in tutorials that were relevant.

**Critical thinking**
Tutors mentioned that critical thinking occurred prior to students performing hands on activities. The students were asked to construct fair testing investigations. The researcher did note that in these situations some tutors were more explicit in their instructions than others in regards to planning investigations. It is possible that tutors who were less explicit but questioned the students more, would provide a more constructivist environment for critical thinking to occur. The researcher also noted that many tutors were not explicit in their explanation of this teaching technique as a future teaching strategy.

**Role Playing**
Role-playing, whereby the students became the model to demonstrate a concept, was only used on some occasions as the design of the unit outlined. These included modelling the movement of electrons through a circuit, and the different states of matter. T1 gave the following example:

*I use the drama with the states of matter, and then when they turn to steam and they drip off the wall, they come down and they lose their energy. I did the toilet paper roll, millions of years, because there are huge conceptual problems with people holding numbers in their head, so I make it out of toilet roll. The fact that it's toilet paper is a humour in itself.*

**Additional teaching strategies**
Further teaching strategies that were identified through researcher observation and tutor feedback. These included:

Further teaching strategies that were identified through researcher observation and tutor feedback. These included:

- Humour – the researcher noted that all tutors had varying levels of humour. T7 noted that she “always emphasised the fun in science and
conscious of creating a non-threatening environment”. The other tutors echoed this sentiment as well, such as T5’s comment in the tutorial when introducing an activity “Let’s have some fun”. Often the humour was embedded in anecdotes from their teaching time.

- Team teaching – the researcher observed some tutors who had concurrent tutorials combine their groups to assist with efficient use of available equipment or to support each other in teaching a concept that one tutor may have been more confident in then the other tutor. This modelled to the students that team teaching is an effective technique for efficiency, as well as demonstrating collegiality.

- Appropriate use of language - the researcher found it interesting that some tutors were more scientific in their use of language, compared to other tutors. It seemed that those that had been teachers of secondary level, used a higher level of scientific language than those who had exclusively taught in primary schools. An example of this is the use of the words ‘mini-beasts’ or ‘creatures’ rather than soil organisms. There was one tutor who used both scientific and common everyday language interchangeably but was very explicit in their explanation in relation to this use of ‘dual’ language.

- Explicit instruction and modelling – The majority of the tutors were explicit in their instructions of activities and relevant scientific literacies. The researcher noted that all tutors did model a variety of strategies, however some tutors need to be more explicit in the explanation of the pedagogical styles and teaching strategies they employed throughout the lesson. T1 “tried to model the roles” that students were assigned as part of the group work activities. T2 demonstrated explicit scientific literacies (for example, the use of investigation planners, and demonstration of scientific tabulation) and differentiation of investigation planning appropriate to various year groups. An example of this is T2 who would go “back to ACARA, but just always going, “Where does it fit? How could you use it?” Because . . . with science especially because their confidence can be
low, they might see an activity and they do not really know how to use it, and so you really can teach them”.

• Various methods of conducting the activities were observed including the use of open-end inquiry, placemat, jigsaw, round robin, bingo activity sheets and demonstrations, were all designed to model techniques that could be used in the primary classroom.

• Extrinsic motivation - The researcher observed the use of extrinsic motivation through disseminating confectionary when “finding the winner” to complete a task efficiently. T3 supports this with her own observations through the following statement when discussing teaching strategies:

I think that’s a bit of a shock, because you think with adults you do not have to bribe them . . . when we built the lighthouses . . . we had a competition . . . and we scored each other. It was all very light-hearted, but it was still that same strategy, where we are going to look at everyone’s model, we are going evaluate it, and then we are going to award a prize to the group that’s done the best job . . . from that point of view you do use very similar strategies, and it does not matter whether you are in a year two classroom, or a university classroom, and I have done the whole gamut, so year two right through to university, and the same strategies work. I do not know how they’d go with stickers, but we can try next year and I’ll let you know . . . we are motivated by exactly the same things we were when we were seven.

Provision of additional materials
The researcher also noted that all tutors brought into the tutorials additional materials from their own teaching background. These included additional contextual or relevant worksheets, models and equipment. T6, as an active primary school teacher, also brought in science worksheets and models from primary school students to demonstrate the level these students can attain using the same activities that the preservice teachers were investigating during tutorials.
As this unit was designed based on social constructivist learning, the tutors were explicit in their use of the 5E Instructional Model; T7 mentioned that she made “obvious connections to literacies of science for students and relevance of the task to diagnostic, formative and summative assessment within the 5E model . . . made the link to Primary Connections book and activity and phase within each lesson”. Similar statements from other tutors as well as the observations made by the researcher supported T7’s statement. T6 also mentioned the modelling of Kagan’s instructional model of cooperative learning (Kagan & Kagan, 2009) to demonstrate other teaching techniques to the students.

Through the use of the constructivist learning tutors also ensured that concept misconceptions were addressed, either through students’ own observations or through discussions. The researcher did note that on a couple of occasions a tutor would inadvertently introduce a misconception such as “bacteria are animals” or that a “flame is fuelled because of a lack of oxygen”. T3 commented that “unfortunately in primary teaching, you need to be an expert across a range of things. It does not mean you have to be a tertiary level physicist, but it certainly means you need a good solid understanding, and you need to bust your own misconceptions in this unit”. This will be discussed in Chapter Seven.

Tutor perception of preservice teacher’s change in self-efficacy

Tutors were able to give some general feedback in relation to their students’ perceived change in self-efficacy in science. T3 mentioned that some students struggled and felt a high level of anxiety with the first STEM assessment, where they had to build a working model using science concepts. T3 did receive feedback from students who had struggled, and commented that:

. . . it was an incredibly valuable learning experience, because once they got over the initial reluctance to engage with building something, they said, by doing, they learnt so much more.

T1 observed, “I think their awareness would be up. I think they would know how to access resources, they would know how to use the Internet, they would know that I said if you do not know, go to Primary Connections”. T5 mentioned:
From day one I could see there was a lot of reluctance with some of the students. They were unsure, they weren't really ... they were tentative and they weren't really prepared to have a go. They were, obviously, very worried they hadn't done science, many of them for years and years and years, but by the end, and especially in week ten, I got a lot of e-mails, and a lot of the students coming up and saying they really felt confident now about going out and having a go teaching science, and they thoroughly enjoyed the presentation of the classes.

T6 had similar experience in his tutorials, where he mentioned:

They [the students] were really nervous . . . their conception, their science knowledge was really poor . . . there was a lot of questioning . . . by week four they were using correct terminology . . . and they were conducting investigations, re-trialing, looking at various variables and it was really professionally fulfilling. I believe the confidence level in the students has really multiplied.

The remainder of the tutors all expressed similar trends in their tutorials. With T7 mentioning that prior to attending the unit:

Students expressed how anxious they were about teaching science, and going into this unit, then at the conclusion of the unit their portfolios show that they were actually really enjoying themselves, and the level of conversation, discussion; they were using scientific language, and trying to use the concepts, in context, in their group work. So, I was amazed to see the level ... that just their degree of progression, from week one, to week ten, and they were willing to have a go, which I thought was fantastic.

Tutor Unit Experience and Concerns

It is important to also get a sense of how the tutors were experiencing the unit as tutors were deemed to be an influence on preservice teachers’ self-efficacy, giving the researcher an insight into tutor attitudes that the preservice teachers may have
experienced. The researcher noted that all tutors were confident during their tutorials and often used “relaxed” body language. Tutors mentioned they were happy with the resources and found them of good quality and clearly linked to the Australian Curriculum. They felt that the unit structure based on social constructivism and the collaborative nature of the first assessment made a huge difference to student engagement and ultimately self-efficacy.

However, it was also noted that some tutors expressed concerns that did create anxiety or angst for them, yet tried not to show this during the tutorials. One tutor had considered not continuing to tutor in the unit after the first assessment. Another tutor expressed they did not want to participate again in future years. Some of these concerns raised were in relation to the disparities with the unit plan and the weekly PowerPoint presentations and with the assessments, as well as the aspect of social media.

T7 mentioned the “importance of cooperative learning in science . . . and the talk amongst students, to . . . clarify their understandings, and address misconceptions they might have . . . is not developed enough in this unit”. T5 felt there had not been enough explicit teaching of process skills. She explains this in the following statement:

*I feel that we do not do very much in relation to process skills. So when we say, "We're going to be observing" they do not really know what observing is. They do not really know what classifying is. They do not really know what inferring, and prediction, and hypothesizing . . . So I think more explicit work on that, because I think all of those skills are embedded in the actual activities that we do . . . I think the 5E model, if we're really going to be doing that five E model, we're going to have to do a lot more work on it, because they do not understand the progression from one E to the next . . . relationship, if we're going to look at planning using Primary Connections [a national government supported primary science teaching resource] and the 5E model, we need to really make that quite explicit, and see there is a developmental progress.*
T6 commented that when doing the activities “sometimes there’s not enough resources on the trolley, for example, there might only be one or two Primary Connections booklets of a particular topic, so there was a lot of sharing, and in that sharing then it’s like they do not have enough time to really go into it”. He felt this did not give the preservice teachers the learning opportunity to fully understand the science behind the activity. At other times it was felt that “there were too many activities for [one] session”.

The area of most concern was consistency amongst tutorials to allay angst and anxiety amongst students who compare what is happening in each other’s classes. This issue caused stress for the tutors. One of the areas of inconsistency was the weekly PowerPoint presentation not being in line with the unit plan or centrally disseminated to the students via electronic means. T7 commented that she would create a tutorial guide for herself and added the PowerPoint slides where they best fitted; therefore, keeping the information consistent with what students had received yet making it work for her. This was evident in her comment about the unit plan that “...[I] have a look at what was suggested in there, we would cover for that week, and there was some pedagogy suggested in there, but it wasn’t coming through in the PowerPoint”. Another tutor commented they would add in additional slides including the week’s objectives and teaching strategies. One other tutor added in further readings, websites or content. T2 felt:

*I think what is really good is you have your basic PowerPoint and people had a little bit of professionalism to go and add a clip here and here... but to a degree that needs to not be too much different, because otherwise that causes angst as well. So I think... the PowerPoint needs to be shorter, people can add little things to supplement it.*

T3 commented that “a standard format, with explicitly stated [objectives, teaching strategies and weekly activities] would make it much easier for staff and students”, thereby reducing her anxiety.

The assessments were another point of angst felt by tutors. Some of the tutors felt that the inconsistency between the unit plan, verbal explanations, and further detail such
as the online rubric increased anxiety for their students. This in turn reflected back on the tutors, who were consistently queried by their students for clarification. Tutors felt that clear rubrics together with explicit detail in the unit plan would have allayed this issue. T2 mentioned some of the tutors had collaborated to create a “new clear rubric really addressing what we’re looking for, makes it easy for everyone . . . make [it] more tangible . . . really consistent . . . probably more than even other subjects, because of the nature of science”.

The increased anxiety of the students around assessments further introduced another area of tutor concern. The GDE-P students had a closed social media group in which they expressed their concerns, anxieties and issues with the units they were enrolled in. This was made apparent to some of the tutors, with one tutor stating:

One of the factors that have really changed my thinking is the fact that the students do have a closed Facebook group they've got the opportunity to, obviously not focus on using Blackboard [an internal university communication site] as much, and the [University] part, but when you actually hear students just use the Facebook rather than the [University] website to communicate, the discussion part, it saddens me to the extent where the opportunity for them to bag tutors, to actually criticise some of the work that's done, knowing that every tutor is different in the way they present, and not so much the science part.

T3 summed up the concern of social media, by saying:

If we had the unit plan that was absolutely word perfect, and we had rubrics in that unit plan, which are incredibly clear, and easy to understand, it would have made the teaching of the unit incredibly straightforward, it would have made the students more confident, and I think ultimately, you end up with just a better result at the end of it.

T2 commented that if you have “a very consistent guideline so there's no room for social media to have in it”.

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These concerns will be triangulated with data from students and further discussed in Chapter Seven.

The notion of entitlement was raised with T1 expressing the following:

_Students will always demand more and more. Students will always scapegoat when they're under pressure, all people will scapegoat and demand, or blame, when they're under stress, because they have to confront themselves . . . What I've been impressed with is how many people do reinterpret the STEM project, so they come up with stuff out of left field, even though they're within that. Now all science and innovation, it's not about prescription, it's about different paradigms of thinking._

**Laboratory Technician Impact**

As mentioned earlier the LT’s role is important in supporting the design of the unit and the tutorial participants, including the tutors and students. This section will outline some of the benefits and constraints from both tutor and LT viewpoints, supported by researcher observations. The LT has had a long-term involvement with the unit, as both a sessional academic tutoring in the unit for two years, then as LT for the past 10 years. The researcher noted that the LT was very familiar with the unit and felt connected with it through the use of the term “we” during the interview.

One of the tutors had mentioned they found a lack of resources for their tutorials on weekends. This can become an issue if the LT is not aware of its impact on the students. During the week there were three tutorials timetabled concurrently, which does create resourcing constraints due to the budget available. However, during these times the tutors were able to team-teach or ‘borrow’ equipment from other tutors. This option was not available on the weekend. LT commented:

_This is only one of five units that I tech so I have to watch that other academics are not doing a bigger unit [of activities], that particular week, because otherwise I can become overwhelmed by the amount of equipment that I've got to be able to then put back into usage._
LT’s background gives scope for observing changes that have occurred throughout the history of the unit, along with observations of the current structure and its students. One of the changes that were observed included the removal of STEM style models, such as mousetrap racers and water rockets that were made by students as part of the science tutorials. LT commented they felt these were “very work intensive” to prepare and these were “more technology and enterprise rather than science”. Through discussions with the Unit Coordinator and basing the unit on the Australian Curriculum these activities were removed. Since that time the STEM focus has returned and some of these have been reintroduced through the assessment, rather than during the tutorial. LT is therefore familiar with the concepts of these activities and when available was able to assist the students when approached. LT stated:

*If they [student] cannot get hold of the academics I do encourage them to come and talk to me so that we can talk through where they're at. Often I find that's all they want to do, is be able to just talk it out, so to speak, out loud, and perhaps go over the documents, and be pointed in the right direction as to what they're looking at, and that's what I feel is often enough for most of the students.*

This did not occur very often during the investigation period; however, this provided another source of assistance to the students who struggled and may have influenced their self-efficacy.

LT who had training in the presentation of this material supported the use of Primary Connections as the primary resource for planned activities and investigations. This is supported by LT’s comment:

*Using Primary Connections has really, we feel, increased the content understanding and it does scaffold the students. The students feel a lot more supported by using that particular resource for the first few times they are teaching a particular unit.*

From an outsiders’ point of view LT mentioned that the students:
[Students] really enjoy the hands-on of the activities and the fact they are discovering things about their own personal misconceptions they have, and they haven't perhaps done this activity since they were in primary school. I often hear comments about, "Oh, I remember doing this at primary school" and when their first assignment is handed in, sometimes I will hear them struggling with the concept behind what they're supposed to be doing, but often by the time they've got to the second assignment, the comments are more, "I understand now. I know what I'm looking for. I know where to find it," and they are feeling more confident about their own understanding of what's going on . . . About week six is often the breaking point for them; they feel that they've got a lot on their plate, their assignments are due, they're struggling, they're hitting a bit of brick wall, and that's sometimes when in class if I hear comments I'll say, "You're doing really well," and, "Keep going," and encourage them.

The researcher had also noted this is where LT is able to give encouragement, which becomes a factor in building students’ self-efficacy.

LT was able to discuss the outline and design of the unit with the Unit Coordinator and commented “I think that [Unit Coordinator] does well in keeping up to date with what is current science thinking and bringing that into the unit”.

Assessment and Attendance Data
The following Table 5 outlines a comparison of all tutors in relation to their number of students, the overall results (given as minimum, maximum and mean scores) and student attendance as a percentage over 10 weeks.
Table 5. Tutor comparison of student assessment and attendance data

<table>
<thead>
<tr>
<th>Tutor</th>
<th>Number of Students</th>
<th>Assessment results</th>
<th>Attendance Mean (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>1</td>
<td>22</td>
<td>67</td>
<td>93</td>
</tr>
<tr>
<td>2</td>
<td>89</td>
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<td>5</td>
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<td>50</td>
<td>92</td>
</tr>
<tr>
<td>6</td>
<td>43</td>
<td>60</td>
<td>88</td>
</tr>
<tr>
<td>7</td>
<td>33</td>
<td>35</td>
<td>88</td>
</tr>
</tbody>
</table>

The assessment and attendance data were obtained and mapped against preservice teacher participants who had completed the initial questionnaire. It is important to note that triangulation is not available for Tutor 7 as this cohort was from the regional campus. The regional cohort did not meet the same standards of research protocols and insufficient posttest questionnaires were completed to allow for further analysis as a comparison group to the metropolitan cohort. However, from tutor vignette data as well as the assessment and attendance data it can be seen this tutor was comparable with their counterparts in the metropolitan setting.

It can also be noted from Table 5 that attendance for all tutors is above 85%. This is a significant finding as it demonstrates that the design of the unit may be an attributing factor to increased attendance, which in turn would increase student engagement. This was an observation made from comparing similar data in the pilot study and the study completed by Lummis et al. (2014). Further discussion will be in Chapter Seven.

Chapter Summary

In order to determine the level of influence the unit design and its tutors may have it was imperative these were first examined. Chapter Five provided the context of the current unit, the background of the tutors and vignette data to provide another source of information that may have bearing on the influence of preservice teachers’ self-efficacy to teach science.
The aim of the unit was to extend preservice teachers personal skills in science content knowledge and pedagogical content knowledge, fostering an appreciation of scientific literacy in society. The design of the unit was based on the social constructivist learning and teaching model, utilising interactive activities and investigations in a collaborative manner.

The use of Primary Connections as its primary tutorial resource gave authenticity to the design, as this modelled how the current science curriculum (as set by ACARA and SCSA) can be taught in primary school settings. As STEM is a current focus within the Australian education curriculum, assessment one was designed with this in mind. The investigation was to be conducted using collaborative methods and focusing on science content within the physical science strand. Assessment two was designed for preservice teachers to collect a portfolio of activities to enhance their understanding of science content required across the four science strands (as per ACARA).

Tutors reflected on the use of a variety of pedagogical and teaching strategies throughout the term. It could be seen that the tutor’s teaching background was a determining factor of the teaching strategies that were most commonly used. The most common and consistent pedagogy, used among all tutors, were discovery and student centred approaches in a collaborative learning environment. The design of the unit ensured that experiential learning was the central philosophy and therefore modelled by the tutors. The next most commonly used techniques included, brainstorming, roleplaying and questioning styles. Tutors also commonly identified the use of humour and anecdotes from their own teaching experiences.

The level of explicit instruction varied among tutors. This included both science content and pedagogical content instruction. It was found that some tutors were very explicit in all instructions; therefore, not allowing preservice teachers to develop critical thinking; whilst others were not explicit enough in their modelling of strategies to demonstrate clearly how a teaching strategy may work in primary school environment.
Tutors also discussed their strengths and weaknesses with their science content knowledge, determined by their teaching background in science. It could be seen that those who were secondary trained science teachers had very strong level of understanding in all science strands, and very specific in one area (e.g., biological sciences). These tutors also had higher expectations of preservice teachers demonstrating greater science content understanding in the assessments. Tutors who were primary trained were versed in all science strands, however the language used was more geared towards primary school students, and could be considered less scientific.

The explicit nature of the tutor’s teaching of content and pedagogy along with how the tutor interacted with their students, could affect preservice teaching self-efficacy. This interaction together with the pre-service teacher findings will be used for triangulation and discussion in Chapter Seven.
CHAPTER SIX
RESEARCH FINDINGS
PRESERVICE TEACHERS

Introduction
Chapter Six will present the preservice teacher quantitative modified STEBI-B data and analysis along with anecdotal data from researcher observations and focus group discussions. The data presented will respond to the research questions and provide further insight into the factors that may affect self-efficacy to teach primary science. As mentioned in Chapter Four, participating preservice teachers were assigned a pseudonym that would identify the tutorial group they attended. In this manner preservice teacher data could be used to triangulate with a particular tutor, and therefore allows for in-depth analysis of tutor and student interaction. For the ease of reading this document, the qualitative data (vignettes) will be in italics.

This chapter will outline the participant demographics and frequencies of gender, prior science learning experiences, as well as the type of science learners within each tutor cohort. As mentioned earlier self-efficacy data will be outlined, which were analysed per tutor, as well as total participant cohort. Factors that may influence self-efficacy were also analysed, including:

- Gender;
- Prior science learning background;
- Type of science learner;
- Tutors’ impact;
- Assessment results;
- Unit design; and,
- Additional factors that were identified by the students (e.g., life experiences).

Participant Demographics
Table 6 outlines the number of the pre and post intervention questionnaire/STEBI-B participants. Those that participated pre intervention will also give a clear demographic representation of the almost the whole unit cohort due to high
participation rate in the research. The participant demographics have been presented as a whole cohort and per individual tutor.

Table 6. Pre and post intervention participants

<table>
<thead>
<tr>
<th>Tutor</th>
<th>Pre Intervention</th>
<th>Post Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>1</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>78</td>
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<td>3</td>
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<td>4</td>
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<td>5</td>
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<tr>
<td>6</td>
<td>33</td>
<td>12</td>
</tr>
<tr>
<td>7</td>
<td>29</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>279</td>
<td>92</td>
</tr>
</tbody>
</table>

The total number of enrolled students for this unit was 422, with 39 withdrawals throughout the semester. The number of students who had withdrawn from the unit was provided by university data. This would give an indication of the success rate of research participation. It must be noted that Tutor 7 data will not be used for self-efficacy data analysis, as the cohort did not respond sufficiently with follow up post intervention questionnaire participation. Therefore, the researcher felt these data were unreliable and not comparable to other data. One potential cause for the small Tutor 7 sample is that the administration of the instrument was not conducted by the researcher face-to-face, but through electronic means. A similar issue was found during the pilot study, where the modified STEBI-B was administered via electronic means. A total of 38 preservice teachers participated in the pilot research, representing approximately 10% of the 2015 cohort. During the thesis study, approximately 71% of the cohort were represented in both pre and post intervention data, and pre intervention data was representative of 88% of the cohort. This level of participation would suggest the robustness of the face-to-face data collection methods.

A total of 54 individuals participated in the focus groups across tutorials from Tutors 1- 6. There were 41 females and 13 male representatives, which was similar in
proportion to the 76% female and 24% male participants in the pre/post questionnaires.

Table 7 demonstrates the science education background of participants, which may have a bearing on their self-efficacy to teach primary science. This table shows a distinction between male and female science backgrounds as a percentage of the total cohort.

Table 7. Science learning experience background of preservice teachers

<table>
<thead>
<tr>
<th>Highest level of science completed</th>
<th>Gender</th>
<th></th>
<th></th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Females (%)</td>
<td>Males (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 9</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td></td>
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<tr>
<td>Year 10</td>
<td>15</td>
<td>12</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Year 11</td>
<td>7</td>
<td>8</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Year 12</td>
<td>45</td>
<td>42</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Undergraduate degree</td>
<td>25</td>
<td>30</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Postgraduate degree</td>
<td>6</td>
<td>8</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

*Note* Total N=270 (97.5% of participants) with N=7 (2.5%) missing data. Female n=204, Male n=66.

The number of participants completing secondary science classes in this sample was higher than expected from the literature (such as studies by Danaia et al., 2013; Mulholland et al., 2004). This will be discussed in Chapter Seven. Through focus group discussions, some participants commented that in the secondary education system they went through (in Ireland and United Kingdom) “*science was not compulsory to study in high school, therefore I opted out*” (Francis). Belle mentioned “*I did most of my primary studies in . . . Indonesia, and we do not really have science . . . no inquiry based learning, no creative thinking*”. This may account for the missing data or have impacted their levels of science self-efficacy.

**Participant science learning experiences**

Through the analysis of the anecdotal text-based questionnaire data and focus group data it could be seen that students had a variety of science learning experiences prior
to tertiary study. These experiences may also affect their self-efficacy and subsequent enthusiasm or reluctance towards continuing science based degrees or careers. Coding the qualitative data for school experience revealed some overarching themes. It was calculated that the majority of students (64%) had positive science learning experiences, whilst 23% had a negative experience. The remainder 13% did not respond to this question.

**Negative learning experiences**

The negative learning experience themes that emerged were:

- Heavy emphasis on theory (11% of comments);
- Too much memorisation and rote learning (10% of comments);
- Science teacher as an influence (26% of comments);
- Science content was challenging (29% of comments); and,
- Not interested in the subject area (24% of comments).

**Heavy emphasis on theory**

Some of the representative comments included, “Lots of worksheets” (Amelia) and Bonnie’s commented:

Most lessons would consist of writing the textbook into an exercise book, very few activities or experiments . . . Had my education been interesting and interactive I would have continued science in further education.

**Too much memorisation and rote learning**

Alfred, from Singapore mentioned that learning science in secondary school “was a very much teacher-led kind of a classroom, instructional methods, so as a result we never had many experiments . . . it was always rote learning, it is the process of auto-synthesis [sic], you memorise it”. Jemima’s comment was common to other participants in that she “hated human biology and chemistry . . . rote based learning”, with Dania adding a common comment that “at secondary level [it was] exam-focused approach with lots of memorising”. Emily summed up the common sentiment with:

My memories of school science were of being taught facts to learn rather than enquiry or discover, hence I do not believe I really understood or enjoyed
science. Undergrad science again wasn't presented as an interesting or enjoyable subject so my learning was that of rote learning and very little has been retained!

Science teacher as an influence on student learning experiences

This theme recurred numerous times with many vignettes stating similar sentiments. The vignettes outlined below are representative of most comments. Cara mentioned “in primary school . . . teachers being disinterested . . . in high school was rather the same with an added dose of a very bad teacher/teachers who made my science learning experience rather uninspiring. I want to do it differently”.

The strength of the teacher’s influence was evident in comments such as:

- “I found myself engaged and enjoying physics, but was not encouraged to continue and I formed more of a dislike for science as a whole learning area” (Alfie);
- “[A] Substitute teacher grade 9-10 crushed my love for the subject - disengaged, not happy in her position! Taught from textbook exclusively without context” (Austin);
- “Science was never a favourite subject and I was never very good at it. I had one physics teacher in an overseas school that was so scary and strict that it put me off the subject altogether” (Freya);
- “Mayhem. Our class was uncontrolled and dangerous” (Archie);
- “High school - completely disinterested due to a teacher who lacked control of class” (Frankie); and,
- “The art teacher took us for science. I do not recall being engaged. In high school my experiences were poor. The teachers I had were focused a lot on behaviour management and they were not positive or inspirational” (Fenella).

Other students recall that their teacher influenced them through the teaching technique they were exposed to in the learning experience. Comments from Emilia and Jessica respectively, demonstrated these observations:
I do not feel I learned much in lessons and couldn't always grasp the teacher's meanings through their teaching methods.

And:

I would have preferred to have the challenging concepts explained or taught using a more hands-on approach. I think that if the teacher found a better teaching style for the difficult content, it would have improved my grades as well as others' who struggled.

Pamela echoed these with her comment that she “did not have effective teachers in high school that communicated science in a way that was memorable for me”.

The teachers’ attitudes and behaviours were another influence on the participants’ engagement with science. Jade found “My teacher was not extremely passionate and I believe this lead to my disinterest to not continue into years 11-12”; whilst Milo mentioned “The chemistry/science teacher however I found to know her subject really well (aka "Nutter Professor") but struggled to convey her subject and to make it interesting or applicable. Hence my lack of interest in Chemistry/science unfortunately”; and Keira’s anecdote “The teachers [in secondary school] were not as fun with the topic as in primary school and I found the subjects a bit dry”, echoes those of others.

Finally, the manner in which teachers interacted with students in the class was also an influence. Kaci’s strong comment below demonstrated how affected students by their educational experience:

I did the mandatory science up to year 10, but hated it and overall would say I do not really like science. Hate doing experiments! Had poor teachers who only focused attention on the students that loved/were good at science [in high school] – [I] had to do a lot of my own study to improve.

Science content was challenging

Many students lost interest in the science learning experiences as they struggled to cope with the content. Florence mentioned, “I thought biology was more interesting than physics and chemistry, which just seemed abstract and too maths orientated”;
Preston mentioned that he “struggled with chemistry as a specialist field in year 11, the step up in level was a bit much”.

It was not just the abstract nature of some of the content but students also struggled “with the basic concepts and didn't really understand 'why' we were required to know compounds, atoms, etcetera. It always felt to me that science wasn't something I would need or encounter in my everyday life and so I didn't understand the need of it” (Chelsea). This demonstrated the need for contextualisation of scientific concepts.

Dale mentioned “I thoroughly enjoyed geography but hated chemistry/physics/biology etcetera at high school because I could not link to people, lifestyles and behaviour”.

Not interested in the subject area

For other students the experience may have been influenced by other factors, including they preferred other subject areas. Florence mentions “to be honest the science lessons were pretty dull, lots of taking notes and not much active participation”. Fabien echoes this with his comment “in high school I found it extremely boring and was not interested”; whereas Sean became “disengaged by scripted nature of investigations”. Martha mentioned that she had a positive experience “but it was not my favourite class so I chose humanities classes for senior years” and Hayden was “more interested in the critical analysis side of the arts”.

There were also participants that were drawn to other subject areas as they were “Scared of science, did not connect with it, so felt like my brain was not 'wired for it’” (Kevin) and “I did not believe I had the capacity to think scientifically, and so struggled significantly in science at high school” (Taiya). These are some of the individual participants where particular note of their self-efficacy scores will be taken into account later in this chapter.

Mixed learning experiences

Some students had mixed experiences and these were made evident through comments, such as Evie’s:

My experience with science has been quite mixed because I love learning about science especially the human body but my marks did not often reflect
this so I was often discouraged. I am although passionate about science and I am excited to do this unit and teach science in primary schools a teacher. I think leaning about science helps you understand yourself and the world around you. It is very valuable.

Amy mentioned feeling out of her depth in secondary school and “didn’t feel comfortable getting low marks”. It is interesting to note this student also withdrew from the GDE-P science unit.

Some students enjoyed the science content, however had mixed learning experiences due to their teachers. Millie explained:

> I had mixed experiences in high school depending upon subjects and teachers, but I definitely had to do a lot of independent study using my own textbooks and tutorial books due to 'incompetent' chemistry teachers in upper high school because I didn't follow their methods of teaching besides being very interested in the subject.

**Positive Science Learning Experiences**

The positive emergent themes that were the most common to participants were:

- Science ‘felt natural’ or ‘came easy’ (33% of comments);
- Practical nature of science (42% of comments);
- Problem solving and inquiry nature of science (11% of comments); and,
- Teachers’ influence on science learning experiences (14% of comments).

Many of the participants all echoed the same sentiments as not just singular themes but a combination of the themes above. Albert verbalised that he “enjoyed science and maths [sic] at school and consider myself scientifically minded”, with Baxter’s comments similar to others of “science made sense – seems very logical”.

The practical nature of science appeals to kinaesthetic learners who would comment they “learn best in this way” (Betsy), and like the interactive nature of “working in small groups” (Edward). Tammy mentioned “science was enjoyable because it was a hands on subject. Science could be related to the outside world easily”.

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Aston stated that he “loved science when I went to school, even though I was never any good at it. It was always interesting to investigate and figure out why things work and happen”, with many others echoing that problem solving and developing an “inquiring mind” (Ellie) is the basis for enjoying science. Pippa found her “science experience was enhanced less from 'conducting' experiments, but more from developing scientific thinking”. She continued “I can see the merit of engaging students through experiments but I believe developing metacognitive practice and concept alteration in primary students is the ultimate goal and can be more applicable cross curriculum in the long run”. Pippa’s science teaching outcomes efficacy scores were analysed as a comparison to others as she was already indicating the importance of scientific literacy at the commencement of the unit.

Finally, the positive experiences were also attributed to teachers who were fun, enthusiastic, engaging and as Clara mentioned “wacky science teachers who made it fun and hands on”. Another example is Fernando who enunciated the influence of his teachers in the comment:

My science teachers were absolutely fantastic. They were my favourite set of teachers by a mile. And mainly, I think, due to the passion and the interest they had in that area, really shone through for me. You can kind of tell that with your teachers, you seem to be aware of how they sort of act in the class, but they really inspired me, and I really enjoyed, and hopefully I can model some of that passionate behaviour to enthuse the children and get them educated really. But more so get enthusiastic about the area of science.

It is positive experiences such as these that the design of the unit was replicating, and extending upon, in order to increase the desire and self-belief to learn and teach science and therefore increase scientific literacy in society. This will be further discussed in Chapter Seven.

Science learning experiences needed to be discussed to outline the basis upon which the unit’s students may have chosen their particular undergraduate degrees. Table 8
indicates the type of undergraduate and postgraduate degrees held by the preservice teachers. This is given as percentages for both genders to allow for comparison.

Table 8. Type of Degrees held by preservice teacher in the unit

<table>
<thead>
<tr>
<th>Areas of U/grad and P/grad degrees</th>
<th>Gender</th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Females (%)</td>
<td>Males (%)</td>
<td>Total (%)</td>
<td></td>
<td></td>
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<td>Arts and Humanities</td>
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<td>Business &amp; Law</td>
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<td>Medical &amp; Health sciences</td>
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<td>8</td>
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<td>Nursing &amp; Midwifery</td>
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<td>1</td>
<td>1</td>
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<td></td>
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<tr>
<td>‘Pure’ Science</td>
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</tr>
<tr>
<td>Other – (e.g., Psychology &amp; Sport Science)</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td></td>
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<tr>
<td>Total</td>
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</tbody>
</table>

*Note* Total N=268 (96.8% of participants) with N=9 (3.2%) missing data. Female n=202, Male n=66. ‘Pure’ science indicates a degree in biology, chemistry, physics, Earth and space sciences (e.g., geology).

Table 8 it can be seen that 68% of degrees are not scientific type degrees. These data are similar to data presented in the literature. This will be further discussed in Chapter Seven.

**Types of science learners**

As mentioned in Chapter Two, Bleicher (2009) identified four types of learners based on qualitative responses received from preservice teachers in relation to their background characteristics of science interest and performance in science courses. These were categorised as:

- Fearful;
• Disinterested;
• Successful; and,
• Enthusiastic.

In a similar way the researcher was able to use anecdotal evidence from text-based questions on the questionnaire to assign participants with a code reflecting Bleicher’s (2009) types of learner. The researcher was able to identify the four Bleicher (2009) categories, along with assigning an additional category of ‘Not clearly identifiable’. This category was created as some participants indicated conflicting evidence, such as:

• They had a positive experience in one strand of science (e.g., biology), but a negative experience in others (e.g., chemistry or physics) and therefore, did not fit into the categories above; or
• They disliked science in secondary school education, but as an adult have changed their attitude towards learning and understanding science.

These examples occurred as all students in this unit had an undergraduate degree and further life experiences prior to entering the GDE-P (such as employment or other postgraduate degree(s)). An example of this was Constance, who mentioned she “did well in biology at high school. Not comfortable with chemistry and physics, but have become more interested in these since having children and wanting to explain the world to them”. Another example of a student change in attitude during adulthood was Kayla who mentioned:

It's completely flipped around, only because I've seen ... I've been in the classroom as a support for students that have had incredible science teachers. Like, everyday there's a theme song they come in and sit down. There's, like a pub quiz, activities, there's games, we're going outside, especially living in the northern hemisphere where everything's so real, so you can see the midnight sun. You see, yeah, the change in the trees, and the climate. Everything's so relevant. So from that experience alone, I love science now.
Table 9 indicates the types of learners, in each tutorial, identified through the anecdotal information given on the pre intervention questionnaire. There are a number of missed cases as not all students completed the text-based questions.

Table 9. Percentage types of learners identified per tutor group participants

<table>
<thead>
<tr>
<th>Tutor</th>
<th>Type of learner (%)</th>
<th>Number of participants (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fearful</td>
<td>Disinterested</td>
</tr>
<tr>
<td>1</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>29</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>38</td>
</tr>
<tr>
<td>5</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

*Note* Learner types adapted from Bleicher (2009)

The types of learners will be analysed with the science teaching outcome expectancy belief (STOE) and personal science teaching efficacy belief (PSTE) of the participants later in this chapter.

**Self-Efficacy Data**

As mentioned in the Chapters Two and Four, self-efficacy is comprised of two constructs, the Science Teaching Outcome Expectancy (STOE) and Personal Science Teaching Efficacy (PSTE) beliefs. The modified STEBI-B (Enochs & Riggs, 1990) was the quantitative survey instrument employed to measure each participant’s self-efficacy. The following section will describe the outcomes of the modified STEBI-B (Enochs & Riggs, 1990) quantitative analysis in relation to the effect the tutors have had on their students’ self-efficacy. Further cross case analyses of categories such as demographic data as factors of self-efficacy will also be examined. Triangulation of qualitative data sources from individual cases will personify the range of self-efficacies that emerged, for both individual tutors and whole cohort.

A one-way ANOVA was conducted to determine the effect of participating in GDE-P science tutorials on preservice teacher self-efficacy. As this phenomenon has two
constructs of STOE and PSTE, each will be reported on separately. There was a significant effect on the PSTE, Wilks’ Lambda = .833, $F(1,271) = 54.41, p < .001$. There was also a significant effect on the STOE, Wilks’ Lambda = .853, $F(1,271) = 46.78, p < .001$. A paired samples t-test was used to make post hoc comparisons between pre and post intervention conditions. The results indicated there was a significant difference between scores of PSTE pre ($M = 28.05, SD = 5.157$) and post ($M = 30.01, SD = 4.271$); $t(272)= -7.38, p < .001$. The results of the second paired samples t-test indicated a significant difference between scores of STOE pre ($M = 29.76, SD = 3.09$) and post ($M = 30.95, SD = 3.25$); $t(272)= -.684, p< .001$. The researcher used an alpha level of .05 for all statistical tests. For both constructs, this suggests that after learning experience participation there was an increase in students’ self-belief to teach science and an increase in students’ science outcomes expectancy beliefs.

A Pearson’s correlation coefficient was used to assess the relationship between the PSTE and STOE, showing there was a small interaction between the PSTE and STOE constructs ($r = .260, N = 272, p < .001$). This indicates these latent variables act largely independently from each other and is consistent with findings by Enoch and Riggs (1990).

As a significant difference was shown between pre and post intervention scores, the Cohen’s $d$ effect size could be calculated. Cohen’s $d$ effect size did demonstrate an increase from pre to post intervention in both PSTE (Cohen’s $d = 0.41, N = 272$) and STOE (Cohen’s $d = 0.38, N = 272$). As the coefficient of 0.2 is considered small; 0.5 is medium; and 0.8 is large (Cohen, 1988; Coe, 2002), the results would indicate there has been a small change in the cohort’s science teaching outcomes expectancy, and a small-medium change in their personal science teaching efficacy beliefs after experiencing the GDE-P unit. Other literature report larger effect sizes; however, the sample size of this study is greater than those that report higher results (Bleicher, 2009; Cantrall et al., 2003; Palmer, 2006). This will be further discussed in Chapter Seven.

Factors that were examined include the gender, science background, type of science learner, experience in the GDE-P unit, along with the tutors’ influence on student
learning and self-efficacy. With each of these factors in place an overall picture can be made of the cohort’s change in self-efficacy.

**Gender and Science learning background as a factor of self-efficacy**

As the majority of preservice teachers in the GDE-P science unit were female (76%), gender was investigated as a potential factor on the development of self-efficacy in science. The level of science education completed prior to attending the GDE-P science unit may also be considered a factor as those with degrees in educationally higher science areas may also affect their learning and consequent self-efficacy. The interaction of gender together with past science learning backgrounds was also investigated to determine if these factors together have an influence on preservice teacher primary-science teaching self-efficacy.

A two-way MANOVA revealed a statistically significant effect of gender on PSTE beliefs, Pillai’s Trace = .082, $F(2, 253) = 11.309, p < .001$, partial eta squared = .082. It was also found there was a statistically significant effect of level of education in science completed prior to attending the unit on PSTE beliefs, Pillai’s Trace = .117, $F(10, 508) = 3.160, p < .001$, partial eta squared = .059. Pillai’s Trace was used for its robustness, as the numbers across groups were not equal. Although, both demonstrated a medium effect, there was a statistical significance. It could be surmised that those with greater science knowledge would have a higher level of understanding to commence with and therefore their self-efficacy would also be higher, than those with lower secondary levels of science knowledge. The interaction between gender and level of science completed on PSTE was not statistically significant.

For both the pre and post PSTE scores it was seen that females were consistently lower in their mean scores ($M = 27.41, SD = 5.047, N = 200$) and ($M = 29.46, SD = 4.241, N = 200$) respectively, compared to males ($M = 30.83, SD = 4.014, N = 65$) and ($M = 31.95, SD = 3.846, N = 65$) respectively. This trend was the case for all levels of science learning backgrounds as demonstrated for both pre and post PSTE in Figure 7 and 8 below. In comparison to the overall sample, there was no significant change in mean scores of PSTE for students with a prior (science) postgraduate degree.
$t(17)=.511, p > .005$. This could indicate the science content knowledge delivered by the unit had not exceeded their prior knowledge.

Figure 7. Estimated marginal means of pre PST
A two-way MANOVA was also conducted on the STOE construct. It revealed a non-significant effect of both gender and level of science completed on STOE beliefs. At this stage of the course, preservice teachers had not completed practicum and therefore it is anticipated that their outcome expectancy would be similar regardless of gender or prior science knowledge. Gender means for both pre and post STOE showed that females were marginally lower than the males overall. Female scores pre and post STOE were \( M = 29.69, \ SD = 2.987, \ N = 200 \) and \( M = 30.84, \ SD = 2.634, \ N = 200 \) respectively, compared to males \( M = 30.22, \ SD = 3.252, \ N = 65 \) and \( M = 31.22, \ SD = 3.219, \ N = 65 \) respectively.

**Types of science learners as a factor**

As mentioned earlier there are different types of learners. When comparing means for pre and post intervention PSTE and STOE scores for each type of learner for the whole cohort, it can be seen from Figure 9 and Figure 10, there were increases in each of the types of learners; however, with varying magnitude.
A one-way MANOVA revealed a significant multivariate main effect type of learner Wilks’ Lambda = .843, $F(8, 400) = 4.446$, $p < .000$, partial eta squared = .082. Power to detect the effect was .996. Therefore, it can be confirmed that the type of learner does have an effect on the pre and post PSTE intervention scores. Given the significance of the overall test, the univariate main effects were examined. Significant univariate main effects for type of learners were obtained for pre PSTE, $F(4, 205) = 9.187$, $p < .001$, partial eta square = .155, power = .999; and post PSTE, $F(4, 205) = 3.541$, $p = .008$, partial eta square = .069, power = .862.

A Tukey HSD post Hoc test for pre PSTE revealed significant differences between learner types of fearful ($M = 24.00$, $SD = 5.336$) and successful ($M = 29.93$, $SD = 4.683$), fearful ($M = 24.00$, $SD = 5.336$) and enthusiastic ($M = 29.75$, $SD = 4.928$), fearful ($M = 24.00$, $SD = 5.336$) and not clearly identifiable ($M = 27.84$, $SD = 4.589$), disinterested ($M = 25.72$, $SD = 4.767$) and successful ($M = 29.93$, $SD = 4.683$), disinterested ($M = 25.72$, $SD = 4.767$) and enthusiastic ($M = 29.75$, $SD = 4.928$) groups.

The post PSTE Tukey HSD post Hoc tests revealed significant differences only between the fearful ($M = 27.73$, $SD = 3.210$) and enthusiastic learner ($M = 30.91$, $SD = 4.305$) types. Full descriptive statistics for the Tukey HSD post Hoc test for the PSTE is available in Appendix L. This may be attributed to the secondary science experiences these students had prior to attending the unit. It can also be noted that the greatest change occurred in the fearful group, who benefitted through participation in the unit increasing their self-belief in personal science teaching efficacy.

Anecdotal evidence from pre intervention focus group discussions clearly demonstrated the differences in attitudes that various type of learners had. Demi commented that she “pretty much failed science in school . . . completely petrified to teach it because of very basic [science] knowledge” and therefore was classified as a fearful learner; a successful learner would mention their “high school science
experience was generally positive . . . was accomplished in humanities more so than science” (Dante); in contrast to an enthusiastic learner such as Aaron, who “in addition to school-based learning . . . had a fascination with and undertaking private reading and experiments in electronics, magnetism, acoustic theory . . . chemistry”; therefore, each starting the unit with their own levels of science content knowledge.

The type of science learners may also have bearing on the attitude of individuals to being able to teach science. Figure 10 demonstrates the change in mean scores for the various types of learners for their pre and post STOE beliefs.

![Figure 10. Type of learners' STOE pre and post intervention](image)

A one-way MANOVA was performed to determine if there was a significance difference of the type of learner on the STOE pre and post intervention scores. The MANOVA did not show significant multivariate main effect, Wilks’ Lambda = .958, $F(8, 400) = .1077, p > .001$. This would indicate that the type of learner did not have a bearing on their pre and post STOE scores.
Keeping the scales of the STOE and PSTE figures the same it can be seen that the students’ science teaching outcome expectancies are more similar to each other. The changes for all learners ranged from +0.28 points (fearful learner) to +1.81 points (enthusiastic learners). It can be surmised that the fearful learners still felt anxious about their role as a teacher of science. The enthusiastic learners, having already a higher level of science content knowledge than the fearful learners, may have benefited from the unit’s science pedagogy learning experiences, which in turn may have enhanced their overall increased appreciation of practice of teaching science.

Focus group discussion participants provided anecdotal data to support the observations in Figure 10. Although Demi had mentioned that she was petrified and included that after the unit “very interested to incorporate it [science] into my teaching”. Demi was classed as a fearful learner and with further investigation it could be seen that Demi’s PSTE had a small positive change and a small negative change in STOE; indicating that although she felt she had improved in her personal self-belief to understand science, she was not confident to teach the subject at this stage. Bree, also categorised as a fearful learner and claimed that she “really struggled with science”, and she seemed to have changed her attitude at the end of the unit with her comment “I believe science can be taught in a very engaging manner and that students will love it”. This would indicate that her experience had been positive and this was reflected in her increase in STOE score. One of the enthusiastic students, Aaron discussed how he enjoyed his secondary science learning experience along with “in additions to school-based learning, I have had a fascination with an undertaking private reading and experiments in electronics, magnetism, acoustic theory . . . chemistry . . .”; demonstrating his enthusiasm for the subject area and had indicated a high PSTE and STOE with no change pre and post intervention. This may indicate this person has a high self-efficacy in science and therefore the unit may have had no direct impact on any changes his efficacy, but instead provided resources for future teaching experiences. This is supported by his comment of “the use of practical examples can be applied to a classroom setting, and active participation in the student role was the most useful”. Ryan, a successful science learner, who had completed a post graduate degree in a science related area, demonstrated an increase in PSTE but not STOE, which is also supported through their comment:
I’ve got a bigger appreciation for the misconception side of things . . . even in the first couple of lessons, I thought about the misconceptions that I had in science, and perpetuating it. So I became aware of making sure that you are using correct language in science . . . that’s the big take away that I have taken . . . my confidence in teaching science hasn’t changed, I’m still pretty confident.

To summarise, after the learning experience of the unit, all learners had an increase in PSTE and STOE. However, there was a trend of the greatest PSTE increase in the fearful and disinterested groups and for the greatest increase in STOE for the enthusiastic group. The least changes for PSTE occurred in the successful group and the STOE the fearful group.

Tutor as a Factor of Self-efficacy

From the literature review it can be seen that teachers and tutors affect their students’ self-efficacy. From the trends for pre and post PSTE and STOE, the following figures 11 and 12, demonstrate that tutors in the GDE-P unit did have an effect.

Figure 11. Mean scores pre and post intervention PSTE for each tutor
Figure 12. Mean scores pre and post intervention STOE for each tutor

As Figures 11 and 12 show, there is an overall positive effect for each of the tutors; however, the actual effect size needs to be calculated as some effects, such as Tutor Five in Figure 11 and Tutor One in Figure 12 show a very small trend. Full descriptive statistics for each tutor will be available in Appendix M. Based on these results a Cohen’s $d$ effect size can be calculated. The calculated Cohen’s $d$ effect size per tutor will be provided in Table 10 for both constructs of STOE and PSTE.
Table 10. Cohen's $d$ effect size of participant STOE and PSTE for each tutor

<table>
<thead>
<tr>
<th>Tutor</th>
<th>Effect size (Cohen’s $d$)</th>
<th>Number of participants (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>STOE</td>
<td>PSTE</td>
</tr>
<tr>
<td>1</td>
<td>0.11</td>
<td>0.47</td>
</tr>
<tr>
<td>2</td>
<td>0.50</td>
<td>0.51</td>
</tr>
<tr>
<td>3</td>
<td>0.36</td>
<td>0.44</td>
</tr>
<tr>
<td>4</td>
<td>0.48</td>
<td>0.62</td>
</tr>
<tr>
<td>5</td>
<td>0.24</td>
<td>0.11</td>
</tr>
<tr>
<td>6</td>
<td>0.43</td>
<td>0.46</td>
</tr>
<tr>
<td></td>
<td><strong>Combined Tutor effect</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.38</td>
<td>0.41</td>
</tr>
</tbody>
</table>

*Note* Effect size of 0.2 = small; 0.5 = medium; 0.8 = large (Coe, 2002).

From the table above it can be seen that tutors differ in their tutorial effect sizes. Tutor One had a very small effect size for the students’ science teach outcome expectancy, whereas Tutor Two had a medium change in the same factor. Therefore, the overall cohort effect is considered small with Cohen’s’ $d = 0.38$ (Cohen, 1988). The personal science teaching efficacy effect size ranged from very small effect to a more moderate effect (Cohen’s $d = 0.62$) between two of the tutors. Giving the overall cohort medium effect size of Cohen’s $d = 0.41$. It is important to note that each of the tutors had varying numbers of tutorials they taught, and therefore varying sample sizes that participated in the research, which consequently affected the calculations of effect sizes. This will be further discussed in Chapter Seven.

The results can also be explained through further investigating the range of changes that may have occurred for each tutor. These extremes can be attributed to individuals who may provide anecdotal information for further insight into some of the positive and negative changes that had occurred within specific tutor groups. Table 11 provides an oversight of the range of changes and percentage of cohort represented for each tutor’s effect on the STOE and PSTE of their students.
Using the above data, it can be seen that all tutors had more students with a positive change compared to a negative change for their STOE belief. It can be seen that the greatest positive change occurred with a student in Tutor 3’s tutorial groups. This student mentioned she “studied science up to year 10. My strengths were in Arts/Humanities . . . the tutor was very clear when explaining the concepts” (Crystal), which gave her more confidence to teach science. The extreme negative scores occurred with two of the tutors of (-6) points. One of these students commented:

I’m still anxious about science . . . I’ve had a very long time of being not confident at all about it . . . so much so that I became very disinterested in it. So, I think I have still got a way to go, in as far as my confidence levels. If I had to choose something to teach, it may not be science, not just yet.

(Reggie)

The majority of cohorts expressed a positive change, which indicated that overall tutors had employed strategies that enabled students to gain an understanding of what it requires to become a primary science teacher and an appreciation of what influence teachers have on their students’ learning. A comment made by Alana demonstrated this:
Prior to the unit, I had little confidence in teaching science to children. Now, it excites me! There are so many resources available, so many fantastic experiments and so many opportunities to be creative. Bring it on!

Table 12. Range of change and percentage of cohort represented for PSTE

<table>
<thead>
<tr>
<th>Tutor</th>
<th>Score change extremes</th>
<th>Cohort represented (%)</th>
<th>Number of participants (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Negative</td>
<td>Positive</td>
<td>Negative</td>
</tr>
<tr>
<td>1</td>
<td>-3</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>-8</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>-9</td>
<td>20</td>
<td>33</td>
</tr>
<tr>
<td>4</td>
<td>-7</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>5</td>
<td>-11</td>
<td>11</td>
<td>34</td>
</tr>
<tr>
<td>6</td>
<td>-14</td>
<td>10</td>
<td>15</td>
</tr>
</tbody>
</table>

From the above data, Table 12, it can be seen that Tutor 3 had a student with the greatest positive change in their PSTE. This student commented that she “recall finding it hard to understand concepts (when in secondary science) . . . unit was engaging and as a result probably feel more confident about teaching science than other subjects” (Jemima). It is interesting to note this student had a positive change in STOE as well. In contrast a student with a large negative change, Roxy commented “I feel generally more confident in the areas of science we discussed in class. However, I feel this was due to learning through discovery, not through our tutor . . . an assignment isn’t the only way to teach us”. Roxy’s comment demonstrated she may have developed an overall negative attitude towards the unit which in turn may have affected the way in which she completed the questionnaire. Dale had a mixed learning experience and mentioned “. . . carrying out investigations as students is valuable . . . I still need to learn about content knowledge behind the investigations”.

It is noted that overall all tutors had greater positive change rather than negative change. Of note is that Tutor 6 did have the greatest cohort of students with a positive change for PSTE. It can also be seen that tutor five had the highest amount of students.
that didn’t demonstrate a change in their PSTE belief, together with a third of the class having a negative change.

The influence of the tutor on the type of learner was measured through the categories that had the greatest change of mean STOE and PSTE scores. The table below represents the highest and lowest changes of STOE and PSTE scores for each learning type per tutor group. The results of these are found in Table 13 below.

Table 13. Changes in STOE and PSTE scores per type of learner for each tutor

<table>
<thead>
<tr>
<th>Tutor</th>
<th>STOE</th>
<th></th>
<th></th>
<th>PSTE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Highest change</td>
<td>Lowest change</td>
<td>Highest change</td>
<td>Lowest change</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Disinterested (+3)</td>
<td>Successful (-1)</td>
<td>Fearful (+4.3)</td>
<td>Disinterested (+1.50)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Enthusiastic (+2.2)</td>
<td>Fearful (+0.6)</td>
<td>Disinterested (+4.3)</td>
<td>Successful (+0.1)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Enthusiastic (+2.3)</td>
<td>Fearful (-1.7)</td>
<td>Fearful (+5.33)</td>
<td>Enthusiastic (+1.8)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Not clearly identifiable (+2.4)</td>
<td>Fearful (+1.5)</td>
<td>Enthusiastic (+4.8)</td>
<td>Successful (+2.7)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Disinterested (+1.3)</td>
<td>Not clearly identifiable (+0.7)</td>
<td>Fearful (+3.4)</td>
<td>Enthusiastic (-1.5)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Enthusiastic (+2.0)</td>
<td>Not clearly identifiable (+1.7)</td>
<td>Fearful (+5.0)</td>
<td>Successful (-3.8)</td>
<td></td>
</tr>
</tbody>
</table>

*Note* Number of score points changed is given in parentheses, where + denotes positive change and – denotes negative change.

A fearful student in Tutor 2’s class mentioned that she “struggled a lot with science in high school . . . couldn’t always grasp the teacher’s meanings . . .” yet after the learning experiences she mentioned that “whilst I enjoyed each activity, I am not yet as confident as I would like with the science understanding”. The researcher noted
this is a common theme amongst fearful type of science learners. As Table 13 demonstrates fearful learners had the lowest change in STOE but in general had increased their PSTE. Within this sample, it could be surmised these learners have become more engaged in science through the nature of the unit design, increased their science understandings, but are still unsure about teaching science and the impact of the teacher’s role on the outcome of student learning. In contrast Table 13 demonstrates that enthusiastic learners are more likely to have the highest change in STOE rather than in PSTE as they are already confident in their science understandings, and from tutorial exposure may have increased their PCK, allowing them to increase confidence in their teaching of science. This area will be further discussed in Chapter Seven.

Another key area that may affect students’ self-efficacy is the modelling and use of pedagogical and teaching strategies, to further develop preservice teacher PCK. Students were asked to reflect on their tutor’s teaching strategies and provide quantitative data on strategies observed as well as qualitative feedback data. It was found that 95% (N=246) students believed that the modelling of science teaching strategies did assist them with their confidence to teach primary science. Eden mentioned “throughout the course various instructional strategies were used, specific to the focus model of the activity. The unit followed a very practical and content rich method which reflected the strategies used”.

The following table demonstrates the breakdown between tutors and their students’ confidence to teach primary science based on tutor modelling strategies.
Table 14. Percentage of cohort per tutor answering "Did modelling of science teaching strategies assist your confidence to teach primary science?"

<table>
<thead>
<tr>
<th>Tutor</th>
<th>% Tutorial participants</th>
<th>Number participants (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>1</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>95</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>95</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>84</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>95</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>

From the table above it appears that students in all tutors’ group felt more confident having observed teaching strategies. This does not indicate what strategies were explicitly modelled and explained.

Table 15 demonstrates the strategies that students were able to identify which their tutors had modelled or explained. In order to determine if the tutors had been explicit in their modelling and instruction of pedagogical and teaching strategies, students were asked to identify if they observed the following: transmission (lecture style), use of models, interactive group work, discovery (inquiry model) method, constructivist teaching and facilitating conceptual change. For example, Delilah mentioned she had identified a conceptual change as “tutor had posed a question . . . critical thinking, then demonstrating the science how it works”, which led to her changing her own misconception.
From the table above it can be seen that all tutors facilitated the various pedagogical and teaching strategies. The use of lecture style teaching was highest in Tutor 1 and 6 with the lowest being Tutors 2 and 4. As the constructivist nature of the teaching had been identified by most the students, Tutor 1 could be considered to be the most explicit in their teaching of constructivist theory and therefore the majority of their students also identified this strategy.

Tutor 6 was identified as using models and modelling in the most explicit manner. The researcher observed this tutor brought in models and examples of work, relevant to the week’s teachings, from students in his primary classes. This provided “real” world examples of what primary students of various levels could achieve. The tutor on occasion had performed the same activities with the primary students as with the tertiary tutorials, which allowed for direct comparison of work. During this observation period, one of the preservice teachers commented they were amazed at what year 4 primary students could achieve.

Using the data provided in the tables above together with qualitative data, a deeper understanding can be reached in relation to each tutor. The tutors will be discussed individually to triangulate data.
Tutor 1

Tutor 1 had the lowest number of participants in the research as they only taught one tutorial. Within this tutorial 42% of participants noted a positive change in their STOE belief and 73% a positive change in their PSTE. Within these constructs, 37% noted a decline in the STOE and 16% decline in the PSTE scores. The remainder had no change in scores. The change in scores was -4 to +6 in STOE and -3 to +7 in PSTE. Within the tutorials approximately 18% were considered fearful learners and at the other end of the scale 41% were enthusiastic learners. Given this together with the number of participants it was calculated this tutor had a very small effect (Cohen’s $d = 0.11$) in the STOE domain and moderate change (Cohen’s $d = 0.47$) in the PSTE domain.

It is important to note that the tutor was able to increase the PSTE of the fearful learners. One of the students, Amelia commented “the enthusiasm, that my tutor has shown me, has made me someone who wasn’t interested in science, be interested in science”; the tutor’s modelling of this style of teaching is “something I would really try to be, when teaching science, because I know that has had a big impact on how involved I have been”. The tutor is aware that over enthusiastic behaviour could impact the learning as well through their comment:

*I know last year some of the people were overwhelmed by what I could talk about . . . their self-esteem for science, or efficacy, can reduce, because if you appear to be the sort of know-all of information that can freak people out. "Oh, how am I ever going to know what he knows?" so that can make you feel rather . . . be a put down.*

Knowing this, the tutor amended their delivery style to ensure students were involved in discussions and through questioning to increase their critical thinking rather than being lectured to. As an example of this, Amelie commented “*I love the interactive nature between tutor and students. Interesting facts that I could relate to . . . use of humour*”.

The researcher observed that the tutor made great effort to ensure inclusivity of all students, which was also noted by one of the students, Aston who mentioned:
The tutor was really good. Very knowledgeable and used appropriate language to teach those that were not familiar with the topic. The tutor also used different teaching strategies to engage us, and used class discussion to get everyone to participate.

The researcher also observed the tutor’s mannerism as being relaxed and approachable during tutorials as they also quietly talked to individual students. This was supported by Annabel, a successful science learner with a post graduate degree in science, who mentioned “I saw students' who has misconceptions feel safe to express this and their lack of confidence in the class. This was respected by the tutor and normalised with examples of his own misconceptions and then went on to explain the current theories”.

The change in the STOE was greatest in the disinterested learning group, with the lowest in the successful learning group. However, the changes were only small, +3 and -1 respectively. This then supports the low change in STOE effect size.

Many students, in this tutor’s cohort, commented on the pedagogical styles that were used with the majority of students (95%) mentioned the interactive; discovery and constructivist strategies had been the used most frequently followed by use of models and creating conceptual change. The researcher noted the tutor used class discussions to elicit prior knowledge or preconceptions, allowed the students to investigate a concept, then discuss findings to check for new or changed knowledge and conceptual understanding. The use of questioning for critical thinking rather than lecture style engaged the students and provided a platform for constructivist learning. This was supported through Amber’s comment:

I think personally my tutor is really good, at posing a question, that we all discuss, and then having to reason out the answer... we come to some really rich discussions around things I think that has helped me personally, consolidate my knowledge in... particularly in physics, which is probably my weakest area.
Specifically, Alfred mentioned the construction of working models for demonstrating concept. Other models that were used were toilet paper geological timelines, which not only brought in some humour but also demonstrated clearly the length of time for geological changes, and human impact on the world. The solar system was made using polystyrene balls; with students becoming part of the solar system to see ‘first hand’ how day and night, seasons and eclipses were formed. The researcher did note that during this activity, many students’ conceptual understanding was changed through body language (face demonstrating a ‘light bulb moment’) and discussions held in groups. Ava summed this up through her comment she “found the modelling of science experiments very useful”. Angus who identified constructivism through the use of “hands on experimentation and discussions” further supported this notion. Anthony felt that through the discovery methods he was “learning new and interesting information and skills every week”. He also found it very interactive through “every week doing group-based discussions”. This was echoed by Anna who mentioned “each week I learnt something new and gained simple understandings of science concepts”. With Amelie mentioning a strategy whereby “the tutor allowed students to explore and used this as an example to the class to show/explain the topic further”.

Many students commented they “found that my science understanding increased over the weeks. We started from basic understanding and built on it. No fear of trying” (Alfred). Some students still feel:

...a little bit unconfident with my science understanding, because although I can see why things happen...I can predict what’s going to happen, I still do not have that full science thing...I still am a little bit nervous in some parts (Amelia).

Whilst another student commented they feel “dragged through the bush backwards, with lots of thorns there I didn’t realise” (Alex), which mainly related to the assessments but also that at times felt that the tutor wasn’t explicit enough in their explanation of pedagogies or strategies that have been used. This student is a fearful science learner, a mid-year in take student and therefore wasn’t as conversant in the language of education as this was their first unit in the course. He also felt that
although the tutorials were “fun”, the tutor knowledgeable and approachable, and felt that he lacked the explicit teaching of the science. He felt rushed to prepare his weekly portfolio rather than understanding the science behind the activity.

In general, the students commented they had enjoyed this tutor’s tutorials and have gained some resources to help with future planning. Students from this tutor’s cohort also made comment about assessments and unit design. These will be discussed later in the chapter.

**Tutor 2**

Tutor 2 had the largest number of student participants, as there were four tutorial groups. This tutor is also a GDE-P tutor in a different education unit, and this has had some further impact on the students as they were comfortable with this tutor and had prior and concurrent knowledge of the teaching strategies this tutor uses. This became evident during observations of the classes by the researcher and was also mentioned by some students as they compared both units this tutor teaches. Both the observations and student comments suggest this has had a positive effect on the familiarity of this student-teacher relationship, as students were comfortable enough to discuss concepts as large groups or approach the tutor for further individual assistance. Edith made a comment in relation to having the same tutor for the education foundations unit, finding her experience from other areas that had assisted with her future planning of integration of subjects. The researcher identified 12% fearful science learners in the total tutorials; however, as there is already familiarity with the tutor, this may assist with their overall self-belief. The majority of the students were enthusiastic and successful learners (37% and 11% respectively), with 25% as those with mixed learning experiences and therefore not clearly identified group.

There were 15% disinterested science learners, who were encouraged to change their opinion of science and this group had the highest change in their PSTE. For example, Sophie mentioned:

*Overall I found this unit a lot more enjoyable than I thought I would. I do not have science background and was very uncertain about the subject*
beforehand. With the unit being delivered in such an interesting and fun way I really enjoyed it.

Maisie commented, “[the] tutor was amazing, very knowledgeable, interesting, engaging, funny, approachable and makes me want to learn science!” Whilst Belle mentioned “it’s just reassuring that our tutors here are actually helping us to excel, not trying to fail us in a way”.

Similar to Tutor 1, this tutor was also found to be approachable, with Sian including this tutor to “be engaging, responsive and caring to the individual needs of the students”. This tutor’s passion for science was evident in observations and students also commented on this with comments such as “[the tutor’s] passion for science is obvious . . . this is contagious” (Brooke) and “Tutor's passion and experience shine through in an approachable nature” (Sean).

Anecdotes given by students it supports the results of the tutor having a medium effect size in both STOE (Cohen’s $d = 0.50$) and PSTE (Cohen’s $d = 0.51$) beliefs. The majority of this tutor’s cohort (67% for STOE and 66% for PSTE) had demonstrated a positive change in their scores. The positive PSTE effect can be supported through comments from students such as Elle’s:

The tutor was enthusiastic and explained concepts really well (starting with small concepts and building up). The tutor gave specific instructions that were easy to follow. The tutor listed the resources we should find to help us with our knowledge and assisting the assignment.

The researcher had observed this tutor is very explicit in their instructions and scaffolds learning concepts gradually.

The effect in the STOE could be due to the additional resources this tutor brought into class as well as the teaching anecdotes that are provided during each learning experience or for a specific activity. Many students commented on this strategy that the tutor employed, such as Marcus mentioning “real life stories added to the teaching message each week” and Emma’s comment “[the tutor] related to stories to
reflect and related it to the experiment which helps me understand”’. The researcher observed that by using the tutor’s own teaching experience it provided a platform for students to gain an appreciation of teaching.

One student commented they were confused at times as there was not clear differentiation between the activities and anecdotes, how science content applies to primary students or adult tertiary students, and how best to teach it to primary students.

Other changes to STOE may have been influence by the teaching strategies this tutor used. The majority of the participants (95%) found the explicit modelling of strategies helpful to them. Edith mentioned “I actually like the inquiry-based learning approach, where it becomes an integrated thing, rather than individual subjects”. It was noted from Table 15 this tutor was identified by 61% of participants to use constructivist pedagogy. This may not have been made explicit enough for the whole cohort to identify this strategy was being used. Baxter and Bonnie identified constructivism and discovery through being “left to have a go and see what happens without being told what to expect” then through group or class discussion the concepts or misconceptions were explained by building on each other’s knowledge and observations. Emma found that she had a lot of misconceptions; however, through group work it helped her understand the concepts. Elsie concluded:

Collaborative learning, group and paired work where the tutor modelled, gave explicit instruction, guided then work independently, or group discussions, debates and visual representations to expand learning/comprehension. Predictions and students encouraged to uncover misconceptions - turning these into learning opportunities.

The researcher’s notes support that Tutor 2 did not spend a lot of time lecturing the class; however, found contradictory evidence suggesting students were given a large amount of anecdotal experience information and then explicit instructions for performing the activities, rather than open-ended discovery. The researcher also supports comments by students in relation to the vibrancy and enthusiasm displayed by the tutor. An example to support this notion was:
[The] tutor was really vibrant and it was easy to stay focused on the things she was saying. They always had an entertaining story about the task at hand - except for the timeline, which I think the toilet paper filled that void”
(Spencer)

Other comments, such as “Our tutor was extremely engaging and delivered the lessons with enthusiasm, giving me confidence to deliver science lessons” (Sasha) and “I learnt new ways to do things and the tutor made science more 'realistic' and applicable to real life” (Madeleine) also demonstrated the enthusiastic nature of the tutor.

The experience as a science educator was also apparent, as the tutor was able to clearly articulate scientific concepts in a manner that was easily understood by students. Barney mentioned “I was not confident with science but now it feels much more achievable. Still feel now it will just be time/experience to make me a good science teacher. I feel I have a good ‘toolkit’ to start after this unit”. Yet, Emilia was the opposite “whilst I enjoyed each activity, I am not yet as confident as I would like with the science understandings”.

As mentioned in Chapter Five, Tutor 2 also instigated and worked with other tutors in a ‘team teaching’ environment. Although this worked well for use of common resources students mentioned they were uncomfortable as the following demonstrated by the following comment:

We had to sit on benches, or stand as there were not enough seating . . . do not know what the benefit of that was, because we never did anything together as a group . . . just teacher talking, students listening, or teacher watching ... or students watching the board (Rachel).

Students from this tutor cohort also commented on the assessments, however, this will be discussed later in the chapter.
Tutor 3

Tutor 3 had a small effect on their students’ STOE (Cohen’s $d = 0.36$) and a moderate effect on PSTE (Cohen’s $d = 0.44$) beliefs. This tutor had 46% combined successful and enthusiastic science learner types with 11% fearful and 29% disinterested science learners. The highest change in STOE scores was found in the enthusiastic group and the lowest with the fearful group. This was contrary to the PSTE results where the fearful group had the highest change and enthusiastic science learners had the lowest change. In general, this tutor had 59% of participants report a positive change in STOE and 62% of participants reported a positive change in PSTE beliefs. In both cases close to a third of the tutor’s cohort had a negative change with only 5% reporting nil change in both STOE and PSTE beliefs. An example of this is a student who was classified as a disinterested science learner due to having interests elsewhere, and had a large positive change (+12 points) in STOE score but a negative change (-5 points) in their PSTE belief. This student commented that the tutor was “excellent and the unit was very enjoyable”; however, her scores indicate that she felt overwhelmed by the amount of science learning. Delvine supports this feeling; she is a secondary teacher retraining to primary education, commented:

... inevitably, the more I learn, the more confident I'll be . . . but then again, the more I learn the more I realise I do not know. [However] being a teacher I know what I need to know as well and so I'm not too scared, because I know I do not need to know everything.

Therefore, this may indicate why Delvine didn’t have a large amount of change in her belief scores. Another student, Delilah, who was classified as disinterested science learner found “assignment two very useful . . . I will use it as a working resource in the classroom”; therefore, increasing her enthusiasm and engagement for the unit with a subsequent +20 point change in their PSTE belief and a smaller but positive change in her STOE beliefs.

A number of students commented that the tutor was “approachable which meant I felt comfortable seeking clarification on subjects I was unsure about. The tutor’s approach made me feel more confident in my abilities” (Caitlin). This comment was supported by another student, who mentioned the “tutor was very approachable and
relaxed ... delivery was clear and uncluttered, and I feel a lot less anxious about teaching science because of [the] thorough and methodological approach” (Callum). The researcher supports this through observation notes, where it was noted that the tutor moved around and sat with small student groups to assist with clarifications of concepts. The tutor had mentioned this was a technique used to “support those that may feel awkward”. The researcher noted that at times the tutor was with one group for a lengthy period of time and was not able to give equal time to other students or groups whilst conducting the same activity. Consequently, some students may have missed out on further information, as the tutor did not conduct many large group discussions or critical thinking allowing all students in the tutorial to benefit from each other’s knowledge during the lessons that were observed.

Table 15 demonstrated that 92% and 87% of participants identified the use of interactive and discovery pedagogical strategies used or modelled. This was the basis for constructivist pedagogy; however, only 69% of participants identified this strategy, which could indicate that the teaching of this pedagogy has not been explicit enough. Alternatively, the students may have interpreted these strategies in different ways.

There seemed to be quite contrasting opinions regarding the same tutorial experience. Dale mentioned they found “carrying out investigations as students is valuable . . . I still need to learn about the content knowledge behind the investigations”; this comment was supported by negative score changes in their STOE and PSTE indicating students have less self-efficacy after the unit than before the unit commenced. Another student also mentioned that when conducting the investigations, the content “has not been clear . . . what age group it’s supposed to be catered towards . . . I wouldn’t know where to base it on, so I would definitely have to use Primary Connections, and the curriculum . . . I would be quite unsure about teaching the science” (Camille). Darren who encountered the “tutor always make the topic relevant and engaging and explained everything thoroughly” contradicted Camille and Dale’s perceptions. Dale and Darren were in the same tutorials whereby differences in individual’s perceptions of their experiences became evident. Danika also supported Darren’s comment, explaining:
The tutor expressed ways how we can teach certain activities . . . I found it extremely helpful when it's made clear how we can relate what we've learned back to the class . . . [it] really opened ideas up.

Chelsea mentioned “our tutor didn't try to explain the concepts above the level needed and was also very good at explaining where primary school students would be at for the different concepts”, which is a strategy that was helpful to a fearful science learner. Douglas came from a science background, and “was really looking forward to this unit . . . I really enjoyed it and learnt a lot”. The researcher also noted this tutor did team-teach with another tutor who had a tutorial running concurrently. Demi commented this had a positive effect on her as “the team teaching showed me that I’m not alone in teaching science”.

Ciara found the tutor modelling investigations with subsequent hands on activities useful learning experiences for her. Delilah mentioned that she had experienced conceptual changes through the “tutor posing a question, then critical thinking, then demonstrated the science how it works”.

It was noted that the tutor used a teaching strategy used with school children whereby students were able to give anonymous feedback, in the form of a written query about a concept or pedagogical understanding. At the end of the lesson this was placed on the tutor’s desk, and addressed at the beginning of the following tutorial. Students found this valuable to consolidate their learning without needing to feel confronted or embarrassed in the group.

This tutor also provided additional resources in the form of worksheets, and amended the PowerPoint slides in order to add additional websites, the lesson outcomes. In this manner extra information was catered for the individual tutorials.

As mentioned with the previous tutors, comments were made in relation to the assessments, which will be discussed later in the chapter.
Tutor 4

Tutor 4 had the largest effect size on the PSTE (Cohen’s $d = 0.62$) of their tutorial cohort in comparison to other tutors. This effect size could be considered medium to large effect. The effect size on the STOE (Cohen’s $d = 0.48$) is considered a medium effect, which is in line with Tutor Two’s effect size. This tutor had the highest percentage of research participants return a positive change in the STOE (70%) scores and second highest for a positive change in the PSTE (76%) scores. With the highest increase changes recorded as 6 and 15 points respectively. For both STOE and PSTE scores there were 15% of the participants with a negative change; with the largest negative scores of -5 and -7 respectively. When investigating the type of learners, this tutor’s cohort had 8% of participants as fearful science learner type, which was one of the lowest amongst the tutors, in contrast had 38% of participants as disinterested science learner types that were the highest number amongst the tutors. From the researcher’s experience and literature review, these students require innovative and engaging strategies to pique these students’ interest. Fiona, who was classified as a disinterested science learner, commented about the tutor:

... she’s good, and she’s done some really good hooks, at the start, she has come in and done some things, you go like, “Oh, that’s a brilliant idea,” and she has given us some really good ideas of resources you can buy from cheap places, so that has been really good ...

Fiona’s comment demonstrates that Tutor 4 impacted on her engagement.

This tutor’s results also demonstrate to have a positive change in all the categories of learner types, with the highest change for STOE being the group that was not clearly identifiable, and the highest as enthusiastic for the PSTE beliefs. The lowest change in the STOE was from the fearful learner group, which was on par with the highest change in STOE for Tutor Five. This might indicate that the personality and teaching strategies used may have had a positive influence on most students, irrespective or their former science learning experiences.

There were some students who expressed some concerns, such as Fenella who mentioned at the end of the unit, “unfortunately I did not feel engaged”. Through
deeper investigation into this individual student, it was seen that she was categorised as a disinterested science learner type, and had not achieved well in her assessment one. This may have lowered her self-efficacy and reinforced her disinterest. Fernando mentioned that he “would like to have seen more explicit modelling of teaching to primary aged students”, which was echoed by Fern who commented that in her experience there had “not been enough modelling of classroom management strategies, spoken about but not modelled by students”. Faith continues this theme with her comment “would have liked if there was more structure around what year group the activity was aimed at, or hear groups it could be tailored to . . . make stronger links to the curriculum each week/activity”. Josh mentioned that he found “the unit was modelling of how science can be taught”. This may indicate that the tutor was not explicitly modelling teaching strategies; however, the design of the unit did model the activities that could be used in a primary school setting.

Freya, who was considered a fearful science learner type, mentioned our tutor has been very good at engaging us in this unit. I found the way they provided activities for us has been really helpful and a great resource for our future teaching”. Jennifer continued with her insight that the “tutor was very passionate, competent and informed and was able to bring the class along throughout the semester” and Jade sums up: “tutor was amazing, just by the look on the students’ faces the tutor adapted their content” demonstrating the tutor’s teaching experience. The tutor was found to be very knowledgeable by most students. An example was Joel who mentioned “tutor was a very knowledgeable . . . really engaging and wanted to impart as much content knowledge to us as possible . . . extremely helpful in answering any questions we had . . . [I] get the sense the tutor wants everyone to do well”. Unfortunately, Fern felt that the tutor did not give her confidence to express concerns and was made to feel she “wasn’t good enough”, as she felt she had a lot to learn in both science content knowledge and PCK, hence affecting her self-efficacy.

Table 15 demonstrated that 58% of students experienced or identified explicit teaching of constructivist pedagogy, with 76% identifying explicit modelling of strategies. Due to the nature of the unit design, many students (85%) did identify the use of both interactive (collaborative) and discovery teaching strategies.
Students mentioned the learning experience using hands-on activities made the tutorials engaging, but some found they didn’t get the “delivery of science understanding not so much” (Frankie). Whereas Jimmy had the opposite experience and has had a positive change in his self-efficacy, he commented “the tutor was engaging and explained the concepts and how to teach them in a relaxed and easy to understand manner. I now want to be a science specialist”. Students also mentioned that the tutor was explicit in collaborative learning strategies, including in activities “each person has a specific role” (Jessica).

Through the use of modelling abstract concepts, such as the phases of the moon, and using easy to access equipment the tutor was found to be very clear on explanations to assist students to accept conceptual changes in their understandings. Faye mentioned that the tutor facilitated “a lot of discussion and class talk . . . debunking misconceptions and highlighting/finding out problems and ways to solve it”. On the other hand, Fiona found that allowing open discovery at times was confusing her as she “did not realise this [an activity about creating phases of the moon] was about misconceptions . . . I knew experiments did not make sense”. This may indicate that at times the tutor was not explicit enough when explaining the aim of the concepts and activities that students were investigating.

Jessica mentioned the tutor supplied own age appropriate models or equipment to demonstrate to the students that science ‘equipment’ does not have to be expensive and can be easily found in ‘every day’ shops to assist with engaging the students in a class. She commented the tutor was,

. . . giving us great strategies . . . great answers to all those questions . . . and would say “Oh, you know, if you just see something at [retail name withheld] that’s really cheap and would explain some kind of science, just buy it, because then it is another thing to show the kids, and they will be interested, and engaged,” and stuff like that. So it was giving us some really good tips, and it was . . . really good.

Jade confirmed this strategy would have increased her interest in science. She commented, “. . . resources were brought in weekly for us to look at. All activities
were engaging. If someone had done these with me in primary school I would have loved science”.

Some students also mentioned the tutor’s style of teaching, including the following example “tutor is not always very serious and enjoys occasional humour that brightens the class mood” (Faye). Florence commented the “tutor has clearly demonstrated their passion for science and that motivated me to want to learn more. I think it offered a good opportunity for me to grow personally”. Florence’s individual PSTE score did increase indicating that she had an increase in her self-belief with the content knowledge, through being motivated by the tutor. Fabien’s self-efficacy constructs of both STOE and PSTE also had a positive change, which was reflected by their comment “tutor is very engaging . . . I feel I have learnt most from this unit out of all of my graduate diploma units”. Again demonstrating that the tutor had a positive effect on this student’s self-efficacy.

Overall, given this unit ran for 10 weeks, one of the students sums up what other also conveyed “I still feel I have much to learn!” However, this tutor had a good effect on improving their students’ self-efficacy, by providing engaging lessons, positive modelling and being explicit in their teaching of both science content and pedagogical content knowledge.

Tutor 5
Tutor 5 had 61 research participants across their combined tutorials. Table 10 demonstrated there had been a small effect size in the STOE belief (Cohen’s $d = 0.24$) and very small effect size for the PSTE belief (Cohen’s $d = 0.11$) for these students. This can be explained through investigating individual changes in Table 12. The extreme negative and positive pre/post intervention PSTE score changes were -11 and +11 points respectively; the PSTE pre intervention ($M = 28.28, SD = 4.997$) and post intervention ($M = 28.82, SD = 4.642$) mean and standard deviations are similar; therefore, resulting in the calculated very small effect size. This was across the tutor’s cohort, yet 46% of participating individuals within the cohort did have a positive change, 34% had a negative change with 20% having nil change. The percentage of participants with the nil change result was the highest amongst the tutors. Similarly,
the STOE pre intervention ($M = 30.10$, $SD = 2.879$) and post intervention ($M = 30.85$, $SD = 3.351$) means and standard deviations again were similar; therefore, calculating the small effect size with the range of change scores deviating from -6 to +6 points of change. For the STOE, 57% of participants were found to have a positive change and 28% a negative change in the pre intervention and post intervention scores. These results may be explained through student feedback.

When investigating the percentage of the type of learners were present in these tutorials, it was found there were similar percentages for fearful, disinterested and successful science learning types (11%, 13% and 15% respectively) (see Table 9) and similar results for enthusiastic and not clearly identifiable groups (22% each). Table 12 demonstrated that the largest pre and post intervention change had occurred for the fearful learning group in the PSTE construct, with a negative change in the enthusiastic learning group.

The feedback from students varied. Some students made comments similar to Kaili, who said “Occasionally the activities themselves were entertaining but overall I was not overly engaged because I already knew the science that was being taught”. Casey added to this sentiment with her comment:

I’m not sure necessarily that I’ve expanded on my knowledge all that much . . . I’m not sure necessarily that we have covered specifics in depth . . . I think they are great activities to do to show, but I am not sure I have learnt anymore about the specifics than what I already knew.

Another example was Kayla who also mentioned that at times she felt there was further information that she required to increase her knowledge. This was evident in the following comment:

I think I would have liked to have learnt more different ones [teaching strategies] . . . our tutor is great in saying, “All the kids will love this,” but that doesn’t really help me teach it, it just is ... I then know the kids will enjoy this activity, not the best way to show them how to teach it.
Further supporting evidence included Kailey who mentioned:

\[
I \text{ still do not see how doing primary science will teach me how to teach primary science and it was very difficult to engage in classes when the objective was so unclear.}
\]

This would indicate that the tutor was not specific or explicit in teaching or consolidating the relevant science content knowledge for the activities, including not being explicit in the PCK aims for the investigations. The researcher noted similar experiences during observations.

The researcher observed that this tutor was very good in using questioning techniques to elicit student prior knowledge, but did not necessarily build upon this knowledge or identify any misconceptions and use explicit constructivist pedagogy modelling to correct these. Honey’s explanation also supported this notion. She commented:

\[
\ldots \text{because I’ve got a science background, I was feeling fairly okay going into it [the unit]. If anything, now, I am feeling a little bit less confident, because there are gaps in my knowledge, and there is quite a lot that I didn’t know, or misconceptions . . . So, I know I have to go and find those things out.}
\]

This would indicate that although misconceptions were identified, the correct science concepts were not further explained or did not clarify scientific concepts for the preservice teachers.

Conversely, the researcher also noted that the tutor modelled inquiry, interactive and discovery pedagogies. The tutor’s students also identified these pedagogical strategies. This was evident in students’ comments such as, “our tutor has done some kind of extra things, like, before you get into the unit of work, get us up moving around, sharing different things” (Kayla) and “my tutor made it very clear about the co-operative of learning strategies . . . the different roles of the kids in the group, and how they all take turns” (Honey). Kayley observed a tutor’s strategy and commented “the tutor treats us as if we were a class of children, and goes through the motions,
and does a group leader . . . the primary connection roles . . . I think it is very good at modelling how we should behave as teachers”.

The following statement that Kayley made supports the notion that perhaps the tutor was not always explicit in their PCK teaching. Kayley mentioned “I don’t know if this is a strategy, or not”, yet was able to give the researcher a pedagogical strategy of discovery through her comment:

> When we were doing the experiments, giving us that bit of extra time to figure things out ourselves, to observe something and go, “Oh, that’s pretty cool,” or, “That’s what’s happening,” and give that moment to allow us to come to that conclusion, or to discover something for ourselves, I think. But I don’t know if it’s a strategy, or not, but it was good.

Rachel was more direct with her feedback, when asked about observing a variety of teaching strategies, she mentioned:

> The only thing we were told is, “Break up into groups of three.” Never, never told, “You should speak as a class, and say this is what we are going to do.” The tutor did mention, “You have to think about now, how you are going to break up the groups,” or, “How are you going to structure this activity, if you have to move around the classroom, how are you going to move around the classroom?” So that’s what they told all of us together, but not in saying, “This is how you can teach,” or, you know, “This is a science teams,” to everybody, “And now we are going and explore it, in a group.” No.

Again this would indicate that the tutor might not have been explicit in their PCK instruction to the whole cohort. The researcher had observed the tutor working with small groups and questioning students within the groups, and therefore perhaps not consolidating the same PCK across all groups.

Students also mentioned their positive learning experiences, such as Honey’s comment: “Coming round to the end of the unit, I definitely have a better idea of where to pitch things, and what each year level is . . . where they are at” and Kai
mentioned “I was able to understand much more than prior and fix misconceptions I had”.

Kate demonstrated her increase in both STOE and PSTE after completing the unit and attributed this to her tutor. The following comment supports this:

[I was] initially apprehensive about attending this unit as I did not personally enjoy learning science at school and I wasn't very good at it. Lessons have been fab and given me some confidence to teach effectively. I have enjoyed learning how to teach as well as re-learning all the content again for myself so it's been a double learning experience!

This statement supports the increase in both her STOE and PSTE after completing the unit with this tutor’s influence. Kaci, another student who had initially been classified as a disinterested science learning style student mentioned the positive effect of the unit through her comment:

I hated science. I was very strong that I didn’t want to teach it, whereas now I feel like I could teach it. I wouldn’t necessarily say that it would be my favourite subject to teach, and that it has created love for science, it hasn’t. But, I definitely feel like I could happily go in and teach it, and be comfortable, and confident, in activities that I had, that wouldn’t necessarily then pass onto kids, my dislike, for the subject. I think, they would enjoy it; I just don’t enjoy it because I don’t like science. But, I think I could teach it, in a way that the kids would enjoy what I was teaching, so I think that’s good, because I never would have thought that at the start of it.

Kaci’s statement is supported by the quantitative results as the STOE score had increased; however, her PSTE had a marginal (-1 point) negative change, which may indicate this student has not increased their self-belief in applying the science content knowledge.
The researcher noted this tutor also amended the weekly PowerPoint presentations to suit their needs and those of their tutorials. For many students this was not an issue; however, some mentioned this was a problem with comments such as Ryan’s:

*I found the notes, week to week, weren’t what our presenter presented us. I have a set of notes which half of it’s irrelevant to what we actually learnt, and just that whole, leaving with a package of information that I can use in my teaching, or go back to, effectively teacher background, it’s not really perfect.*

The researcher noted that the tutor did not make use of the complete PowerPoint presentation, and at times missed the science understandings, as these were not made explicit.

The researcher found the tutor to be friendly, relaxed and approachable during the observation periods. The students also identified these qualities. Kloe sums up the consensus of the majority of students with the comment:

*Our tutor has been fantastic. Teaching a unit from 5:30-8:30pm can be very exhausting and normally I would switch off. But the level of engagement and interesting content was fantastic. I have looked forward to each class and more importantly I am now even more excited to teach science in the classroom. A really fun and informative unit!*

Karlie also echoed this comment and stated:

*I definitely think that having a very qualified tutor, and the content of the unit is very interactive, very engaging. I feel like I have a lot of ideas, about how I would teach primary science in the classroom, so, yeah, I feel very confident about teaching primary science.*

Further comments were made in relation to the assessments, which will be discussed later in the chapter.
Tutor 6

Tutor 6 had small-medium effect sizes for both STOE and PSTE beliefs (Cohen’s $d = 0.43$ and Cohen’s $d = 0.46$ respectively). The change in scores for STOE ranged from -5 (a negative change) to +12, and the PSTE ranged from -14 to +10. This would indicate that some individual students’ self-efficacy had been strongly influenced by their learning experiences. Table 9 showed that a third of the tutor’s cohort were classified as enthusiastic science learners, a third as a not clearly identifiable group, 21% as successful science learners, and only 4% each for fearful and disinterested science learners. Table 13 demonstrates this tutor had an effect on fearful students’ PSTE beliefs, as this group had the greatest change in pre and post intervention scores. One of these students, Tallulah supports the quantitative data with her comment “I wasn't very confident coming into the unit though feel very confident now”.

During observations, the researcher noted that the tutor explicitly modelled teaching practices and strategies appropriate to primary school classes. This included using a wooden train whistle to gain attention of students. Once the tutor had the attention of the group, the strategy was explicitly explained for group management. Students observed and supported this statement with comments such as “the tutor always included behavioural management tips in with the lessons which made the activities more applicable” (Paris).

The researcher noted that the tutor used vast amount of open-ended questioning to elicit prior knowledge and to engage students and introduce an activity. The students were encouraged to use inquiry methods and discovery pedagogy to participate in investigations or activities, as part of an overall constructivist approach. The researcher also noted that the tutor is not closely involved with the students during investigations and activities. The tutor allows free movement and discussion during activity times. It was observed that at times a number of students would not be actively engaged in specific activities but rather discussing or working on their assessments instead. Peter mentioned “to begin with I found the delivery style hard to follow and not very structured. As the semester went on I became more comfortable with the style of the class”. It could be surmised that the tutor did not give an explicit explanation of this teaching strategy at the start of unit, instead used this method
consistently to allow students to become familiar with the style of teaching. Phoebe who commented also noted this:

[The tutor] starts the lesson as though [they] would start a primary class, and gets us to think about it as you would normally in class, in getting the inquiry-based questions happening.

Some students felt disconcerted by the constructivist and inquiry model of instruction and commented, “I wish we talked about the science more rather than just hands on all experiments for the most part” (Penny); “I would have preferred for the tutor to be more specific with our goals. Coming from a science background I was able to follow but had to help classmates that weren't about some concepts” (Paige); “I would have preferred more explicit instruction in the teaching at some points” (Peyton); and Phoebe’s comment “there could have been more explicit teaching after each activity to clarify our understanding and how to teach it in the class”. Again the researcher believes this teaching strategy may not have been explicitly explained to alleviate student concerns. Other students would disagree with this, as shown through Tamara’s comment:

The tutor demonstrated all instructional strategies consistently and paused to explain them. The tutor provided everything necessary to help me become more confident in teaching science.

Students also mentioned they found the tutor to be “wonderful, funny, engaging and easy to understand” (Tara); “tutor was approachable and helpful regarding any misunderstandings” (Tahlia); and “tutor to have a wealth of knowledge” (Tia) yet able to “answer various students’ questions without being overbearing or excessively dry” (Padraig). Patrick found that “good examples [were] provided of how to interact with students and what sort of expectations to have”. Pixie became more confident as she found:

. . . the tutor was able to inspire my interest in science by giving plenty of real world examples of applying science in the classroom. One of the most helpful and inspiring aspects of the tutor's teaching was teaching from the children's
perspective. I found this useful as it helped inform my strategies for engaging students.

Researcher observations concur with these statements and found that as this tutor has recent relevant primary school science teaching experience, it allowed the pedagogical strategies were modelled easily. It also provided explicit instruction opportunity to assist students to appreciate the need for thorough planning in both content and equipment requirements for science lessons.

Explicit modelling was also reflected by data in Table 15 whereby over 90% of participants had identified the use interactive, discovery and modelling strategies. Students were able to identify particular activities or investigations that were used to demonstrate pedagogical strategies. These included the use of modelling abstract concepts such as phases of the moon, seasons, electrical circuits and the change of states of matter. Tia commented that she “loved the experience of actually doing the activities” with Phoebe commenting that she had a conceptual change of how candles work through investigation first and then scientific explanation. Paige also had a conceptual change through the activity of moon illumination and shadows. This demonstrated that physical activities and active engagement have been beneficial tools for students’ scientific learning and understanding.

Comments in relation to the assessment will be discussed in the next section of this chapter.

Assessment Results as a Factor of Self-efficacy

Students commented on anxiety levels they felt whilst doing the assessments. This anxiety could become a factor of students’ self-efficacy and a Pearson correlation analysis was performed to determine if the assessment results had a relationship with the STOE and PSTE outcomes. A Pearson correlation was run to determine the linear relationship between overall assessment results and post intervention STOE scores. There was a small positive relationship between assessment results and post intervention STOE scores, which was statistically significant ($r = .186$, $n = 262$, $p < .005$). A Pearson correlation was also run to determine the relationship between overall assessment results and post intervention PSTE scores. It was found there was
a small relationship, which was statistically significant \( r = .171, n = 262, p = .006 \). It was found in general, for both constructs, that those students with higher marks also had higher post intervention STOE and PSTE scores.

Participants commented on specific areas of both assessments. Assessment one was a STEM investigation, see Appendix N, which some students found interesting and beneficial, while others struggled with the science content knowledge. Comments from those that had a positive experience included “we’ve been given a STEM project for life” (Jasper). Phoebe mentioned that she enlisted the assistance of her children and “really enjoyed that process”. She also commented that she felt “the poster for me was just a bit of an add-on at the end, like, it didn’t really seem purposeful”. Phoebe also felt disappointed with her oral presentation, as “it was more of a conversation, between them and myself . . . So I felt uncomfortable that I wasn’t getting across what I had prepared . . . I was getting interrupted all the time with questions from the other group”. This could indicate that the tutor was not explicit enough in their instruction for group presentations. The researcher had also observed this occurring in this particular tutorial, and noted that some students had become nervous and unsure of their content knowledge.

Fern felt out of her depth with the first assessment and commented that she “had great intentions, but then when I went to do it, it was like, “What am I writing? What am I actually putting here? And there is no point asking the tutors, because they didn’t know either”’. She confirmed this affected her self-efficacy and didn’t feel encouraged to complete the assessment. Ryan supported this with his observation and commented:

> There weren’t many students who had science backgrounds. So for them, their anxiety coming into the course was quite high and then to have the goal posts shifted, and then to be not really scaffolded very well, it just pushed it even higher.

Ryan summed up these students “were focusing more on the assessments, rather than making themselves better teachers”. This would indicate there was a lack of coherency between the assessment expectation in the unit plan and the tutors’
expectations. It also seemed there was confusion amongst students as tutors did not provide the same consistency of information across all tutorials. These were also observations made by the researcher through incidental conversations with research participants.

Students mentioned they didn’t understand the purpose or aim of the STEM project, with comments such as:

*I'm actually a little bit confused about the level issue with the STEM project, because I would never give a mousetrap car to primary school kids, too dangerous! And so I've tried to look for where it fits into the curriculum, and it fits best into year two and that's not going to be appropriate, so I guess that's something a bit weird about that STEM project.*

This would indicate the need for tutors to be explicit in their introductions about the purpose and aim of assessments as a learning tool for preservice teachers.

Some students had not been in an educational setting for some time, and struggled with the scientific language required, commenting:

*To say that you come into this course, you should have minimum of year 10, and aiming up to, like, university level, that to me is what is terrifying, because I don’t think I need to know that to teach primary school. It’s the science knowledge . . . I think for some people who don’t have that prior knowledge for science, or it’s very low level prior knowledge, I think it’s very difficult to expect people to be at that level when they are not.* (Amelia)

Fiona mentioned that she spent a lot of time researching how to write a scientific report as she had struggled with the language, but this has led to her increased science content learning. These struggles also affected her self-efficacy with the science content.

A student who had a higher tertiary science educational background commented that:
I even found calling it a lit review really weird, because it wasn’t a review of the literature, it wasn’t this person says this, this person says this, this person disagrees, but supports this. It wasn’t really a lit review, and you’ve called it a lit review, but it wasn’t. (Bentley)

Other students in the focus group had also agreed with this comment. This would indicate that language used needs to be explicitly explained in a consistent manner across all tutorials. Casey also mentioned that many students had struggled with graphing, and were marked accordingly. They believed that “you [the tutors] need to teach us that if you are heavy on it, and it’s something that’s so broad, if everyone’s doing wrong, then it should have been taught to us”. The researcher did note that in many observations of tutorials, the tutors did discuss and provide examples of how to correctly present scientific data. Constance articulated what other students had also mentioned, with the comment “the first assignment didn’t really assist my teaching practice apart from the science concepts research. Too much time wasted on constructing cars”, where other students had mentioned their STEM project focus including solar ovens. Chloe made a comment that although she found the activities interesting, she “would have found it more helpful to have been tested on scientific pedagogical skills as opposed to the STEM project which only focused on one theory and not how you would teach it”.

The researcher had also observed some students struggled with the construction of their models, asked their tutor to assist, but didn’t wait for any explanation in relation to how best to construct using scientific principles. For example, there were students who left the not functioning battery operated vehicle with the tutor, in the hope that the tutor would problem solve the reason why it didn’t work and then hand it back to them as a working model. As the students were not present when the tutor diagnosed the issue, they missed the benefit of learning the science skills required to problem solve an issue. This further demonstrated their low self-efficacy in relation to science; which may translate to low efficacy to teach science. These observations and student comments demonstrated some of the frustrations that students had faced with the first assessment, which could affect their self-efficacy.

Students also commented on the second assessment. Fern mentioned she:
. . . really liked the second assignment. For starters, it gets you coming to tutes [sic] each week, which I think is good, because certainly for me I get far more out of being there, than I do out of reading a book. I think you get a much better understanding, it’s good to get some varieties of ideas, whether they are ones that you actually do, or not, in classes, there’s a couple of ideas there. I like the fact that it’s, the idea, that you can get started early, and you don’t have this huge pressure at the end.

Many students like Fern, mentioned they would prefer to have a template available at the commencement of the unit so there would be consistency among tutorials. Students mentioned that their tutor would give them suggestions throughout the tutorials which activities would be deemed suitable for assessment two.

Constance mentioned the benefit of an eight-week portfolio as being “useful and applicable to teaching” and Jasper added that it becomes a resource for teaching the various science strands. Carys agreed with this and found “the hands on activities were well constructed and produced them in an assignment will cement [her] knowledge”.

There were also students who did not see the value in assessment two, as an example, Marcie commented “the lectures were interesting however I don't feel that the assignments have assisted me in anyway at all”. Marcie’s overall assessment score was 69%, which was approximately the average for the cohort. Her STOE had a very small increase (+2 points) and PSTE a very small decrease (-1 point). Hence, the data support her assertion that the assessments have not changed her self-efficacy.

Alex mentioned that the tutorials felt rushed and they missed out on science and pedagogical learning, finding that “you are too worried about taking a photo for an assessment, which became a distraction to learning”. Ryan supported this with the statement “I found the photos were stupid. Because everyone was getting their cameras out, and not actually learning about the concepts, of what we were trying to teach the kids”.
Some students mentioned they saw the value in the second assessment, yet they their attitude towards its design was contrary. Penny’s comment was an example of this attitude, as she found the weekly content interesting, yet commented:

_I disliked the format of this unit . . . having to write up details of every session including taking many photos and notes detracted from the learning. It was very anxiety provoking and I lost focus._

Ewan found the number of portfolio entries excessive when commencing the assessment, however, in latter lessons saw the value in the visual representations, and commented, “you don’t need to go into a huge long explanation . . . the details are in the photograph”.

The optimistic views, satisfaction and concerns with assessments suggest an influence on the self-efficacy of students. The implications of these influences will be discussed further in Chapter Seven.

**Design as a Factor of Self-efficacy**

During the focus group discussions participants discussed the unit design, how it benefitted them and the areas of concerns and how these may affect their self-efficacy. The main themes that emerged when discussing the interactive, inquiry based and social constructive pedagogy of the design, along with student self-efficacy, were the:

- Change in students’ content knowledge;
- Change in students’ confidence with science understandings;
- Change in students’ pedagogical content knowledge;
- Unit’s text resources; and,
- Additional content to be included in future design to benefit learning.

**Change in students’ content knowledge**

Many students commented that through being a participant of activities and models, they were able to observe abstract concepts in a concrete manner, consequently addressing their conceptual understandings. Some mentioned how the “activity or
investigation can make abstract concepts relevant to primary school students” (Mel). Students found that their conceptual understandings may have been incorrect or alternative to the correct scientific understanding. Amber explained “...just in terms of understanding concepts, and overcoming misconceptions... I feel more confident going forward in teaching, but also having lots of interaction, interactive activities, and models to show, has been invaluable”. Bentley commented on the importance of diagnosing student misconceptions:

I found interesting... that we have to be aware of what our misconceptions are... the unit has highlighted that we have these misconceptions and it's pretty useless if a teacher just brushes it off, or that, ‘It just happens because.’ If we don't understand it, that not only do they have misconceptions but their parents will and we will... I thought that was pretty useful to have that drawn to our attention.

Mohammed backed up this statement:

The unit was very real. Not only were concepts explained, but misconceptions were also taught to prevent teachers from providing 'logical' but false information. The activities were interesting and delivered at a real level. Not at a pragmatic uni-style level.

Other students mentioned that their misconceptions were highlighted and they were able to change their understanding and know how they can teach the correct understandings to primary students; subsequently, they mentioned this led to increased self-efficacy with the content knowledge. This was supported by comments such as “I think that’s the biggest fear that anybody goes in, they are not too sure, and now we do. I know that everybody that you talk to, seems to be very confident with that” (Serryn). Karlie commented, “I feel very ready to go out and teach primary science”. Both of these students also had increased scores for both their STOE and PSTE beliefs.

There were also students who had not felt they had a change in content knowledge, as their background was a post-graduate science degree. However, they found that
through the activities, investigations and models, their content knowledge changed “from a very narrow, but experienced, thing with science, to being broader, more basic level” (Honey). Another example is Bella’s comment:

So I know from my career that science is very exciting, and I would like to pass that on to children . . . you're at such a high level, yeah, you don't know how to teach it to make it basic and just simple, and not over-complicated . . . this unit's been helping with that, and . . . it's helping me bring up to speed with areas that I'm not so confident in.

Change in students’ confidence with science understandings
Students’ confidence in their science understandings varied. Table 16 demonstrates the level of confidence for each science understanding strand (as per ACARA, 2014) students perceived at the end of the unit. Refer to Appendix H questions 31 and 32 which elicited the preservice teachers’ confidence levels in relation to the various science understanding.

Table 16. Percentage frequency of student confidence in science understanding

<table>
<thead>
<tr>
<th></th>
<th>Biological Science</th>
<th>Chemical Science</th>
<th>Earth &amp; Space Science</th>
<th>Physical Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all confident</td>
<td>7</td>
<td>6</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Not very confident</td>
<td>8</td>
<td>22</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Somewhat confident</td>
<td>27</td>
<td>41</td>
<td>32</td>
<td>30</td>
</tr>
<tr>
<td>Very confident</td>
<td>38</td>
<td>21</td>
<td>37</td>
<td>32</td>
</tr>
<tr>
<td>Totally confident</td>
<td>20</td>
<td>10</td>
<td>16</td>
<td>13</td>
</tr>
</tbody>
</table>

From Table 16 it can be seen that students were most confident in the biological science, despite the design having the least amount of this science understanding content. It also demonstrates that at least a third of the cohort is confident with Earth
and Space science and physical science. These were two areas of content that the unit design concentrated on, as these are often seen as areas of weakness in understanding. From these data it would indicate that a greater concentration on chemical science content would increase student content in this area in line with the other science strands.

Emilie stated “Whilst I enjoyed each activity, I am not yet as confident as I would like with the science understandings”, yet her PSTE belief score had increased by 12 points on the post intervention. Emilie had been categorised as a fearful science learner, and perhaps still felt she had more content to learn, which affected her confidence.

Others felt that assessment one had improved their knowledge in one specific area; for example, Scarlett explains:

> My STEM investigation in the first assignment, taught me Newton’s laws of physics, which I already knew, but when I saw it in action in a mousetrap car. . . it was different, like it was a light bulb thing that went off, and to most of the activities that we have done in the seminars have been … yeah, have been fun but have taught us really important basic science.

As many of the STEM projects were physical science based, this statement may also explain the results of confidence with the physical sciences as described in the table above.

Through the assessments students had to research the various science understandings. Researching science of the activities has also increased the science understandings by students. An example of this was Milo’s comment about the modelling of and participation in activities that: “Forces you to look into primary science experiments/activity and research the science behind these”.

Marja’s comment captured what others also stated: “I think my scientific understanding has improved, a lot. It’s certainly a unit that I’ve not struggled with, but I have been challenged in it more than I anticipated”.
Change in students’ pedagogical content knowledge

As mentioned earlier the inquiry model used as part of the social constructive pedagogy assisted the students with their conceptual understandings. It also allowed for modelling of activities and investigations that would assist primary school students with the science understandings in an interactive manner. Some examples of students’ comments that supported this notion included:

- “Hands-on experience . . . we are actually doing experiments or investigations, ourselves gives us a lot of guidance as to how you would do it in the classroom because it is actually laid out specifically for you, what you would do in that situation” (Karlie);
- “The hands-on approach got the unit helped with understanding the content and enabling ideas and links to how I could integrate the activities into the classroom” (Elija);
- “I've enjoyed all the discovery and have heaps of ideas of teaching now” (Amber); and,
- “I am definitely much more confident using the enquiry model in the classroom” (Phoebe).

Not all students were engaged, or enjoyed the practical-based delivery. One student mentioned they found the workshops to be wasting time and feeling like they were a primary school student as it was “only going through activities for primary students . . . rather than getting a university education”. The researcher notes that although this is one student’s comment, it may represent other students who did not self-select into the focus groups or respond to the questionnaire.

Integration with other subject areas was another pedagogical strategy that students found beneficial. How science can be integrated in a cross curriculum method was also part of the design of this unit. An example of this was Alanna who mentioned how her confidence has changed over time in her following comment:

I was really nervous about doing the unit mainly because I don't have a particular interest in science, but I think what I've found in the last three or four weeks is just breaking it down to a child level and not complicating it for
them, that what I like best too is the fact that we're looking at science in integration, across their whole learning experience, and I've found that that's been really, really useful to be able to do that, to see it across the whole of their learning experience, and not so hard.

The use of the constructivist pedagogy 5E model during tutorials was also an area students commented on. Students mentioned how this model can form the basis for teaching and how science content can be learnt. An example of this was a comment made by Ryan, who stated:

... when you are teaching ... you can fill yourself up with understanding, you don’t have to have that right now, when you walk out of the university, but you have to have the belief in yourself, that you can do it, and you’ve got the knowledge of this is the five step process, and you know this is how we can teach it to the kids.

Unit’s text resources

As mentioned in Chapter Four one of the teaching resources that is used in primary schools is Primary Connections. Part of the design of the unit is its use and a basis for many of the activities and investigations that occur in the tutorials. As this resource is produced on informed research it was considered most appropriate by the unit coordinator. Many students mentioned that Primary Connections resources have assisted with their confidence in being able to teach primary science. Examples that demonstrate this notion are

- Hallie mentioned: “While I do not know every area well enough now, I am confident about how to find information and valuable resources to use. I can think more creatively about how to help students”;
- Marja commented: “I feel more confident in just being able to step in, and have resources at hand, like Primary Connections . . . it was really good to see that the resources that we are exposed to here, are likely to be in the classrooms that we go into, or they are going to be easily accessible”; and,
- Phoebe stated: “knowing the primary connections is there . . . that I can easily access that when I need to, has definitely helped. It gives you a bit of confidence, so you have got something to back up, just in case”.

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Some students mentioned they found there too much reliance on Primary Connections books as a weekly resource and would have preferred to have also been exposed to other resources throughout the semester, not just in a couple of tutorials.

The unit also had a science teaching pedagogical text. This resource had varying opinions with most students finding the text “either too deep or heavy for me, for my knowledge, for my understanding, and went about students’ conceptions, and didn’t actually tell you a lot about the science” (Rachel). These comments may indicate that tutors were not explicit enough in their use of the text as a pedagogical resource, which may affect students’ confidence with pedagogical understandings.

In general, students found to have benefitted from the resources made available. One student summarised this notion with her comment:

*I am not great at science but after this unit I am confident I will be able to teach engaging lessons. I know where to find resources and create easy experiments. I am confident that while I do not know everything I know enough to be a good science educator!* (Beatrice)

_Additional unit content_

Students made a couple of suggestions that may assist with increased confidence to teach primary science. This confidence may affect their STOE results.

One of the areas was in relation to assessment. Students felt there to be a lack of design focus on how to assess primary school students and felt this would impact their future teaching. This was demonstrated in comments such as:

*I would feel capable still in teaching it, but I still don’t think that we’ve had anything in assessing. So I am not sure how I would necessarily grade my students, or what really to look for in my students, but teaching it, I could do quite comfortably now.* (Casey)

Delvine also mentioned the use of technology:
[If] a school wants you to be really competent in using technology on a daily basis; [however] ... there's absolutely no training at ECU, and I think science, yes, looking up a website is great, but I think there's so much more to using information technology that we are not taught here, and I think we need to be the cutting edge. I think we, as a university ... as graduates, we should be going into the school and teaching them what is out there, and what we can use, because I think it should be cutting edge, and I think that's something that's done poorly across all units.

The researcher did note that the use of interactive whiteboards was not included in the design of the units, as this technology was not available in the tutorial rooms. Other forms of technology were used including a digital microscope with an iPad interface.

Another area where students would have liked to experience further development is how to differentiate between different learner types and age groups. One comment that reflects this: “The safety of students must also be better understood with more initiative given to special needs and high needs students” (Ronnie); another student mentioned they would have “liked to see how topics can be scaffolded to different year groups in accordance with ACARA” (Reuben). This may reflect back to the explicit nature of concept teaching by individual tutors.

The final area that students expected to have been included was lesson planning. This was expressed in comments such as “Creating a document that packs in the curriculum in details would help” (Baxter).

In general, the design of the unit seemed to create a positive experience for most students. Some examples of comments that demonstrates an increased level of self-efficacy in primary science include:

- “The investigations were very important for me because I am a visual learner” (Ellen);
- “The hands on approach to the unit helped with understanding the content and enabling ideas and links to how I could integrate the activities into the classroom” (Elija);
• “Actually seeing and doing activities and linking them to the curriculum is extremely worthwhile. I was not confident with science but now it feels much more achievable. Still feel now it will just be time and experience to make me a good science teacher. I feel I have a good ‘toolkit’ to start after this unit” (Barney); and,

• “I think it comes down to that old saying, knowledge is power . . . we felt power ... a lot of us felt a little bit powerless as to trying to control a classroom, teach some science, and now we can, so we in the control now, and we go in there and go, ‘Okay, that’s fine, we can do it’” (Serryn).

Student identified factors of self-efficacy

Other themes that emerged from the focus group discussions as possible influences of preservice teacher self-efficacy were:

• Feeling of entitlement;
• Peers;
• Social media;
• Mid-year intake; and,
• ‘Outside’ influences.

Feeling of entitlement

The researcher had noted that during focus group discussion and observation periods, students often commented they would prefer to be supplied templates or examples of previous students’ work for assessments. Some students such as Alex expected they “need to come out with the teaching pack that I can just use from first year”.

Another example of entitlement comments included Bentley’s comment: “I think an example paper would have been beautiful. Maybe on an experiment that none of us had, but just to show us how it was supposed to be done”. The researcher noted that many of these students also expressed they wanted further explicit details on how to set out the assessments, how to have questions answered and how to do a scientific report. In addition to this, students wanted to be provided with methods to make it ‘easier’ for them to quickly finish the assessments. The researcher noted that the unit plan did provide explanations; however, it expected students to do further research in
relation to academic writing and scientific graphing. This notion will be further discussed in Chapter Seven.

**Peers**

Student peers were considered an influence in both negative and positive means. In general, most students found working with a partner for assessment one was beneficial. Josephine, for example, mentioned her partner was an engineer where the science “*just fell out of his mouth*”, which made it easier for her to understand the science concepts required for the STEM investigation. In this manner she benefitted from another student’s content knowledge and felt more confident in herself. Conversely Alex commented that he was working with a student with similar science background, and both struggled with the content initially and had to do further research which was found to be very time consuming.

Tiana found that group work benefitted her, as “*it was good to build relationships with other people . . . working together to solve . . . problems, and seeing how that could work in class*”. This demonstrated the benefit of social constructivism during tutorials.

Peer influence extended to another area of influence; this was social media.

**Social media**

As mentioned in Chapter Five, social media was an area of concern for the tutors. It was found that some students also found this an area of concern. For example, Alana mentioned: “*a lot of people are too much stressing, about what other people are saying, and doing, whether they are doing the right thing*” and found a level of possible “*collusion*” whereby she continues with “*there’s a difference between just having a discussion, then you going away and finding your resources, or going away and writing it, to actually, posting the resources that everyone should put in there*”.

Whilst the researcher was observing a tutorial, a student mentioned the closed Facebook page had raised some level of anxiety with some people about one of the assessments as there was some “*argument*” between the social media group members, and comparison made between tutors, tutorials and the information that tutors provided for their students. This particular student had tried to put a “*lid on it*”, by
telling fellow students to go to individual tutors for clarification and not directly to Facebook. This may be an area of further research and will be discussed in subsequent chapters.

*Mid-year intake students*

Approximately 26% of students commenced the GDE-P in second semester, the semester in which this research was conducted. The experience of being back in a tertiary learning environment, including its technology, was daunting to some as it was considered a “paradigm shift” (Alex). Others felt they had lack of knowledge in some areas or the use of acronyms associated with teaching, such as ACARA and SCSA, or terms such as pedagogy. These concerns led to increased levels of anxiety during the tutorial sessions and throughout the semester, which then impacted upon their STOE beliefs.

*Outside influences*

These influences are those outside of the university, yet still as influential on the students’ self-efficacy, which included family life. Students mentioned the difficulty of juggling the household, assessments and readings within a short timeframe of a 10-week course. This also had an impact on being able to work collaboratively with another student on assessment one. As an example, Phoebe commented:

*I’ve got two young kids and partners, they work as well, and they have got kids . . . it’s really difficult to collaborate, and try and do it [the assessment] together . . . I ended up just doing the car myself, because it was easier.*

*Chapter summary*

The data presented in Chapter Six outlined the effect that the design and the tutelage had on preservice teacher self-efficacy. It was found that participant demographics were represented by 88% of the total cohort on the pre intervention survey. The gender breakdown of participants was 76% female and 24% male. These data are in line with similar representations in the pilot study and with literature (Odgaard, 2014).

Demographic data demonstrated that preservice teacher science learning background varied, with the greatest percentage (44%) completing year 12 science subjects, and a
quarter of the cohort completing an undergraduate degree in a science related field. Along with these data the majority of students had responded they had a positive science learning experience whilst at secondary school. This is an area that will be discussed in Chapter Seven, as these data have varied from other literature. Positive experiences were attributed to the passion and knowledge of the teacher, the problem solving and inquiry nature of science, and being a practical subject that helped kinaesthetic learners. The negative experiences that preservice teachers had were analysed into the main themes of: the amount of theory that had to be learnt and the method of learning (which could lead to the feeling of boredom), the influence of the science teacher including their teaching techniques, the complexity of science content, and their preference for other learning areas, such as humanities. There were also preservice teachers who had mixed experiences with science; where they had a negative experience in secondary science education, however, as an adult have had positive experiences and see the benefit of scientific literacy in society.

Science learning experiences in secondary education also attributed to the type of science learner a preservice teacher could be categorised as. Data suggested that the type of learner also affected their self-efficacy in science. Those classified as fearful and disinterested science learners had the lowest self-efficacy scores in comparison to those classified as enthusiastic science learners. Therefore, it was imperative these students were catered for sufficiently, through unit design and tutor delivery, to assist them to increase their self-efficacy for both science teaching outcome expectancies and personal science teaching efficacy beliefs.

It was found that the overall cohort self-efficacy for both STOE and PSTE had improved with the design and delivery having a medium effect size. The effect sizes per tutor did vary, with some having very low effect in either STOE or PSTE scores, and other having a medium-large effect on student PSTE scores. The greatest effect occurred on the fearful science learners. Some of these students had mentioned that if they had been exposed to secondary science in the same manner as what they experienced in the unit, then they would have continued with science into senior secondary education levels. Some mentioned that the awareness of negative experiences they may have had would not be perpetuated with their future students, as they feel more confident and equipped to find out the science content that is required
and deliver this content in a collaborative constructivist manner. This indicated there has been an increase in both science content knowledge and pedagogical content knowledge.

Each tutor’s practice was analysed using data provided by the participants. These data showed that most tutors used common teaching approaches, and also highlighted tutors ranged from explicit to not explicit with the science content and pedagogical content delivery. Teaching strategies identified by tutors but not by preservice teachers may have been used but not been explicitly explained. This was found to affect preservice teacher self-efficacy.

The assessment results were also found to have a relationship with post intervention STOE and PSTE scores. The relationship was found to be small yet statistically significant.

Preservice teacher vignette data demonstrated the overall design of the unit to be beneficial for their self-efficacy. In general, preservice teachers mentioned the social constructivist nature and the interactive activities had extended their subject content and pedagogical content knowledge, and therefore increased their confidence. Students who had a graduate or postgraduate degree in a science field felt that their subject content knowledge had not necessarily increased; however, they had felt they had improved in their pedagogical content knowledge. There were concerns highlighted which included the assessment designs and lack of clarity in the unit plan, which created a perceived lack of consistency between the tutors. These concerns were highlighted as factors that affected student self-efficacy and confidence.

Further discussion on triangulated data will be addressed in Chapter Seven.
CHAPTER SEVEN
DISCUSSION

Introduction

Research findings from tutor interviews, the preservice teacher questionnaire instrument (modified STEBI-B), focus group discussions and researcher observations were presented in Chapters Five and Six. Chapter Seven discusses the implications of the triangulated findings, linked to the research questions:

1. What are the preservice teachers’ science teaching efficacy beliefs pre and post intervention?
2. To what extent does a tutor’s teaching of the GDE-P Science unit’s science concepts impact preservice teachers’ self-efficacy constructs?
3. To what extent does the tutor’s modelling of GDE-P Science unit’s pedagogical content impact preservice teacher’s self-efficacy?
4. How did the preservice teachers perceive the design of the GDE-P Science unit influence their self-efficacy in primary science teaching?
5. What perceived factors in the GDE-P Science unit did the preservice teachers believe would enhance their science and pedagogical content self-efficacy?

The research questions and related findings form the basis of four themes for discussion. These include preservice teachers’ pre and post intervention science efficacy beliefs in relation to:

1. Preservice teachers’ demographics and prior science learning background as a basis for science self-efficacy and attitude;
2. Tutor’s background and delivery of science content and pedagogical content;
3. Overall design of the GDE-P unit; and,
4. Preservice teacher identified factors.

These themes will be discussed from research findings and linked to significant literature.

Prior to discussing each of these themes it is important to reiterate this research is based within the context of an intrinsic case study, the GDE-P science unit and its cohort of students, and as such cannot be considered generalisable in a broad context.
However, this case study does give further insight into factors that might affect preservice teacher self-efficacy.

Within this chapter the constructs of self-efficacy will be presented again using the acronyms of STOE for science teaching outcome expectancy and PSTE for personal science teaching efficacy beliefs. It is also important to mention that causality in quasi-experimental human sciences investigations may be considered probabilistic rather than deterministic (Cohen et al., 2011). Therefore, the language of causality will be used when results are discussed through inference rather than definitive measures, as causation is not often observable.

It is important to note the difference between this study and many other literature findings. Research in preservice teacher self-efficacy to teach primary science has predominately been based on smaller numbers of participants or over a longer period of time (for example, Fitzgerald et al., 2012; Ginns et al., 1995; Howitt, 2007; McKinnon & Lamberts, 2013). The other point of difference is this study concentrated on GDE-P students as compared to undergraduate bachelor degrees (for example, Enoch & Riggs, 1990; Ginns et al., 1995; Mulholland et al., 2004). Preservice teachers in a four-year undergraduate degree have greater exposure to develop their science content and science pedagogical content knowledge through requiring completing two units of science. These units combine both science content methods and science teaching philosophies. During this time, the preservice teachers also complete school-based practicum, which research has found to enhance their STOE beliefs (McKinnon & Lamberts, 2013; Palmer, 2006a; Petersen & Treagust, 2014).

Conversely the GDE-P science unit is a relatively short 10 week program that is required to combine science content and pedagogical content knowledge. As the GDE-P science unit is completed in the second semester, with the school based practicum after the completion of this unit, preservice teachers have had limited opportunity to explore the teaching of science constructively. Therefore, leading to a lower science teaching outcome expectancy when initially attending the unit. Further differences are highlighted in the areas of GDE-P students’ maturity (i.e., not directly from secondary education into tertiary education):
• Greater numbers of students with a richer workforce background (greater number of years in a professional or leadership role); and,
• Students with rich and diverse life experiences.

These life experience might alter the student’s beliefs and attitudes towards science; for example, where:
• Retraining as teachers might see them applying beliefs and attitudes into their new field; and,
• Mature students might display an enhanced ability to critically articulate their strengths and weaknesses.

Consistent with the literature, the results indicated an overall improvement in the preservice teacher self-efficacy in science teaching from the commencement of the unit to its completion. This study showed a higher effect in the PSTE compared to the increase in STOE. The results showed a relatively small effect in preservice teacher STOE and a medium increase in PSTE. These results are considered lower than other research had shown, including the pilot study results (Cohen’s $d$ STOE = 0.83 and Cohen’s $d$ PSTE = 0.71, N=17). The number of participants is used in the calculation of Cohen’s $d$, which can significantly affect the outcome of effect size. Cohen (2013) suggests to be able to accurately detect a small effect size of 0.2 you would need approximately 226 participants pre and post intervention. However, large effect of 0.8 can be detected with approximately 28 participants in the pre and post intervention. As this study’s sample was greater than 226, the smaller effect size is considered easier to detect. Larger sample sizes have a smaller error and greater reliability, or offer more precise results (Cohen, 2013). In this case, the chance for this effect size be detected is greater than 80% as the sample size has increased the statistical power. Studies with lower number of participants tend to over inflate the effect size; however, other research elements may also affect power (Cohen, 2013). As the number of participants varied per tutor cohort, the effect sizes will be considered indicative trends and will be discussed in conjunction with additional factors.
Preservice teachers’ demographics and prior science learning background as a basis for science self-efficacy and attitude

As mentioned above, the levels of PSTE and STOE had increased with the participants’ involvement in the GDE-P science unit. The findings demonstrated in this study are similar to other researchers’ findings, whereby the PSTE effect was greater than the STOE effect (Gibson & Dembo, 1984; Menon & Sadler, 2016; Petersen & Treagust, 2014; Tschannen-Moran et al., 1998). The higher effect in PSTE was also evident in the participant anecdotes and discussions expressing views of gaining confidence in the science content, and seeing themselves as future teachers. The larger increased effect in PSTE could be attributed to preservice teachers’ engagement in the social constructivist learning in a hands-on interactive environment. These experiences may contribute towards positive perceptions of science and the teaching of science (Menon & Sadler, 2016). The influence of the learning environment would allow students from various undergraduate degree backgrounds, or those unfamiliar in science, to increase their confidence in science content knowledge. This notion echoed many other researchers’ findings (Menon & Sadler, 2016; Mulholland et al., 2004; Tschannen-Moran et al., 1998).

The lower STOE effect, as compared to the PSTE effect, could be explained through the fact that preservice teachers had not experienced formal classroom teaching (Menon & Sadler, 2016), and yet were expected to answer questions about their future teaching attitudes. The lower STOE scores may be attributed to preservice teachers struggling to answer the STOE items. It is possible that preservice teachers may have difficulty answering these items due to their limited amount of teacher training, or alternatively, may not yet know how to judge themselves in relation to effective teaching as they have limited experience within a school environment. This will be further discussed in relation to tutor content delivery and the design of the unit later in the chapter.

The science educational background of the preservice teachers could be linked with the science learning experiences they had in secondary education. Many researchers (Avery & Myer, 2012; Cobern & Loving, 2002; Mulholland & Wallace, 2003; Schoon & Boone, 1998; Tosun, 2000) mention that primary school teachers often
have a negative experience with science. Appleton (2003) suggested that a lack of science content knowledge together with negative science experiences would result in decreased efficacy. Researchers have found that both positive and negative experiences impact upon preservice teachers’ self-efficacy to teach science and an individual’s future engagement with the subject (Danaia, Fitzgerald & McKinnon, 2013; McKinnon & Lamberts, 2013; Rennie et al., 2001; Settlage, 2000). This study demonstrated that some preservice teachers had negative school experiences; however, the majority of participants had positive experiences, as well as having completed senior science in secondary education. However, in line with the literature, the findings did confirm that those with negative science experiences also had lower levels of self-efficacy and self-reported low levels of science content knowledge. In support of the literature, students who had positive science learning experiences also had higher levels of self-efficacy and had continued with science at a tertiary level (Sangueza, 2010).

This study highlighted that many students had completed at least one senior secondary science unit; however, the majority of degrees reported in the data were in non-science based degrees. Many researchers have commented that preservice primary teachers lack senior secondary science (for example, Avery & Meyer, 2012; Danaia et al., 2013) in contrast, this study’s finding demonstrated that 77% of GDE-P students had completed a science subject area in at least senior secondary classes. Similar to Tosun (2000), it was found that those who continued with a science related study, the majority (42%) of students completed a degree in an area of biological sciences, followed by Earth & Space sciences (16%) and very low numbers in both chemical and physical sciences. As the biological science understandings were the greatest, it seems that experience in other science areas is much lower and this could explain the expression of concern by many participants about teaching general science. Rice and Roychoudhury (2003) suggested that a lack of science knowledge would hinder the development of confidence in preservice teacher science teaching. However, this was not demonstrated in this study, as prior science learning did not have a statistical effect on the science teaching outcome efficacy.

Consistent with the literature, this study’s findings demonstrated a statistically significant effect of prior science education on preservice teacher PSTE, highlighting
this as an important factor of what influences their beliefs and confidence levels. Echoing findings by Mulholland et al. (2004), this study also found that participants who had higher levels of PSTE scores were those who had completed at least senior secondary science, in comparison to those who had only completed middle years’ science classes. Findings from this study indicated that participants with low PSTE scores felt the amount of time spent researching science needed to be increased prior to teaching primary students, as one strategy to prevent misconceptions from being perpetuated. Again this echoed the findings of Tosun (2000), along with the notion that participants with a greater science knowledge base were confident to use appropriate activities and language to demonstrate the science understandings rather than feeling overwhelmed by content.

Findings in relation to gender as a factor of primary science self-efficacy were consistent with the literature (Riggs, 1991), whereby males had a higher level of self-efficacy in PSTE belief than female preservice teachers. These findings were contrary to those found by Mulholland et al. (2004). It could be surmised that the science experience of females in schools and society may be a factor of this effect on the PSTE belief (Riggs, 1991). It was found there was no statistical difference between genders on their STOE belief, which was a similar finding by Mulholland et al. (2004) and Riggs (1991). It could be surmised that irrespective of gender the STOE is impacted greater through teaching experience rather than science education experience.

The preservice teachers’ prior learning experiences also directly influenced the type of science learners students had become, ranging from fearful through to enthusiastic learners. The findings suggest that those who were successful and enthusiastic learners also continued in tertiary science studies. The finding echoed that of Bleicher (2009) who found fearful science learners were the least confident in their ability to learn science. This was also demonstrated in the findings whereby participants who were low in their PSTE and STOE scores, had expressed a lack of science confidence in the group discussions, didn’t have good prior science learning experiences and degrees in areas other than science. Some of these participants verbalised their fear and used words such as “anxious” and “worried” when discussing how they felt about science. However, these participants had the greatest increase in their post PSTE
scores, even though these results remained the lowest of all groups. These findings can be explained using Bandura’s (1977; 2012) theory that an individual’s performance is strongly affected by an individual’s confidence to perform. In this study the lack of confidence prevailed throughout the semester, and was evident in very little change for STOE values. Conversely, the enthusiastic learners had the highest levels of pre/post PSTE and STOE scores, with the greatest increase in their STOE. This finding supports Bandura’s (1977) argument, that the students’ learning experiences increased their confidence and belief they can make a difference as a science teacher. Mulholland et al. (2004) also explained the higher levels of PSTE and STOE could be attributed to students who were enthusiastic in science as they would also have been successful in their prior experiences of learning science.

Consistent with Bleicher (2009), this study also found there was no significant difference between successful and enthusiastic science learners. As suggested earlier, the enthusiastic science learners were also considered successful in taking science classes, and as such these learners could be grouped together. This study did highlight the need for an additional category whereby there may be a mixture of attitudes and accomplishments towards science on a longer term. This category was labelled ‘not easily identifiable’, and included participants who were representative of an ‘average student’ with a learning type between the two extremes of fearful and enthusiastic. Further study examining this group may lead to a deeper understanding of the reasons for their attitude change over time between attending secondary education and postgraduate education, towards science and their levels of science self-efficacy.

Dewey (cited in Bleicher, 2007) argued that a lack of interest in a subject could undermine an individual’s confidence to learn it. This would suggest that the disinterested group would have the least change in their self-efficacy constructs. Bandura (2012) also commented that self-efficacy will determine an individual’s influence on “regulating their own motivation, thought processes, performance level, emotional states, or altering environmental conditions” (p. 15). Therefore, individuals with low self-efficacy may sabotage their own learning through avoidance. However, the findings suggest this group had been engaged and enthused enough during the learning experiences to have a significant attitude and belief change in both their STOE and PSTE results. These findings supported Bleicher (2009), that students
who lack interest should not be characterised by a lack of confidence to learn science. In fact, their data have helped to gain further insights on how these attitudes and beliefs may be influenced through unit design and tutor delivery. These will be discussed later in the chapter.

**Tutor’s background and delivery of science content and pedagogical content**

Many research papers into self-efficacy have looked at a specific factor that influences a preservice teachers’ self-efficacy to teach primary science, and often report whether there was an effect or not (Bergman & Morphew, 2015; Bleicher & Lindgren, 2005; Enochs & Riggs, 1990; Gibson & Dembo, 1984; Lakshmanan et al., 2011; McKinnon & Lamberts, 2013). The findings from this study highlight the importance of looking at a number of factors that affect self-efficacy in combination with each other. Whilst it is easy to look at the data and quickly surmise that one tutor may be better than another tutor, it is imperative that all factors are discussed in combination with each other to give a holistic view across the complete cohort and their tutors.

As mentioned in the literature review, the influence of teachers on their students’ learning is considered paramount. Similarly, the influence of tutors at a tertiary institution is also seen to affect their students’ learning and self-efficacy. Howitt (2007) surmised that the teacher educator is an important influence on the preservice teacher’s confidence towards the teaching of science and attitude towards science. In this study, tutor influence has been placed under scrutiny and measured through the lens of preservice teacher self-efficacy data along with researcher observations and additional anecdotal/contextual preservice teacher data. The data provided by the tutors form a valuable basis and reference points to allow for triangulation in this discussion. It is important to note that the tutor team provided a source of rich background experiences, which further adds complexity to the discussion. Similar to preservice teachers’ previous academic experiences, tutors’ prior learning and teaching experiences affect their beliefs and play a role in how they conceptualise their teaching tasks, decision making and interpretation of their PCK (Thomson et. al., 2016).
Tutor background experiences ranged from very experienced tertiary educators to those that have a couple of years of experience in a tertiary setting, yet may have greater number of years of experience and currency at the ‘coal face’ of a classroom. Further differences in experiences included the number of years some tutors had with scientific or educational research and others with curriculum development. All tutors were experienced educators in various fields and these educational experiences along with their attitudes towards science also added to the complexity.

The rich contextual experiences of a tutor are part of the fabric that makes them who they are and how they teach. Grasha (1994) formulated five teaching styles of expert, formal authority, personal model, facilitator and delegator. However, their study found that teachers would use a mixture of each style dependent on the emotional climate of the class. For example, an emphasis on the expert/formal authority blends created a ‘cool’ emotional climate with little expression of emotion or dialogue between tutor and student. In contrast, a ‘warmer’ emotional climate would be created with a blend of expert/facilitator/delegate types, whereby there is greater interaction between tutor and student with sharing of information. The findings highlighted that it was the latter blend that was most common among the tutors in this unit. This may be an area for further research to investigate the five styles and their impact on student self-efficacy.

Cripps Clark and Groves (2012) argue that the teacher’s purpose and roles are inextricably bound to their identity and their emotions and that it is not enough to only address content knowledge, pedagogy and pedagogical content knowledge. The level of complexity increases with the increased number of tutors required to teach across many tutorial groups within the same unit. Therefore, this also provided a rich source of data to allow for multiple comparisons and for a deeper investigation into similarities and differences that may affect the preservice students’ self-efficacy. Most of the similarities are obvious, yet the differences observed were at times very subtle. This must be kept at the forefront of thought when reading through the following section of this chapter.

There are a number of different factors involved within any teaching domain, with Howitt (2007) expressing that science teacher educators are required to be role
models. They must be passionate about the learning area of science, create positive and supportive learning environments, be approachable to their students, and model effective teaching and learning strategies that have been ‘trialled and tested’ (Petersen & Treagust, 2014; Rice & Roycoudhury, 2003). Science teacher educators must also see the need in providing assistance to preservice teachers to locate and use resources that are based on significant educational research to teach primary science (Hackling, 2014; Skamp, 2014). Resources such as Primary Connections were used in the unit, as these provided a source of support to preservice teachers, and have been found to positively impact teacher science self-efficacy (Hackling, 2014; Petersen & Treagust, 2014; Skamp, 2012). This will be further discussed later in the chapter.

All tutors demonstrated a passion for science, with most tutors leaning towards the biological sciences as their most preferred area of study. However, as they were experienced all round teachers of science, they also had further content knowledge in other science understandings as well. The depth of knowledge in the other science areas seemed to be determined by prior teaching levels and passion for science in general, which increased their repertoire through professional learning. The tutors that have taught secondary science classes demonstrated a subtle difference in their instruction of science concepts compared to those well versed in primary science teaching, from researcher observations. It could be assumed that the nature of teaching senior sciences leant more towards accountability and critical thinking of science concepts in greater depth, whereas primary sciences leant more towards student engagement with science rather than deep understanding of science concepts. This may have accounted for the complexity of science understanding explanations that were given during tutorials. Some preservice teachers had mentioned they felt that although they were engaged in the activities the science was not explained in depth, and were missing a “piece of the science puzzle”. In contrast others mentioned they found the explanations were “beyond what we need for primary school”, yet did see the benefit of understanding a science concept in depth. Research has shown that subject content knowledge is an important factor of preservice teacher self-efficacy (Chng et. al., 2015; Rohaan, Taconis & Jochems, 2012; Schmidt & Moust, 2000; Velthuis et. al., 2014). This study’s data demonstrated that tutors who were more explicit in teaching the science understandings in depth also had the greater personal science teaching efficacy effect sizes amongst their cohorts. In general, these tutors
also had secondary science teaching experience; however, further research is required
to determine if a relationship between these factors exists.

As mentioned earlier, a positive and supportive learning environment is essential for
influencing preservice teachers’ self-efficacy. Bandura (1977) described the need for
tutors to be aware of reducing high emotional arousal in order to reduce avoidance
behaviour. These behaviours can be based on prior failure, observation of failure
within their learning environment or through negative language by others. Therefore,
it is important this is mitigated in a classroom setting (Tosun, 2000). Research has
shown that in science education, emotions are of the same importance as learning
cognition, as emotions set the tone for the learning environment (Belloccoli et al.,
2013). It was found that the emotional arousal of the tutors related to their
pedagogical styles with negative emotions associated with direct transmission styles
and positive emotions associated with student-focused approaches (Trigwell, 2012).
These finding were also observed in tutorials, where body language and facial
expression of students could be interpreted as ‘boredom’ or ‘elation’. Some avoidance
examples included: students turning to their mobile phones (held on laps); working on
assessment rather than task at hand; turning away from the tutor whilst the tutor was
explaining scientific concepts; or avoiding involvement in class discussion about an
activity. Positive emotions included shrieks of ‘wow’, clapping of hands and animated
facial expressions in forms of smiles, which could be interpreted as a student having a
‘Eureka’ or ‘light bulb’ moment when a misconception was challenged and changed
through experiential activities. Tutors in this unit demonstrated their teaching
experience and skills in being able to ‘read’ the students’ subtle emotional levels, and
change activities or discussions accordingly. Hargreaves’ (2000) argument that strong
emotional bonds between teachers and students influence high-quality learning holds
steadfast in this research. Hargreaves (2000) also reported that at tertiary level of
education the relationship between professors and students had a larger professional
distance due to less frequent exchange between the two parties and larger class sizes.
In this study it was seen that those tutors who were present more often on campus or
taught across a range of units that the preservice students also took, also had increased
interaction with them. The observations showed this led to greater familiarity with
each other, allowing students to be more willing to ask for assistance, and provided a
more relaxed teaching environment. It also allowed one tutor to make specific links
between units that are being taught concurrently, thereby broadening the preservice teachers’ pedagogical content knowledge. The supportive nature of the tutors was beneficial to all preservice teachers, in particular to those with low self-efficacy. Research has shown these preservice teachers need on-going encouragement to see themselves as teachers of science as not all have had positive prior experiences with science (Menon & Sadler, 2016; Velthuis et al., 2014).

Howitt (2007) described that learning environments need to be positive and supportive which would allow students to minimise their anxiety and encourage freedom to experiment and discuss their opinions. Data from preservice students’ anecdotal feedback suggested that the majority had experienced very positive emotional learning environments, with only a small number of individuals mentioning they had not experienced a ‘safe’ learning environment. These students found it confronting to be called upon to give answers in front of the whole class, which made them feel uncomfortable with their level of science content knowledge. The characteristics of the tutors that preservice teachers and the researcher observed, were triangulated with the tutor self reflections, and supported Howitt’s (2000) research they possessed enthusiasm, passion for science, used humour, were approachable and friendly. These characteristics made the tutors central to the teaching experiences (Howitt, 2007).

Chng et al. (2015) proposed that effective tutors possess qualities, such as appropriate domain knowledge; empathic attitude towards their students’ learning; and able to articulate in a manner that is easily understood by their students. Many students commented that their tutor “wanted us to succeed and not fail”, “used appropriate language that I could understand” and that “the tutor was knowledgeable and made the science engaging”. The findings in this study also supported Schmidt and Moust’s (1995) notion that tutors who are socially congruent created a learning environment in which students were encouraged to participate and exchange ideas, thereby allowing students to construct new knowledge.

Harnessing the preservice teachers’ emotional and intellectual commitment to science would also increase their motivation to participate in the teaching of this subject area (Cripps Clark & Groves, 2012). Therefore, it could be assumed that explicit
modelling of a positive emotional climate is paramount to the improvement in preservice teachers’ self-efficacy leading to success of future science teaching. Tutor related behaviour allow for the development of positive partnerships, which has an influence on the willingness of students to engage in constructing new knowledge (Chng et. al., 2015); although Watters and Ginns (2000) suggested that tutor behaviour didn’t have an effect. However, Watters and Ginns (2000) posit that a positive and supportive learning environment should model a culture of learning science, and that both teaching of science and science content knowledge is valued. Findings from this study indicated that emotional arousal was managed, and the general cohort experienced positive learning environments that engaged them, which led to supporting their self-efficacy. Comments such as “it was fun”, “the tutor was knowledgeable and approachable”, “I love the interactive nature between the tutor and student; and the use of humour”. The vignettes demonstrate a positive emotional environment was achieved. For a deeper investigation into this assumption, further specific research into the relationship of emotional climates and preservice teachers’ self-efficacy will need to be conducted.

Positive science experiences are also developed from providing authentic teaching methods concentrating on student centred cooperative learning activities, and making strong connections with prior knowledge, supported by continuous feedback to all development of science and pedagogical content knowledge (Howitt, 2007; Rice & Roychoudhury, 2003; Watters & Ginns, 2000). These experiences are important in the development of PCK (Appleton, 2003; Velthuis et al., 2014) along with providing science content to develop efficacy in personal science teaching efficacy (Thomson et al., 2016). The findings from this study indicated that some of the tutors provided the feedback directly to their students during small group discussion, or through anonymous questions posed at the end of the lesson. These questions were answered at the commencement of the following tutorial; therefore, minimising anxiety of an individual to ask in a larger forum. Many preservice teacher participants also mentioned the amount of constructive feedback provided on assessments was greater than expected and were able to reflect on it and improve in future assessments. The outline of the unit ensured that the student centred approach was at the core of its design. This will be discussed later in the chapter.
Further to the literature review, Howitt (2007) posits that PCK is made up of various factors including science content knowledge, science pedagogy, science activities, investing scientifically and children’s view of science. However, the development of PCK increases with the teacher’s own teaching science experiences, as it draws on science knowledge, curriculum, pedagogy and how children learn; it is built on a repertoire of success with science content placed in pedagogical contexts (Appleton, 2003; Appleton & Kindt, 2002; Cahill & Skamp, 2003). Kind (2009) sums up “pedagogical content knowledge (PCK) is a concept that represents the knowledge teachers use in the process of teaching” (p. 170). As such it could be surmised that increased teaching experience together with knowledge may also develop intuitive PCK whereby some strategies become second nature (Burke & Sadler-Smith, 2006; Sadler-Smith, 2008). Intuitiveness in teaching could be described as “a process in which instructors efficiently code, sort and access experientially conceived mental models for use in making instructional decisions” (Burke & Sadler-Smith, 2006, p. 172). Teachers are able to easily and effortlessly implement solutions to immediate classroom problems on the spot (Burke & Sadler-Smith, 2006). Findings from this study indicated this may be the case, as tutors demonstrated and used a large number of pedagogical strategies but were not always observed being explicit in their instruction of the strategies or pedagogical theories they were using.

The explicitness was determined by the feedback received from preservice teachers and triangulated with tutor self-reflections. Self-reflections by the tutors demonstrated they were able to articulate which pedagogical strategies and theories they used during tutorials. As the researcher also has teaching science experience, the distinguishing of pedagogical styles and theories were observable; however, preservice teachers without teaching experience would find it subtle or indistinguishable and did not provide feedback on all the strategies that had been employed. Examples from researcher observations included one tutor’s use of Bloom’s taxonomy of questioning techniques (Stanley & Moore, 2013) to ensure student critical thinking, yet did not explain to the students how the questioning styles would benefit them as a teaching strategy for science teaching. Another tutor often employed inquiry style learning in their tutorials whereby there was minimal interference with the students in order for them to critically think about how to conduct an investigation; yet this tutor did not make it explicit about this teaching
strategy nor the science content knowledge, therefore data for this tutor’s showed that students in this cohort did not have a large change in pre and post self-efficacy scores in both STOE and PSTE. Conversely another tutor was explicit with both the science content knowledge and pedagogical strategies that were being used, which may have resulted in the data demonstrating a higher level of change for STOE and PSTE for their tutorial cohort along with a greater number of teaching strategies identified by the preservice teachers. Therefore, it is paramount that tutors need to be mindful of ensuring that their teaching strategies are carefully reflected upon and explicitly instructed to preservice teachers. The development of preservice teacher PCK would also lead to an increase in their science teaching outcome efficacy. According to Howitt (2007) all tutors should endeavour to be a role model to the preservice teacher.

As mentioned in the literature review, mastery experiences are important for preservice teachers’ self-efficacy. As preservice teachers in a GDE-P course have not had practicum prior to attending the unit, vicarious experiences are employed whereby the tutor models PCK skills through meaningful full activities and learning experiences, required for teaching primary science (Palmer, 2006b; Tschannen-Moran et. al., 1998). If the tutors ensure they have clearly articulated and explicitly modelled these skills, the observer (preservice teacher) can more readily identify with the model and this has been shown to impact self-efficacy (Tschannen-Moran et. al., 1998). Again the findings of the study have shown that tutors who were more explicit in their modelling also had a greater effect on their preservice teachers’ self-efficacy.

As discussed earlier, inquiry science teaching is common practice among the tutors; however, research has shown that often this style of teaching is new to most preservice teachers. This style of teaching required the tutor to be nurturing, requires explicitly modelling, reinforce learning and taking small steps (Avery & Meyer, 2012) in order for preservice teachers to grasp the nuances of this teaching strategy. In a similar fashion the design of Bybee’s 5E’s instructional model used in this study, would also require the same expectations from the tutors. As there are no primary school children involved in the teaching of the GDE-P unit, vicarious experiences would also require the tutor and preservice teachers to some extent to role-play teacher and students in a primary classroom during activities. The findings showed that some preservice teachers did acknowledge this occurred with comments such as
“we were treated like children”, a couple of tutors did not clearly articulate this as a pedagogical strategy; however, majority of tutors did explain the reason for this. The data supported similar findings by Palmer (2006b) whereby this strategy did assist with improvement of preservice teachers’ confidence to teach primary science activity effectively. It is important that potential problems could arise if this strategy is not explained clearly to the students, as students may find they are not treated as adults, leading to a lower level of respect towards the tutor. This occurred on one observable occasion.

Palmer (2006b) also commented that tertiary educational settings are vastly different to primary school settings, and techniques to motivate and engage adult students may not be as effective with primary children, leading to false expectations of efficacy. The finding in this study suggested the opposite to Palmer’s (2006b) comments, as one tutor successfully used very similar techniques employed during primary teaching to motivate their tertiary students. Therefore, it comes back to the need for tutors to be explicit in their discussions with preservice teachers in conjunction with simulated learning experiences.

Tosun (2000) discussed that collaborative teaching strategies should not be considered only the domain of K-12 teachers, but should become part of the teaching strategies across all education sectors. This use of this strategy would influence teacher belief systems, and positively influence the teaching of science in primary schools (Tosun, 2000). The researcher observed this instructional strategy was employed by a number of tutors who had concurrent classes with mixed feedback from the preservice teachers. The tutors found this strategy very helpful to share resources and knowledge; however, the students found that the overload in a classroom caused discomfort and distracted their learning or “didn’t see the point of doing it”.

Research literature has shown that explicit approaches to the nature of science instruction, has been shown to be effective for engaging and development of understandings (Akerson, Abd-El-Khalick & Lederman, 2000; Bell, Matkins & Gansneder, 2011; McDonald, 2010). In the context of the Bell et al. (2011) study, the nature of science refers to the key ideas and principles that underpin science
understanding and a way of knowing, which sets it apart from other modes of knowing; it includes scientific literacy and the literacy of science. Bell et al. found that preservice teacher participants who had experienced explicit instruction were able to apply their nature of science understandings “appropriately to novel situations and issues” (p. 414). This would lead to increased level of confidence with preservice teachers’ personal science teaching efficacy. Conversely, implicit instructional approaches were underpinned by the view that the science understandings would solely be developed through inquiry based teaching, without the need for explicit science instruction, and were found not to be successful in developing the nature of science views (McDonald, 2010). Abd-El-Khalick and Akerson’s (cited in McDonald, 2010) research also found that explicit teaching did not result in all learners improving their nature of science understandings. This study would support these findings as not all participants increased in their PSTE scores, but also decreased in their scores. To suggest causality, the relationship would need to be investigated with further research conducted in tutor explicit teaching and preservice teacher self-efficacy outcomes.

As mentioned earlier, there are many factors in a tutorial that affect the effectiveness of tutors’ influence with preservice teacher self-efficacy. As a team of tutors the effectiveness of their tutelage was considered to have had medium effect on the students’ PSTE and STOE. Within these results there was disparity among the tutors, which need to be explained in conjunction with other data to determine tutor effectiveness. For example, the findings demonstrated one tutor had a very small effect on their students’ STOE; yet this group, compared to other tutor groups, also had the highest percentage of fearful learners and the highest percentage of successful and enthusiastic learners. The peer interaction of these extremes may also affect the efficacy outcomes, with at least a third having a negative change in their STOE scores. It could be surmised that in this group may have had decreased emotional climate due to the micro processes of interaction including gestures, univocal discourse, prosody (Hargreaves, 2000) of the more enthusiastic learners effect on the fearful learners, and therefore, the subtleties of pedagogical instruction may not have been clear. In contrast, this group had approximately two thirds of the group returning a positive change in their PSTE scores. It could be surmised that the tutor facilitated a rich discourse of scientific concepts by enthusiastic and successful learners, which in
turn had a positive effect on the fearful learners by increasing their science content knowledge. This tutor must have also been engaging in their teaching approaches to elicit the greatest positive change for STOE in the disinterested science learner group and the greatest change for PSTE with the fearful science learner group. The anecdotal data from preservice teachers suggested this tutor was very knowledgeable in science content, effectively modelled science teaching strategies, used humour and personal anecdotes to further explain concepts. Preservice teachers also identified this tutor often used a transmission style of teaching. The data also revealed these preservice teachers felt they realised how much science content they did not know or had misconceptions about, which could have led to another reason for the very small STOE effect and medium PSTE effect.

Conversely, the combination of factors for another tutor demonstrated a medium effect on the preservice teachers’ STOE belief and a moderately large effect on their PSTE belief. This tutor’s cohort had a low number of fearful type science learners but over a third were disinterested type learners and a third a combination of successful and enthusiastic learners. This combination could be considered difficult to engage in STOE outcomes; however, the medium effect size would suggest this tutor’s approach to pedagogical content knowledge instruction was engaging and explicit. Preservice teacher feedback suggested this tutor demonstrated passion for science, was explicit in their teaching of both content and teaching strategies, and employed relatively low amount of transmissive teaching strategy. Further data showed that over 70% of the cohort had a positive increase in both the STOE and PSTE scores and the lowest negative change compared to other tutor groups. The greatest change occurred in the scores of the disinterested learner group for the STOE and fearful learner group for the PSTE. This would suggest that explicit and in depth science content instruction was performed in a manner, using language that was not confronting, complicated and easy to follow.

The preservice teacher data supported Bandura’s (1986) notion that potency of social persuasion, such as performance feedback, is dependent on the tutors’ trustworthiness, expertise and credibility. These characteristics were commented on by preservice teachers and provide a strong basis of tutor requirements for effective instruction.
In summary, for tutors to be able to give effective PCK instruction there must be explicit instruction and depth in science content and science teaching. This must be performed through explicit modelling of attitudes, values, beliefs and assumptions about science teaching and learning (Rice & Roychoudhury, 2003) to affect a positive outcome of preservice teacher self-efficacy. Tutor characteristics that were found to affect self-efficacy in a positive manner included building of personal relationships, passion for science, knowledgeable in both science content and science teaching strategies, and being approachable to their students. Intuitive teaching was found to be least effective and the researcher would recommend that part of the design of the unit is to provide explicit instruction in relation to pedagogical content knowledge required to be discussed and modelled in the tutorial context.

**Overall design of the GDE-P unit as a factor of self-efficacy**

The design of the unit was discussed in Chapter Four; however, the impact of this on the self-efficacy of preservice students to teach science will be discussed in this section. The design allowed for tutors to apply a variety of teaching practices within a framework of hands-on, collaborative and constructive activities. The design of the unit allows for mastery experiences (Bandura, 1977; Bandura, 1997; Bloom, 1984; Mansfield & Woods-McConney, 2012), as well as vicarious experiences (Bandura, 1997; Mansfield & Woods-McConney, 2012; Palmer, 2006b), to further enhance preservice teacher self-efficacy.

Bleicher (2009) discussed the phases of the learning cycle as exploration, invention, identification and clarification of concepts on the impact of the various types of science learners. Through observation these phases appeared to be subtly included in the design, with one tutor using this cycle explicitly with their cohort. As this was subtle, preservice teachers did not comment on the learning cycle as a teaching strategy they observed. According to Menon and Sadler (2016), the involvement of explicitly taught learning cycle would also benefit the students’ self-efficacy.

Many preservice students provided explicit descriptive feedback on how the unit’s activities assisted with the improved learning of science content and/or pedagogical content knowledge. The students claimed these activities demonstrated how science
could be made contextual and applicable to teaching primary students. In addition, the students underscored how important science education was for improving global scientific discourse. These findings were similar to the literature (Avery & Meyer, 2012; Howitt, 2007; McKinnon & Lamberts, 2013; Rice & Roychoudhury, 2003), whereby the improved understanding was a key factor to increased confidence in the subject content and perceived science teaching. The incorporation of activity and inquiry based science learning experiences were found to be imperative to improved confidence of preservice teachers (Petersen & Treagust, 2014) as their interactivity with ‘realistic’ activities through the lens of a primary school student allowed them to interact with science in meaningful learning environment (Howitt & Venville, 2009).

The use of easily accessible materials for the activities seemed surprising to many preservice teachers; for example, the use of ice-cream tubs and plastic cups instead of glass measuring beakers, or the use of the Sun as a source of heat, rather than a Bunsen burner or stove. Many preservice teachers had experiences of senior secondary science, and therefore their memory was heavily influenced by the materials and equipment used at these levels. The use of ‘everyday’ items also ensured science was made contextual to primary school students, and this notion was found to be influential to the increased confidence of teaching science, which is consistent with the notion of mastery experiences being integral to efficacy beliefs (McKinnon & Lamberts, 2013; Woolfolk Hoy & Burke Spero, 2005). This made science more accessible, with students mentioning how easy and fun science could be.

In line with literature (Howitt & Venville, 2009; Palmer, 2006b), the use of role-play as a teaching and learning strategy was also incorporated with success. This provides an opportunity for preservice teachers to re-engage in science and re-experience curiosity of science from a primary student’s point of view (Petersen & Treagust, 2014). Preservice teachers reported they benefitted from this experience to make abstract concepts concrete, and found the joy of learning science again through this.

The use of activity and inquiry based science teaching was achieved through workshop style delivery. The results from this study were similar to McKinnon and Lamberts (2013), whereby the majority of preservice teachers identified the tutorial style as beneficial influence to their motivation, confidence and self-efficacy to teach
science. A small number of preservice teachers found that the length of the tutorial attributed to an overload of information, and would have preferred a short lecture on pedagogical theories, coupled with a practical tutorial to demonstrate and experience the theories. In all cases, collaborative and constructivist tutorials were paramount to their science learning. Literature suggests that workshop activities positively influences science teaching efficacy, including specialist activities such as planetarium, museum and science centre visits (McKinnon & Lamberts, 2013). As this unit is over a short 10-week period, these informal education sector activities are not possible to be integrated; however, specialists in a field could be invited as guest speakers during tutorials.

The incorporation of deep learning, as described in Chapter Three, was provided through the first assessment that offered students an in depth insight into a sustainable STEM project that built their scientific knowledge through critical thinking, together with providing an opportunity for microteaching of the concepts. Although preservice teachers reported they initially found the assessment very difficult, frustrating and time consuming, they did see the benefits of the assessment when it was completed. The use of analytical problem solving in a meaningful and contextual environment is considered integral to deep learning approaches (Bergman & Morphew, 2012; Gordon & Debus, 2002) as this style promoted learning through stepping through varying levels of cognitive complexity (Biggs & Tang, 2011). Similar to Avery & Meyer (2012) study, preservice teachers employed entire scientific process from designing the STEM device through to completion, whilst concurrently investigating the science required for understanding. The deep learning approach could have beneficial impact on preservice teacher PSTE as this may be enhanced through resolving difficult situations (Gordon & Debus, 2002); whilst executing the assessment employing skills, such as critical thinking, problem solving, difficulty and understanding the ambiguity of science (Avery & Meyer, 2012; Volkov & Volkov, 2015). Gordon and Debus (2012) posit that facilitating the development of deep learning approaches during preservice teacher education will produce teachers with better problem-solving capabilities that will sustain their self-efficacy when in the teaching role.

Collaborative learning through teamwork in tutorial activities and assessments were encouraged throughout the unit. A collaborative learning environment is a social
process as students learn by working with other students; therefore, attendance is required for successful learning (Teague & Corney, 2011). Preservice teachers reported these opportunities were beneficial through consistent phrases such as “team work allowed us to problem solve issues together; we collaborated to learning ideas and concepts”, with similar comments echoed in Volkov and Volkov’s (2015) study. Teamwork also allows for a source of deep learning, as a team may create synergy and work towards a common goal (Volkov & Volkov, 2015). As mentioned before collaborative learning was encouraged; however, the researcher’s observations and preservice teacher feedback noted this was difficult for some students due to: location, part-time nature of their study, and other challenges such as balancing study with having young families, all which resulted in time constraints on teamwork. Some students with perceived low-level science knowledge found they benefited from those who had a specialist science background (for example, a geologist or engineer in the same tutorial). This could lead to further issues arising such as plagiarism, unfair distribution of work or one team member benefitting greater than another (Teague & Corney, 2011). Therefore, it is essential that primary-science teacher lecturer and tutors ensure explicit instruction of the nature of collaborative learning theory, whereby it sets an “environment where students have a stake in each other’s learning” (Teague & Corney, 2011, p. 1242). Bandura (2012) considers this as exercising collective agency, whereby to the collaboration performance depends on interdependent efforts, which contributes to a collective efficacy of the group’s productivity.

Assessments were designed to ensure preservice teachers attended the tutorials, which in turn created an environment of engagement in the subject. In previous years, students were able to attain a pass in the unit by completing the assessments and not attending the classes. This model wasn’t aligned with the philosophy of the unit, and may have also affected the preservice teacher’s self-efficacy to teach primary science. Literature has shown that attendance and engagement are integral to improvement of mastery and vicarious experiences as they strongly influence science teaching efficacy (Mansfield & Woods-McConney, 2012; Petersen & Treagust, 2014; Rice & Roychoudhury, 2003). There was a small minority of preservice teachers who stated they didn’t enjoy the “forced attendance”; however, the majority believed this increased their engagement with the unit, allowed for development of networks with
other students and with the staff, and was beneficial to their learning. This may be an indicator of self-efficacy level as Bandura (2012) posits that those with low self-efficacy tend to struggle with any perceived institutional impediments and find that their efforts are futile, hence not wanting to engage; whereas those with high self-efficacy will problem solve and continue with high efforts.

Research has demonstrated for improved self-efficacy for primary science teaching, a preservice teacher science education course needs to be designed to include science subject content along with science pedagogical content (Bergman & Morphew, 2015; Palmer, 2006b; Watters & Ginns, 2000). This study confirmed the literature that for the design of course to effectively influence preservice teacher science self-efficacy it needs to include: an inquiry approach, extensive hands-on activities, group investigations, contextual and relevant primary classroom activities, tutors’ modelling teaching techniques and an environment that emphasises success and fun (Palmer, 2006b; Rice & Roychoudhury, 2003, Watters & Ginns, 2000). Similar to Menon and Sadler’s (2016) research, it was found that preservice teachers with low self-efficacy benefitted from hands-on inquiry based learning experiences to support their subject content understanding where the higher self-efficacy preservice teachers’ pedagogical content understanding was supported.

The design of the unit included the use of the Australian Academy of Science’s Primary Connections programs to demonstrate to preservice teachers that programs are in place to assist with their future primary science teaching. The use of these professional learning and curriculum resources during the tutorials have supported the notion by Hackling, Peers and Prain (2007) that these programs provide a positive impact on preservice teachers’ self-efficacy. Preservice teachers found these resources easy to use and provided scientific content they could use immediately, without the need for extensive research in science content they consider themselves to be not familiar enough with; therefore, allaying their concerns with teaching science in a constructivist manner. Some students found there to be too much reliance on the use of Primary Connections programs during tutorials and would have preferred to be exposed to other resources during all the tutorials.
The results of this study provided evidence that preservice teachers experienced positive changes through the design of the unit. This further confirms that the design of the unit has been developed through research informed practice.

**Preservice teacher identified factors influencing science self-efficacy**

This study has highlighted a multitude of factors that influence preservice teacher self-efficacy. As mentioned earlier, most research investigated one aspect as a factor of self-efficacy to teach primary science. However, as Bandura (2012) articulated that self-efficacy is made up of various factors, which can be manipulated by an individual to “create environments that enable them to exercise better control of their lives” (p. 12). As such, factors that preservice teachers identified themselves should also be taken into account when discussing their overall changes in self-efficacy. These factors may negatively or positively influence their self-efficacy. For example:

- Sense of entitlement;
- Peers;
- Social media;
- Mid-year intake; and,
- ‘Outside’ influences.

**Sense of entitlement**

This theme derived from comments made by preservice teachers in focus group discussions. Entitlement could be defined as a pervasive sense that one individual should be entitled to more than someone else, and to have an expectation of special treatment without reciprocation (Lessard, Greenberger, Chen & Farruggia, 2011). This has been found to be an increasing phenomenon whereby “individuals believe they should get what they want, when they want it, often without the regard for the well being of others” (Fisk, 2010, p. 102) and negative feedback could lead to “retribution, which may include retaliation, disengagement and turnover” (Fisk, 2010, p. 102).

Discussions during this study’s focus groups were directly related to what they (the preservice teachers) perceived they should be provided with from the tutors and the unit plan. Singleton-Jackson, Jackson and Reinhardt (2010) found tertiary students
initially arrive with an expectation of being able to voice their opinions and have a significant degree of control on their learning experiences. Findings from this study found that participants believed tutors should be:

- Engaging;
- Knowledgeable;
- Ensure that all students passed their assessments;
- Given a complete ‘how to teach science toolkit’;
- Provide a step by step guide or template for assessments; and,
- Provide examples of previous students’ work to guide their outcome.

These are similar findings to Fullerton’s (2013) study, which reported that students believed they are customers or consumers of a university, and as such “expect to get quality in service because of the high price they pay for college” or “have the right to go elsewhere for better service” (p. 32). The notion of being a customer sets expectations on the role of the student, classroom environment and the teaching staff (Fullerton, 2013).

Fullerton (2013) also reported that students expected the “professors to ‘give’ grades to students who were experiencing personal or medical issues outside of class” (p. 35), which echoed comments that tutors required to demonstrate empathy when marking assessments. Comments such as these could be considered as exploitive interactions and expectations of special treatment as a form of exploitive entitlement (Lessard et al. 2011). Preservice teachers in this study commented that the amount of time spent on an assessment didn’t equate to the mark they believed they deserved. This could be classified as non-exploitive entitlement as it relates to self-worth and fairness (Lessard et al., 2011). This non-exploitive entitlement of self-worth reflects directly back to self-efficacy factors, where those that have expressed negative self-worth in their assessments have also reported lower self-efficacy. As mentioned earlier disengagement and turnover were ways in which individuals could retaliate with negative feedback; however, as tutors gave constructive feedback this assisted them in their self-belief and confidence.
As mentioned earlier, many GDE-P students have rich workforce backgrounds, which included lawyers, medical staff, geologists, nutritionists, psychologists, human resources, as well as secondary teachers and tertiary academics. Many of these have been in positions of leadership, and as such would have worked under time critical stressful situations, whereby they may have had support from various other staff. As such the researcher believes that similar support demands could also be made upon academic staff. The GDE-P students’ expectations would be different to those directly out of secondary education where the teacher student relationship would be seen to have disproportional with the teacher having a higher role than that of the student. The role within the GDE-P tutor student relationship could be seen to be proportional on professional level, and disproportional towards the student who believes that, as they are the consumer, the tutor is held more accountable for the students’ success (Fullerton, 2013). Bandura (2012) stated that individuals might not have direct control of environmental determinants, and therefore exercise proxy agency, whereby they influence “others who do have resources, knowledge, and means to act on their behalf to secure the outcomes they desire” (p. 12).

The researcher would argue that over indulging the students’ expectations by providing them too much detail would also reduce the need for critical thinking, which is a skill imperative to effective teaching (Avery & Meyer, 2012; Gordon & Debus, 2012; Volkov & Volkov, 2015). This factor as an influence on self-efficacy is an area that requires further research to determine its validity.

**Peers**

As mentioned in the literature review, research has demonstrated that peer support is an important factor of self-efficacy. Bandura (1977, 2012) discusses the triadic nature of self-efficacy, whereby self-efficacy is also developed through social modelling and social persuasion. In this study participants commented on the perceived benefit through small and large group discussions with their peers in relation to science concepts and pedagogical concepts. Some participants found they were “not the only ones” who were experiencing difficulties and became more perseverant in dealing with these difficulties with support from their peers. They found that their content knowledge improved or broadened by discussing and observing peers that were more versed in other content knowledge and therefore increased their belief in their own
capability (Bandura, 2012). Similar to the sense of entitlement, peers could be considered a source of proxy agency (Bandura, 2012) for understanding. In this case individuals may exercise collective measures to pool their knowledge, skills and resources to affect positive change for their future (Bandura, 2012).

**Social Media**

A large amount of literature exists in relation to the use of social media in tertiary education. With the prevalence of the use of social media as a communication tool (Hew, 2011; Rowan-Kenyon et al., 2016) it is also a factor that may affect students’ self-efficacy. Research has shown that use of social media could influence the academic standard of the user (Kirschner & Karpinski, 2010) and may have both positive and negative effects on the learner (Rowan-Kenyon et al., 2016). Participants in the focus groups suggested that social media was a component of their self-efficacy; however, many did not interact within this group. Those that did use the social media found they often became confused through conflicting information from various other users, which increased their anxiety levels and decreased their confidence in understanding the requirements for assessments. In turn this could have affected their self-efficacy. However, the researcher believes this finding has isolated an alternative source of influence on self-efficacy of a student, and its impact on self-efficacy for teaching primary science would require further investigation.

**Mid-year intake students**

This study highlighted the need for students to experience foundations of education in general prior to attending subject specific units. The preservice teachers who were a mid-year intake student believed they were “missing valuable information” about the complexity of teaching and learning; the general education unit was offered in the first semester of the year only. These participants found the educational language used difficult to understand at times, and did not have the basis of learning and teaching theories to build on in a science-teaching context. The study found these students also had a lower STOE score, which indicates the level of self-efficacy is lower due to anxiety from a factor outside of the primary-science unit.

**‘Outside’ influences**

Many of the preservice teachers in the GDE-P unit did not enter the course directly after completing their Bachelor degree, and hence, were returning to study after a
period of time. Outside influences were defined as factors such as family/household and concurrent work constraints. These influences impacted on the amount and quality of time students had to study, and as such, also affected their anxiety levels. Similar results were found in a study by Collins, Hay and Heiner (2013), who found that students who were parents also indicated that their learning experiences, in short intensive courses, were more difficult than expected due to similar constraints. A number of participants who spoke about outside influences were the same as those who seemed to have a sense of entitlement. Therefore, it could be assumed that time poor students would require/demand greater input from the teaching staff to scaffold assessments, which subsequently reduces the amount of time they had to spend working on them. Again the anxiety levels were seen by the participants to affect their self-efficacy, and in particular their PSTE. This study has highlighted the need for further research into how influences outside the learning environment could also affect an individual’s self-efficacy into learning and teaching primary science.

**Chapter Summary**

This chapter discussed both the quantitative and qualitative findings together as related to the research questions:

1. What are the preservice teachers’ science teaching efficacy beliefs pre and post intervention?
2. To what extent does a tutor’s teaching of the GDE-P Science unit’s science concepts impact preservice teachers’ self-efficacy constructs?
3. To what extent does the tutor’s modelling of GDE-P Science unit’s pedagogical content impact preservice teacher’s self-efficacy?
4. How did the preservice teachers perceive the design of the GDE-P Science unit influence their self-efficacy in primary science teaching?
5. What perceived factors in the GDE-P Science unit did the preservice teachers believe would enhance their science and pedagogical content self-efficacy?

The first research question asked about comparison of science efficacy beliefs prior to and post intervention. It was found that the demographics and prior science learning background of preservice teachers were factors that influenced their self-efficacy in science. The level of influence each factor had was dependent on the positive or
negative science learning experiences preservice teachers had in secondary science education rather than primary science education. Many students in the cohort did have a positive experience in secondary science education, whilst others mentioning they had positive changes in attitude towards science influenced through life experiences. Irrespective of the preservice teachers’ science learning background and further educational experiences, the overall effect of the intervention was an increase in both STOE and PSTE beliefs.

The second research question was about investigating the teaching of science concepts and measuring the effect of individual tutors on preservice teacher self-efficacy to teach primary science. It was found that all tutors had a positive effect on preservice teacher self-efficacy, however, individual tutors had varying effects on both the STOE and PSTE constructs. The effects ranged from very small (Cohen’s $d = 0.11$) to medium effect (Cohen’s $d = 0.50$) for STOE and very small (Cohen’s $d = 0.11$) to medium large (Cohen’s $d = 0.62$) for PSTE beliefs. These findings indicated that the tutors possessed advantageous characteristics, were knowledgeable at their level of expertise and the variation of effect size was greatly determined through level of explicitness when teaching.

The notion of explicit teaching was closely linked to research question three, whereby the modelling of pedagogical strategies and theories were also required to be more explicit for preservice teachers to benefit their STOE beliefs. The findings suggested that the teaching of science experience of tutors is also an important factor to consider, as there seemed to be a difference between intuitive and explicit teaching methods. For both research question two and three, it is important to note that tutors impacted the fearful and disinterested learners in increasing their PSTE belief scores, with two of the tutors also influencing the disinterested learners to increase their STOE scores. These findings would be considered a positive result in the ability to change the negative attitude and confidence towards science in these preservice teachers. The findings also demonstrated there are various factors including building personal relationships with students; demonstrating empathy, approachability and fairness; intuitive versus explicit teaching and modelling; personal characteristics and science teaching background; as well as the preservice teachers themselves; together
impact on the effectiveness of a tutors’ teaching and modelling science content and pedagogical content knowledge.

Preservice teachers participating in the focus groups responded to research question four. It was found that many students were surprised by the interactive, collaborative and inquiry nature of the design, whereby they experienced the science content in a manner that was engaging. The findings also demonstrated that preservice teachers understood the benefit of teaching primary science using a constructivist approach and resources were readily available to assist them as a graduate teacher. The opportunity to reflect on their own science understandings, together with acquiring new knowledge has influenced their self-efficacy to teach primary science. Many commented on being able to identify their own misconceptions through hands on activities and experienced a change in their concept understanding to ensure these are not perpetuated in their future teaching. The findings did show that some students found there was so much information that it may become overwhelming, and this had a negative effect on them; however, others mentioned that this effect would be negated with the support of resources. It was found that students had the greatest improvement in was physical and chemical sciences. The design of the unit concentrated on these areas, as historically these are the content areas of science understandings that are least understood. In addition, the improvement may be a result of the low initial content knowledge of the preservice teachers in physical and chemical sciences. The area of greatest concern with the design of the unit was found to be the interpretation of assessment guidelines and outcomes. The ambiguity is an area that impacted on their confidence, which could lead to negative self-efficacy in understanding of science concepts and teaching strategies.

Finally, research question five asked preservice teachers to identify influential factors on their self-efficacy. The findings indicated that students found tutor modelling of activities, use of anecdotes, making science concepts contextual, along with the nature of the unit design, were amongst the most beneficial for their confidence and understanding. The discussion also focussed on additional factors that preservice teachers had identified that influenced their general self-efficacy. The impact on general self-efficacy may also affect their primary science-teaching efficacy as Bandura (2012) articulated that an individual’s functioning is influenced by the
interplay of their “intrapersonal influences” (p. 11), including their personal
determinants, environmental determinants and behavioural determinants.

The conclusions of this study along with recommendations and implications for future research will be discussed in Chapter Eight.
CHAPTER EIGHT
CONCLUSIONS AND RECOMMENDATIONS

Introduction

The purpose for this research study was to investigate the influence and impact the design and tutors of a GDE-P science unit had on the preservice teachers’ self-efficacy to teach primary science after attending and experiencing this unit. This research was instigated in response to the continuing need to ensure that primary preservice teachers are prepared and self-confident enough to teach primary-science in order to ensure primary students’ attitude and understanding of science is improved. The current trend of Australia’s primary science literacy is such that the country is falling behind other countries in the Asian Pacific region (Martin et al., 2016; Thomson et al., 2017). Understanding the interactions within the tertiary classes will also allow the development of appropriate teacher educators’ professional development, unit design content and activities that are likely to encourage student participation, increased science content knowledge and science pedagogical content knowledge to facilitate an increased self-efficacy (Bleicher, 2009; Bellocchi et al., 2013; Bybee, 2014; Howitt, 2005; Shulman, 1987).

This research was underpinned by Bandura’s (1977) social cognitive theory, which includes the construct of self-efficacy as a product of a triadic reciprocation including environmental, personal and behavioural factors. As the construct of self-efficacy is complex it was investigated using a mixed methods pragmatic paradigm, whereby the pragmatism of using post-positivist paradigm linked to quantitative research methods and interpretivist-constructivist paradigm linked to qualitative research methods provided a source of rich data for analysis. The quantitative method elicited data through administering the modified Science Teaching Efficacy Belief Instrument Form B (STEBI-B) (Enochs & Riggs, 1990) administered to the preservice teachers using a pre/posttest design. The qualitative methods elicited observational data, vignette data from additional survey questions along with rich narratives from preservice teacher focus groups and interviews, as well as interview data from tutors, unit coordinator and laboratory technician. The qualitative data provided a deeper
insight into how the factors influenced each other and provided a basis for understanding the quantitative findings for self-efficacy.

The research topic was investigated through the following research questions:

1. What are the preservice teachers’ science teaching efficacy beliefs pre and post intervention?
2. To what extent does a tutor’s teaching of the GDE-P Science unit’s science concepts impact preservice teachers’ self-efficacy constructs?
3. To what extent does the tutor’s modelling of GDE-P Science unit’s pedagogical content impact preservice teacher’s self-efficacy?
4. How did the preservice teachers perceive the design of the GDE-P Science unit influence their self-efficacy in primary science teaching?
5. What perceived factors in the GDE-P Science unit did the preservice teachers believe would enhance their science and pedagogical content self-efficacy?

Based on the findings and discussion presented in Chapters Five, Six and Seven, Chapter Eight will present the final conclusions of this research. It will also include the research limitations, further recommendations for future research and implications for tertiary education.

**Conclusions and Recommendations**

Reflecting on the research questions, the main conclusions that can be drawn from the data is the need for tutors and course designers to understand:

1. The influences of preservice teachers’ science learning background and learning styles and current demographics to form their attitudes towards science;
2. The tutor’s own demeanour, knowledge and teaching strategies; and,
3. The need for appropriate course and unit design that will meet the mastery and vicarious experiences for increasing preservice teachers’ self-efficacy to teach primary-science.
These conclusions will be discussed under the headings of high level of preservice teachers’ primary-science teaching self-efficacy, tutors’ influence on their students’ self-efficacy and unit design influence on preservice teachers’ primary-science teaching self-efficacy.

Conclusion One: The Influences of Preservice Teachers’ science learning background and learning styles and current demographics to form their attitudes towards science

This conclusion is in response to the first question posed in relation to the preservice teacher primary-science teaching self-efficacy pre/post intervention. Preservice teachers completed a questionnaire which included questions to elicit information related to their demographics along measuring self-efficacy through the administration of the modified Enochs and Riggs (1990) STEBI-B. There were 370 responses to the initial survey, and 277 participants with both pre/post data that could be analysed for self-efficacy. The high initial response rate found that 70% of students participating in the study were female, which was consistent with other research literature. It was also found that the majority of the students came into the unit with a minimum of a year 12 science subject, of which 26% also had an undergraduate degree in a field of science and 7% had a postgraduate degree in science. Although the majority of students had a degree other than science, many students mentioned they had positive learning experiences in most pre tertiary science classes and were excited to come into the GDE-P science unit and ready to learn how teach primary science. This finding was contrary to research literature where most students reported feeling anxious about teaching and learning science (McKinnon & Lamberts, 2013; Mulholland et al., 2004; Palmer, 2006). The overall trend for this research found an increase of self-efficacy in both PSTE and STOE beliefs. The overall STOE increase was small, which could be attributed to preservice teachers having a small increase in the belief that students can learn science under effective instruction. These preservice teachers had a relatively high level of STOE belief to demonstrate their understanding of the importance of a teacher’s role at the commencement of the GDE-P science unit, and this belief was only slightly changed after the learning experiences; whereby it can be concluded that vicarious experiences provided in the unit are not enough to stimulate large changes in the preservice teachers’ expectancies. Similarly, the PSTE scores were also relatively high suggesting these students’ background and
enthusiasm attributed to a positive belief in their ability to teach primary-science, which was slightly increased over the period of GDE-P science unit experience; therefore, concluding that the unit design and tutors had an effect on their beliefs.

Similar to findings by Bleicher (2009), it was found that preservice teacher learning background, type of learner and current demographics were stronger driving forces of the attitude towards science rather than gender. Again supporting Bleicher’s (2009) research, it was found that successful and enthusiastic type learners are similar in their self-efficacy beliefs and can be grouped together. It was also found that the PSTE and STOE beliefs were increased most by the fearful science learning types, and these students appeared to benefit the most from the GDE-P science unit learning experiences. Students who were disinterested also had an increase in their PSTE and STOE beliefs, indicating that the design of the units and tutor’s emotional climate was such that students were engaged and enjoying their learning experiences. It could be surmised that those that had a positive attitude and confidence to science already had a higher level of PSTE and STOE beliefs and this created a ceiling effect whereby any change was marginal. Further anecdotal data had demonstrated that some of these students had believed it would be easier to teach primary school students as they were enthusiastic and confident; however, after attending the unit found that their expectations were unrealistic and that primary teaching was a far more complex than initially thought, leading to a slight decrease in their scores. Hence, the overall results for both enthusiastic and successful learning styles were capped through the ceiling effect, only producing a marginal change in their self-efficacy. It was concluded that the unit design should be engaging and set realistic learning experience expectations for preservice teachers to allow all students to gain a view of what a primary science classroom could be like.

It was also concluded that in order for preservice teachers to feel their self-efficacy is increasing in science, they need to feel that their tertiary education self-efficacy is also addressed. This was demonstrated through some students struggling to re-enter the tertiary education sector after not being in a ‘learning’ situation for a long period of time and others demonstrating their sense of entitlement. Many students had professional careers in which they were often autonomous or a leader and their expectations of receiving university assistance were higher. They felt that the
university should provide explicit details about the unit and science content, so they did not need to research to find information or problem solve. The notion that university students are consumers of the university’s services was similar to findings by Fullerton (2013). Therefore, it can be concluded that postgraduate course designers must take these factors into account, and to ensure that explicit instruction is given on how to re-enter postgraduate learning and clear expectation of what it constitutes to be a postgraduate student.

The research also demonstrated the influence of social impacts on self-efficacy development, including the impact of social media. Consistent with Bandura (1977, 2012) and Rowan-Kenyon et al. (2016), agents such as social media can shape interactions between peers and increase anxiety around learning. Therefore, GDE-P science preservice teachers need to be supported to allay general learning anxiety as well as content specific anxiety through appropriate university structures.

**Conclusion Two: Tutors’ Own Demeanour, Knowledge and Teaching Strategies**

This research was able to explore six different approaches that tutors had in the same context of the GDE-P science unit. Similar to the research by Morrell et al. (2003), the learning environment that preservice teachers had in the various science classes was dependent upon the individual tutor and their preferred pedagogical strategies. Due to the nature of the unit’s design, all tutors used the constructivist theory of instruction and provided vicarious experiences through the use of hands-on activities and modelling. The differences between the tutors became apparent in the emotional climate they set, the varying amount of critical discourse that was provided during learning experiences, the strength in their scientific content knowledge and the explicit teaching of science pedagogical content knowledge.

The effect each of the tutors had on their students’ learning and self-efficacy varied greatly, from some tutors having little effect to others having a medium-large effect in both PSTE and STOE belief constructs. This supports the research of Howitt (2007) that tutors are an important influence on the preservice teachers’ attitude towards science and the confidence to teach science. If preservice teachers’ primary-science self-efficacy is to improve, then tutors must use the most appropriate teaching
strategies to facilitate this with the understanding of the self-efficacies that preservice teachers enter the GDE-P science unit with.

The primary and secondary science teaching background of the tutors could also be a determining factor of their science teaching strategies. Those with predominantly primary science teaching were found to employ pedagogy to engage students and make the learning experience ‘fun’ without the explicit instruction in science content or science pedagogy. These tutors also ‘seemed’ to more-often model the primary classroom, whereby the preservice teachers were the ‘primary school’ student and the tutor took the role of ‘primary school’ teacher (Howitt & Venville, 2009; Petersen & Treagust, 2014), without the explicitness of explaining why and how this became a vicarious experience to learn from; therefore, employing an intuitive teaching style whereby some strategies are second nature (Burke & Sadler-Smith, 2006; Sadler-Smith, 2008). Those with secondary science teaching experience were found to be more explicit in their teaching of both science content and science pedagogy content, as the nature of secondary science teaching is such where there tends to be explicit transmission of science content supported by practical activities; rather than primary science teaching has the hands-on activities constructing the science understandings by the students. The research data had shown that preservice teachers who had tutors with greater secondary teaching experience had a greater increase in their PSTE and STOE; therefore, it can be surmised that explicit teaching strategies need to be used to influence primary-science self-efficacy.

This research also confirmed that emotional climate (Bellocchi et al., 2013) within a classroom is an important factor that tutors influence. The strong positive emotional bonds (Hargreaves, 2000) were evident between some tutors and their students, providing a climate whereby successful interactions were observed and characterised by verbal and non-verbal actions. These included focus of attention, collective laughter and expression of joy during class discussions and activities between both tutors and their students. The tutors’ non-verbal actions of enthusiasm, humour, empathy and approachability were also found to be factors that preservice teachers found as an influence on their self-efficacy, which was in line with Howitt’s (2007) findings. It could be surmised that the behaviour and setting of a warm emotional
climate in the learning experiences by the tutors allowed for the students’ general learning self-efficacy to be increased but not necessarily their STOE or PSTE.

The amount of critical discourse within the learning experiences also allowed for deep learning experiences, and as such should be encouraged to maintain student engagement and deeper understanding of concepts (Gordon & Debus, 2002). The tutors’ ability to articulate the appropriate amount science content knowledge may have also affected the preservice teachers’ PSTE; as those who experienced too much in depth information felt overwhelmed, yet others who didn’t receive enough content felt underprepared, and both could have the same outcome of reduced PSTE. Therefore, it would be important that all tutors are made aware of varying strategies that should be employed and the depth of science content to be taught as part of their learning experiences they facilitate through written communication. This also includes the need for strategies to facilitate deep learning experiences to be explicitly included in the design of the unit.

**Conclusion Three: The Need for Appropriate Course and Unit Design that will Meet the Mastery and Vicarious Experiences for Increasing Preservice Teachers’ Self-efficacy to Teach Primary Science**

The design of the unit attempted to include a variety of science pedagogical theories. These included the social constructivist theory (Bybee et al., 2006) with the use of discussions and hands-on activities to provide inquiry activities; the use of the learning cycle (Bleicher, 2009) during the second assessment; and the use of problem solving for deep learning experiences (Bergman & Morphew, 2012; Gordon & Debus, 2002) of science content and processes during the STEM assessment. The development of problem solving capabilities would enhance not only the PSTE, due to the science context, but also sustain the general self-efficacy to become resilient to problem-solve when in the role of the teacher.

The use of constructivist approaches (i.e., discussions, hands-on activities and cooperative learning) was beneficial in demonstrating year level appropriate teaching activities, but also to assist preservice teachers identify their own misconceptions or alternative conceptions through experiencing the ‘science’ themselves. The use of teamwork for in class activities and assessment investigations also allowed for deep
learning experiences as collaborative learning experiences may create a synergy and support mechanism to work towards common goals (Volkov & Volkov, 2015). This also creates a forum for peer social persuasion, which is an integral part of the development of self-efficacy. It could be surmised that students working in a science context will therefore develop science self-efficacy.

As mentioned earlier, the use of hands-on activities was an integral part of the design of the unit. These activities enabled students to learn problem-solving and critical thinking skills through designing and conducting their investigations. Similar to Avery and Meyer (2012), students were often frustrated in needing to investigate a seemingly easy investigation, with complex possible variables. By the completion of the unit they understood the process of scientific inquiry through engaging first-hand and felt more empowered to teach this to primary students. This provided a vicarious experience of learning scientific processes required to meet the standards as per ACARA (2015) Australian Curriculum: Science inquiry processes. The experience of developing their own STEM project also allowed students to gain some insight into the frustrations that their future students might have when conducting science investigations. Therefore, these experiences formed part of both their science content and science pedagogical content knowledge. To ensure that students appreciated this notion it would be imperative this knowledge was explicitly explained during tutorials. Again these vicarious experiences formed part of the development of science self-efficacy.

From the findings it can also be concluded that preservice teachers who were fearful or disinterested benefitted from the teaching strategies and the primary-science pedagogical theory that were used in the design. These students reported their change in enthusiasm and attitude towards science, and it was found that these experiences had also increased their science self-efficacy. This was in line with findings from Bleicher (2009) and Tosun (2000), whereby preservice teachers reported they found that an increase in science content and pedagogical knowledge was attributed to increased confidence in using a variety of appropriate activities and scientific language. This in turn supports Bandura’s (1977) notion that ‘behaviour’ and ‘personal’ influences in turn affects self-efficacy.
As preservice teachers in a GDE-P cohort have a large variety of science backgrounds, it was important to note that those with science backgrounds were helpful to peer explain the scientific understandings of certain topics, such as geological rock formation. As the design of the unit needs to include primary science content along with primary science pedagogy, there is limited availability to specialised science expertise; therefore, it is important to acknowledge this may be available in a postgraduate teacher education setting, and as such an ‘expert’ in an area may be asked to present to the whole class or create a synergy with industry for an ‘expert’ to assist with science content delivery as a future network opportunity for graduate teachers. This in turn becomes a form of modelling social constructivism within the tutorial context.

As mentioned in Chapter Seven, the exposure to the Australian Academy of Science’s Primary Connections programs have been found to have a positive impact on preservice teachers’ science teaching self-efficacy, which further supports research literature (Hackling, 2014; Hackling, Peers & Prain, 2007; Petersen & Treagust, 2014). Some preservice teachers found there to be too much reliance on the use of these resources and would have preferred to be exposed to a greater range of resources. This may indicate that tutors were not explicit in their introduction to explain the reasons for use of the Primary Connections. However, it can be concluded that continuing exposure to resources have shown to be imperative to create a positive impact on preservice teachers’ science teaching self-efficacy.

Finally, the design of the unit’s assessments was such that students were required to attend the learning experiences from which they drew the required information to complete the tasks. It was found this ‘forced’ participation was well received by most students, especially with those with high self-efficacy and found to be beneficial for preservice teacher engagement in their overall learning of primary-science and relevant pedagogical strategies. Those that seemingly complained about the ‘forced’ participation had low self-efficacy, which was perpetuated throughout the learning experiences similar to Bandura (2012) who posits that individuals with low-self efficacy belief tend to struggle with constraints and diminish their efforts.
In conclusion, these findings confirmed studies by Mansfield and Woods-McConney (2012) and Petersen and Treagust (2014) where engagement in learning experiences increased the preservice teachers’ mastery and vicarious experiences, and along with social persuasive influences from both tutor and peers they worked together to form preservice teachers’ science self-efficacy (Bandura, 2012).

**Recommendation One: Proactive preservice teachers**

For preservice teachers’ primary science teaching self-efficacy to improve, it is recommended they are made aware of the role of a teacher of science along with how self-efficacy is shaped; therefore, they can become proactive in their building of resilience and confidence for their future teaching role.

Throughout the research it was found that preservice teachers who were classed as ‘not easily identifiable’ had greater industry experience or were mature-age students and their ‘learning style’ was found to be representative of an average self-efficacy between the extremes of fearful and enthusiastic science learners. Further investigation into the reason for changes in their attitude to science would be beneficial to further understand postgraduate primary science attitudes and beliefs, and would allow for tutors and unit coordinators to appropriately plan units and how these students are taught.

**Recommendation Two: Tutor training and support**

For appropriate instruction of postgraduate preservice teachers in primary science it is recommended that tutors be provided with some professional learning to be made aware of postgraduate student attributes. By being aware of these attributes tutors can ensure they employ explicit style of teaching to clearly explain science content and science pedagogical concepts. As content knowledge is a factor of self-efficacy it would be recommended that tutors have a strong grasp of all relevant science content, in order to be able to articulate the subject matter in such a way that preservice teachers understand it without being overwhelmed or alternatively be left feeling underprepared. Another area that tutors need to be made aware of is the high sense of entitlement by postgraduate students; therefore, needing to address this notion appropriately through providing explicit instruction and feedback to their students.
Consistent with literature, this research has demonstrated that tutors bring to the learning experiences their unique teaching styles, varying areas of strength in science content knowledge and pedagogical knowledge (Bergman & Morphew, 2015). Giving tutors some autonomy to allow for their individuality could also lead to inconsistencies of information dissemination and varying levels of assessment expectations set. It is recommended that a single source of information along with one set of assessment expectations with clear rubrics be given to the tutors and preservice teachers. To ensure that all tutors have the same assessment expectations, science content and pedagogical content knowledge for a teaching unit, there should be professional development time allocated prior to commencement and prior to marking of assessments. This would still allow the tutors to continue teaching using their unique styles, yet bolster preservice teacher self-efficacy by reducing their anxiety and confusion.

**Recommendation Three: Explicit instruction through unit design**

For preservice teachers’ primary-science teaching self-efficacy to be affected by the unit design, it is recommended that a variety of pedagogical theories be applied to assist with mastery and vicarious experiences within the context of the unit. Although this unit did attempt to use a variety of theories and experiences, these were not always explained explicitly to the preservice teachers. It is recommended that a comprehensive weekly outline be provided to the students of the unit underscoring the pedagogical theories that will be used and that all assessment documents are presented clearly with explicit explanation of required expectations. The inclusion of Bybee’s (2014) suggestion of including an in-depth science investigation, introduction to engineering design (STEM investigation) or study of scientific breakthrough, and science teaching applications in a classroom would be beneficial for preservice teachers’ future teaching. The continuation of providing vicarious experiences through interactive activities would be advocated. Along with the use of one major resource, Primary Connections, it is advocated that alternative sources should also be made available weekly to allow preservice teachers to gain exposure to a variety of sources from which they can choose their level of support they require for their future teaching. These strategies will also work towards appeasing the students’ sense of entitlement.
As limited authentic mastery experiences were facilitated within the GDE-P unit, and research has found this to have significant impact for increasing self-efficacy (Bandura, 1977, 2012; Howitt, 2006), it is recommended that science teaching practicum experiences to be run concurrent with an integrated science teaching course. This would allow for theoretical and vicarious science teaching experiences to be put into practise simultaneously, providing authentic science teaching mastery experiences; alongside providing a forum for reflective and supportive discussion with academic staff and peers that can be used to plan for subsequent teaching lessons. Research by Knaggs and Sondergeld (2015) and Cantrell et al. (2003), demonstrated this form of learning and teaching cycle could be seen to be most beneficial to improved primary science teaching self-efficacy; whereby the preservice teacher is both learning the science and learning to teach the science simultaneously.

**Limitations of the Research**

As this research was an intrinsic case study it provided a deep insight into extensive rich data of a contextual nature; as such the researcher acknowledges that trends can be explored and warns that generalisations should not be made.

One of the limitations was in relation to the collection of preservice teacher focus group data. Although an attempt was made to select participants for specific focus groups based on their pre STEBI-B results, this was found to be difficult to manage due to the large number of tutorials over several days, including the weekend, with the result that participants chose to self-select an appropriate timeslot that favoured them. The GDE-P students participating in the interviews were self-selected volunteers, which is a unique group of participants. The nature of purposive sampling includes acknowledging the risk that only students with strong attitudes towards issues maybe more vocal. While the GDE-P students had strong views regarding most issues discussed, it is also acknowledged that some of these students, by their own admission, had low levels of scientific literacy or high levels of scientific literacy. Therefore, the varying scientific knowledge of the students who volunteered to be interviewed underscores a concern for those with low self-efficacy to opt out of participating in the focus group discussions. As these groups were self-selecting it
also created an inequitable number of participants representing each tutor, and this could bias the data for particular tutors.

Another limitation requiring acknowledgement is the low Cronbach alpha scores for pre and post STOE results. This may be due to lack of mastery experiences such as primary science teaching exposure that preservice teachers had prior to and during the learning experiences in the unit, which may have made it difficult for accurate reflection of the items on the STEBI-B. It may be more appropriate to investigate their general teaching outcome expectancy rather than the science context. In addition to attending the GDE-P science unit participants may also be enrolled in other concurrent classes and practicum, which may also have an impact on survey responses. These concurrent experiences may contribute to measuring general teaching self-efficacy rather than science teaching self-efficacy.

Similar to Bleicher’s (2009) findings, this research also found that students who were categorised as successful and enthusiastic learners were found to be similar in their results, and as such should be grouped together. It was found that not all participants completed anecdotal information in relation to type of learners, and therefore, these questions should be reworded to ensure these are completed. Also similar to Bleicher (2009) it is a limitation of this study that the absence of strong statement of interest from a successful science learner might simply reflect a missed opportunity to express it, rather than an instance of an excellent student who was truly not enthusiastic about science.

**Recommendations for Further Research**

This research has highlighted the need for further research in a variety of areas. With more universities leading towards postgraduate Master of Teaching degrees, postgraduate students bring with them a wealth of life experiences and expectations; research into the self-efficacy of postgraduate learners needs to be addressed to further understand their needs as a learner and how teaching staff support them as learners.
As most research into preservice teacher primary science teaching self-efficacy has occurred within undergraduate education courses, it would be pertinent to complete comparative research between undergraduate and postgraduate teacher education courses to determine if there are differences between the preservice teachers’ science teaching self-efficacy, and the impact of tutors and unit design upon them. Comparative longitudinal studies of primary science teaching between graduates from a four-year undergraduate degree and two-year postgraduate degree, into their in-service primary science teaching may also determine the long term impact of the design and tutelage during their respective university science teaching courses.

As preservice students mentioned varying methods of primary and secondary science learning experiences due to diverse ethnic, cultural and government (such as in Indonesia, Ireland, England, Malaysia and Singapore) backgrounds; future research into these diverse educational and cultural factors may be beneficial to determine their level of impact on primary science teaching in Australia. Subsequently, future research may provide further insight into how to improve Australia’s global results in science literacy.

This research also highlighted social media as a potential factor of impacting self-efficacy on preservice teachers; therefore, research to measure this impact on preservice teachers’ level of anxiety and teaching self-efficacy would also be beneficial in developing strategies to best affectively support preservice teachers.

**Chapter Summary**

**The Significance of This Research**

This research has demonstrated that both unit design and tutors have an impact on the primary science teaching self-efficacy of preservice teachers. The amount of impact varies between tutors, as each are unique in their delivery of content and course material, setting up a variety of emotional climates within their classrooms. It was found that tutors who were more explicit in their explanation of scientific concepts and their use of various pedagogical strategies, had greater effect on their students’
science teaching self-efficacy. Therefore, it could be surmised that explicit instruction is an impacting factor.

Since the 1980’s literature has suggested the need for improving primary science teaching self-efficacy for in-service and preservice teachers in order to be confident in teaching primary science for future improved scientific literacy. In contrast to other literature, this research has shown that the majority of postgraduate preservice teachers entered the unit with a higher level of PSTE, which may be indicative by the demographic results showing that the majority of students completed some form of science up to and including their final secondary education. Similar to other research, this study also demonstrated that the reliability of the STOE construct is lower than the PSTE construct and as such the general teaching outcome efficacy could be measured rather than in the context of science.

It was found from the vignette data that the current design of the unit did have an impact upon preservice teacher science teaching self-efficacy. It provided relevant science content along with science pedagogical content, which allowed for vicarious experiences, contextual mastery experiences but with limited authentic mastery experiences. Through focus group and vignette data, it was found that preservice teachers felt an increase in their sense of confidence about science content and their science teaching self-efficacy, which was attributed to the hands-on practical nature of the unit.

The research has also highlighted the complexity of factors that impact upon postgraduate preservice teachers’ self-efficacy, whereby the general self-efficacy (Roberts & Henson, 2000) as a postgraduate learner has impacted upon their science teaching self-efficacy.

As Lederman and Lederman (2015) mentioned, the profession of teaching is complex and continually impacted by differing contextual and political issues; therefore, it is difficult to have one method of educating future science teachers. Along with this each new cohort of preservice teachers will have differing background experiences, attitudes and confidences. This research has highlighted these, and demonstrated the importance of designing specialised science content units whilst providing both
vicarious and mastery experiences to demonstrate teaching approaches that can be used in future primary classrooms. Therefore, it is important for the current design and delivery to be such to ensure increased self-efficacy in preservice teachers to ultimately provide a basis for their confidence and attitude towards wanting to learn more science and to teach this in the primary classroom.
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APPENDIX A

Information Letter for Student Participants

EXPLORING THE IMPACT OF PRESERVICE PRIMARY SCIENCE EDUCATION ON STUDENTS’ SELF-EFFICACY

Information Letter to Participants

Date 1st July 2016

Dear students

You are invited to take part in a research project that is being undertaken as part of the requirements of a Doctor of Philosophy degree at Edith Cowan University in the School of Education. The aim of the study is to investigate if the structure and pedagogy of the SCE4103 unit has an impact on preservice teachers’ self-efficacy on teaching science to primary school students. The self-efficacy of preservice teachers is based upon people’s beliefs in their capabilities, including the feeling of mastery of both subject and pedagogical content knowledge.

You are invited to participate in this study as it is directly related to the unit you are studying as part of you Graduate Diploma (Primary) of Education. The data from this study will be used for future development of this unit.

Your participation in the study will include completing two questionnaires, one at the beginning of SCE4103 unit and one in the final week. The questionnaires will be conducted during the tutorial classes taking about 15 minutes to complete. These questionnaires will determine any changes in your self-efficacy before and after you complete SCE4103. Additionally, you may be asked if you would like to participate in a follow-up focus group, which will be conducted after the final tutorial. The focus groups would involve sharing your experiences of participating in the SCE4103 tutorials at ECU and experiences prior to entering the Graduate Diploma of Education (Primary) course, and how these experiences have contributed to your
self-efficacy to teach science. The focus group discussions will be audio recorded for data analysis and would take approximately half an hour of your time. The focus groups will be conducted on ECU Mount Lawley campus during week 9, either before or after your tutorial, with refreshments at a campus café.

Information provided as part of the project will only be used for research purposes, including publication. Your identity will not be disclosed at any time. All of your responses (questionnaire and focus group) will be de-identified, with the use of a pseudonym, and data will be stored securely in a locked cabinet at Edith Cowan University, only accessible by the researcher. The data from the project will be kept for 5 years at the ECU Repository, unless they are used for a further longitudinal study, in which case they will be kept for a further 5 years after the completion of the longitudinal study. You may request a copy of the findings of the research project.

Discussion and self-reflection of your own experiences may cause the feeling of discomfort. Therefore participation in the research project is entirely voluntary. You are able to withdraw from the research project at any time, without penalty or explanation. Your withdrawal from the project will not affect your relationship with the researcher, project supervisors nor with Edith Cowan University. Withdrawal or not participating in the research project will have no bearing or impact on your ability to successfully complete the unit. It will also have no impact on your relationship with your lecturer or tutor, or on their assessment of your performance in the unit. If you choose to withdraw, every effort will be made to erase any questionnaire data. Due to the complexity of multiple voices in a focus group audio recording, erasure of focus group data will not be able to be performed.

It is anticipated the research will lead to the publication of a Doctor of Philosophy thesis investigating the perceived effect that a Graduate Diploma (Primary) of Education provide feedback to improve the experience of SCE4103 content and pedagogical instruction within ECU teacher education course.

If you would like to participate, please complete and sign the attached Informed Consent Document and return this to the researcher. If you have any questions or require any further information about the research project, please contact Christina Norris at cmmorris@our.ecu.edu.au.

The Edith Cowan University Human Research Ethics Committee has approved the research project (Project number 12776). If you have any concerns or complaints
about the research project and wish to talk to an independent person, you may contact:

Research Ethics Officer
Edith Cowan University
270 Joondalup Drive
JOONDALUP WA 6027
Phone: (08) 63042170
Email: research.ethics@ecu.edu.au

Thank you for your participation in this research project.

Kind regards

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Information Letter to Participants

Date 1st July 2016

Dear Colleagues

You are invited to take part in a research project that is being undertaken as part of the requirements of a Doctor of Philosophy degree at Edith Cowan University in the School of Education. The aim of the study is to investigate if the structure and pedagogy of the SCE4103 unit has an impact on preservice teachers’ self-efficacy on teaching science to primary school students upon completion of this unit. The self-efficacy of preservice teachers is based upon people’s beliefs in their capabilities, including, the feeling of mastery of both subject and pedagogical content knowledge.

You are asked to participate in this study as it is directly related to the unit you are tutoring. Data from my Master of Education by Research study conducted in 2015 suggested that tutor interaction was a factor of students’ self-efficacy. The extent that tutor interaction (in particular the pedagogical and teaching approaches used) may affect preservice teachers’ self-efficacy to teach primary science is an area that has had limited Australian based research. Therefore, tutors are invited to participate in this study to assist in the explicit investigation of this relationship through providing anecdotal data, to give further insight into the extent of tutor interaction of preservice teachers’ self-efficacy to teach primary science. Data from this study will be used for future development of this unit and can be used as professional development for its tutors.

You are asked to participate in a one-on-one semi-structured interview at the conclusion of the unit. The interview will focus on tutors’ demographics, teaching...
philosophy and practices, perceptions of their preservice teachers’ self-efficacy throughout the unit, and the preservice teachers’ attitude towards the unit. These discussions will be audio recorded for data analysis and may be up to an hour long. Along with the interview you will be asked to reflect on pedagogical strategies that were used during the learning experiences by completing some pedagogical checklists throughout the course. The researcher may also conduct some tutorial observations to focus on the pedagogical strategies using the same checklists as you will complete. The tutorial observations will in no way be assessing your teaching, only looking at the practices during the lesson experiences. Impartial observation can allow for concentrated focus on the pedagogical strategies that may have an influence on preservice teacher learning. The observations will be available to the tutor at the completion of learning experience. These can be used as a professional learning opportunity.

Information provided as part of the project will only be used for research purposes, including publication. Your identity will not be disclosed at any time. All of your responses will be de-identified, with the use of a pseudonym, and the data will be stored securely in a locked cabinet at Edith Cowan University, only accessible by the researchers. The data from the project will be kept for 5 years at the ECU Repository, unless the data will be required to be used for a further longitudinal study, then will be kept for a further 5 years after the completion of the longitudinal study. You may request a copy of the findings of the research project.

Discussion and self-reflection of your own experiences along with observations made during learning experiences may cause the feeling of discomfort. Therefore participation in the research project is entirely voluntary. You are able to withdraw from the research project at any time, without penalty or explanation. Your withdrawal from the project will not affect your relationship with any of the researchers, or with Edith Cowan University. Withdrawing or not participating in the research project will have no bearing or impact on your ability to successfully tutor the unit or future sessional work. If you choose to withdraw, every effort will be made to erase any collected data.

It is anticipated the research will lead to the publication of a Doctor of Philosophy thesis investigating the perceived effect that a Graduate Diploma (Primary) of Education science unit has on the preservice teachers’ self-efficacy to teach science. Your involvement would help inform the future educational design of SCE4103
content and pedagogical instruction within ECU teacher education course.

If you would like to participate, please complete and sign the attached Informed Consent Document and return this to the researcher. If you have any questions or require any further information about the research project, please contact Christina Norris at cmnorris@our.ecu.edu.au.

The Edith Cowan University Human Research Ethics Committee has approved the research project (Project number 12776). If you have any concerns or complaints about the research project and wish to talk to an independent person, you may contact:

   Research Ethics Officer  
   Edith Cowan University  
   270 Joondalup Drive  
   JOONDALUP WA 6027  
   Phone: (08) 63042170  
   Email: research.ethics@ecu.edu.au

Thank you for your participation in this research project.

Kind regards

Christina Norris  
PhD Candidate  
Edith Cowan University  
School of Education  
Email: XXXXXXXX  
ph: XXXXXXXX

Principal Supervisor:  
A/Prof Geoffrey W. Lummis  
Deputy Director  
Edith Cowan Institute for Education Research

Associate Supervisor:  
Professor David McKinnon  
Director  
Edith Cowan Institute for Education Research

Associate Supervisor:  
Dr. Julia Morris  
Post Doctoral Research Fellow  
Edith Cowan Institute for Education Research  
Ph: XXXXXXXX  
Email: XXXXXXXX
APPENDIX C

Information Letter for Laboratory Technician as participant

EXPLORING THE IMPACT OF PRESERVICE PRIMARY SCIENCE EDUCATION ON STUDENTS' SELF-EFFICACY

Information Letter to Participants

Date: 22nd September 2016

Dear Laboratory Technician,

You are invited to take part in a research project that is being undertaken as part of the requirements of a Doctor of Philosophy degree at Edith Cowan University in the School of Education. The aim of the study is to investigate if the structure and pedagogy of the SCE4103 unit has an impact on preservice teachers’ self-efficacy on teaching science to primary school students upon completion of this unit. The self-efficacy of preservice teachers is based upon people's beliefs in their capabilities, including, the feeling of mastery of both subject and pedagogical content knowledge.

Literature has shown that there are many factors that may impact on a preservice teacher's self-efficacy, including their surrounding environment comprising of influences by others' perceptions, enthusiasm and interactions.

You are asked to participate in this study as your role, as Laboratory Technician would provide another insight into the hands on elements of the unit through the provision of materials required to deliver the unit. As you have been involved in this unit for a number of years you may also be able to provide anecdotal information in relation to what changes have occurred to the design of the unit, through the provision of the class materials As well as being an approachable, not teaching member, you may have had interaction with the students from this unit, which may provide another layer of anecdotal observation of students’ abilities and attitudes.
Data from this study will be used for future development of this unit and can be used as professional development for its tutors.

You are asked to participate in a one-on-one semi-structured interview at the conclusion of the unit. The interview will focus on your role and your perceptions of the preservice teachers’ self-efficacy and attitude towards the unit. These discussions will be audio recorded for data analysis and may be up to half hour long.

Information provided as part of the project will only be used for research purposes, including publication. Your identity will be not be disclosed at any time. All of your responses will be de-identified, with the use of a pseudonym, and the data will be stored securely in a locked cabinet at Edith Cowan University, only accessible by the researchers. The data from the project will be kept for 5 years at the ECU Repository, unless the data will be required to be used for a further longitudinal study, then will be kept for a further 5 years after the completion of the longitudinal study. You may request a copy of the findings of the research project.

Participation in the research project is entirely voluntary. You are able to withdraw from the research project at any time, without penalty or explanation. Your withdrawal from the project will not affect your relationship with any of the researchers, or with Edith Cowan University.

It is anticipated the research will lead to the publication of a Doctor of Philosophy thesis investigating the perceived effect that a Graduate Diploma (Primary) of Education science unit has on the preservice teachers’ self-efficacy to teach science. Your involvement would help inform the future educational design of SCE4103 content and pedagogical instruction within ECU teacher education course.

If you would like to participate, please complete and sign the attached Informed Consent Document and return this to the researcher. If you have any questions or require any further information about the research project, please contact Christina Norris at cmnorris@our.ecu.edu.au.

The Edith Cowan University Human Research Ethics Committee has approved the research project (Project number 12776). If you have any concerns or complaints about the research project and wish to talk to an independent person, you may contact:

Research Ethics Officer
Edith Cowan University
270 Joondalup Drive
Thank you for your participation in this research project.

Kind regards

Christina Norris  
PhD Candidate  
Edith Cowan University  
School of Education  
Email: XXXXXXXX  
ph: XXXXXXX

**Principal Supervisor:**  
A/Prof Geoffrey W. Lummis  
Deputy Director  
Edith Cowan Institute for Education Research

**Associate Supervisor:**  
Professor David McKinnon  
Director  
Edith Cowan Institute for Education Research

**Associate Supervisor:**  
Dr. Julia Morris  
Post Doctoral Research Fellow  
Edith Cowan Institute for Education Research  
Ph: XXXXXXX  
Email: XXXXXXX
APPENDIX D

Informed Consent Document for Student Participants

EXPLORING THE IMPACT OF PRESERVICE PRIMARY SCIENCE EDUCATION ON STUDENTS’ SELF-EFFICACY
(Ethics application No. 12776)

Informed Consent Document

CHIEF INVESTIGATOR: Christina Norris
School of Education
Edith Cowan University
Email: XXXXXXXX
ph: XXXXXXX

By signing below, you agree to the following:

• I have received a copy of the Information Letter outlining the research study.
• I have read and understood the information provided.
• I have been given the opportunity to ask questions and have had my queries answered to my satisfaction.
• I am aware if I have any further queries I can contact the research team or the ECU Research Ethics Officer.
• I understand that participation will involve the answering of a questionnaire two times throughout the unit, and agree to this.
• I understand that I may be invited to participate in an audio recorded Focus Group discussion, and can choose to become part of this group.
• I understand that all data collected will be kept confidential and that the identity of participants will not be disclosed without prior consent.
• I understand the purpose of this research study and how the information may be used.
• I understand that I can freely withdraw from further participation at any time, without explanation or penalty.
• I understand that data collected for this research project may be used in a longitudinal study and agree to this.

I ________________________________________________ have read the above conditions and understand that participation is voluntary. I hereby agree to the above terms and am willing to participate in the study.

SIGNED BY: _________________________    DATE: ______________________________
Student ID: ______________________________
APPENDIX E

Informed Consent Document for Tutors

EXPLORING THE IMPACT OF PRESERVICE PRIMARY SCIENCE EDUCATION ON STUDENTS' SELF-EFFICACY (Ethics application No. 12776)

Informed Consent Document

CHIEF INVESTIGATOR: Christina Norris
   School of Education
   Edith Cowan University
   Email: XXXXXXXX
   ph: XXXXXXX

By signing below, you agree to the following:

• I have received a copy of the Information Letter outlining the research study.
• I have read and understood the information provided.
• I have been given the opportunity to ask questions and have had my queries answered to my satisfaction.
• I am aware if I have any further queries I can contact the research team or the ECU Research Ethics Officer.
• I understand that participation will involve the completion of a pedagogical/teaching strategy checklist throughout the unit, and agree to this.
• I understand that there may be observation of a learning experience to determine the pedagogical and teaching strategies that have been used to engage students.
• I understand that I am invited to participate in an audio recorded semi-structured interview, and can choose to become part of this discussion.
• I understand that all data collected will be kept confidential and that the identity of participants will not be disclosed without prior consent.
• I understand the purpose of this research study and how the information may be used.
• I understand that I can freely withdraw from further participation at any time, without explanation or penalty.
• I understand that data collected for this research project may be used in a longitudinal study and agree to this.

I ________________________________ have read the above
(print name)

conditions and understand that participation is voluntary. I hereby agree to the above terms and am willing to participate in the study.

SIGNED BY: ___________________________  DATE: ____________________________
APPENDIX F

Informed Consent Document for Laboratory Technician

EXPLORING THE IMPACT OF PRESERVICE PRIMARY SCIENCE EDUCATION ON STUDENTS' SELF-EFFICACY
(Ethics application No. 12776)

Informed Consent Document

CHIEF INVESTIGATOR: Christina Norris
   School of Education
   Edith Cowan University
   Email: XXXXXXXX
   ph: XXXXXXX

By signing below, you agree to the following:

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- I have read and understood the information provided.
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- I understand that I am invited to participate in an audio recorded semi-structured interview, and can choose to become part of this discussion.
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- I understand that data collected for this research project may be used in a longitudinal study and agree to this.
I ___________________________ have read the above

(print name)

conditions and understand that participation is voluntary. I hereby agree to the above
terms and am willing to participate in the study.

SIGNED BY: ___________________________ DATE: ___________________________
Pre intervention science teaching efficacy belief instrument

This instrument was used as the pre intervention diagnostic test of the primary science teaching self-efficacy of the preservice teachers. This questionnaire also includes items to elicit demographic information.

Science Teaching Efficacy Belief Instrument 1

<table>
<thead>
<tr>
<th>Pseudonym Name:</th>
<th>Surname &amp; Student ID: ________________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender: Female</td>
<td>Male □ Male □</td>
</tr>
<tr>
<td>Enrolment Status: Part-time □ Full-time □</td>
<td>Graduate Diploma of Education Primary Course</td>
</tr>
<tr>
<td>Level of Science completion: year 9 □ year 10 □ year 11 □ year 12 □ U/grad. □ Postgrad. □</td>
<td></td>
</tr>
<tr>
<td>Area of Undergraduate/ Postgraduate Degree: Arts &amp; Humanities □ Education □ Nursing &amp; Midwifery □ Medical &amp; Health Sciences □ Business &amp; Law □ Engineering □ Performing Arts □ Science □</td>
<td></td>
</tr>
<tr>
<td>If degree is SCIENCE background what area best describes your major: Biological science □ Chemical science □ Environmental science □ Physical science □ Space science □</td>
<td></td>
</tr>
<tr>
<td>Briefly describe your own science learning experiences:</td>
<td></td>
</tr>
</tbody>
</table>

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate number to the right of each statement.

<table>
<thead>
<tr>
<th>Read each statement carefully before responding.</th>
<th>Strongly Agree (SA)</th>
<th>Agree (A)</th>
<th>Uncertain (U)</th>
<th>Disagree (D)</th>
<th>Strongly Disagree (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 When a primary school pupil does better than usual in science, it is often because the primary teacher exerted a little extra effort.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2 I will continually find better ways to teach primary school science.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3 Even if I try very hard, I will not teach primary school science as well as I will most other KLAs.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4 When the science grades of primary school pupils improve, it is often due to their teacher having found a more effective teaching approach.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5 I know the steps necessary to teach primary school science concepts effectively.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6 I will not be very effective in monitoring science experiments in the primary school.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
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<td></td>
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</tr>
<tr>
<td>7</td>
<td>If primary school pupils are underachieving in science, it is most likely due to ineffective science teaching.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>I will generally teach primary school science ineffectively.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>The inadequacy of a primary school pupil’s science background can be overcome by good teaching.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>The low science achievement of some primary school pupils cannot generally be blamed on their teachers.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>When a low achieving primary school pupil progresses in science, it is usually due to extra attention given by the teacher.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>I understand science concepts well enough to be effective in teaching primary school science.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>Increased effort in science teaching produces little change in some primary school pupils’ science achievement.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>The teacher is generally responsible for the achievement of primary school pupils in science.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>Primary school pupils’ achievement in science is directly related to their teacher’s effectiveness in science teaching.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>16</td>
<td>If parents comment that their child is showing more interest in science at primary school, it is probably due to the performance of their child’s teacher.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>17</td>
<td>I will find it difficult to explain to primary school pupils why science experiments work.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>18</td>
<td>I will typically be able to answer primary school pupils’ science questions.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>19</td>
<td>I wonder if I will have the necessary skills to teach science in primary school.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>Given a choice, I will not invite the principal to evaluate my science teaching.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>21</td>
<td>When a primary school pupil has difficulty understanding a science concept, I will usually be at a loss as to how to help the pupil understand it better.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>22</td>
<td>When teaching primary school science, I will usually welcome pupils’ questions.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>23</td>
<td>I do not know what to do to turn primary school pupils on to science.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>24</td>
<td>I do not feel I have the necessary skills to teach science in primary school.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>25</td>
<td>After I have taught a science concept once, I will feel more confident teaching it again.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>26</td>
<td>I find science a difficult topic to teach.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>27</td>
<td>I understand science concepts well enough to teach primary school science effectively.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>28</td>
<td>I know how to make primary school pupils interested in science.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>29</td>
<td>I feel anxious when teaching science content in primary school that I have not taught before.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>30</td>
<td>I wish I had a better understanding of the science concepts I will teach.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
### APPENDIX H

**Post Intervention Science Teaching Efficacy Belief Instrument**

This instrument was used post intervention to allow for pre/post analysis, and also included items to elicit anecdotal data.

**Science Teaching Efficacy Belief Instrument 2**

<table>
<thead>
<tr>
<th>Pseudonym Name: _____________________________________</th>
<th>Surname &amp; Student ID: ________________________________</th>
</tr>
</thead>
</table>

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate number to the right of each statement.

<table>
<thead>
<tr>
<th></th>
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<th>Uncertain (U)</th>
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<td>I will continually find better ways to teach primary school science.</td>
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<tr>
<td>17</td>
<td>I will find it difficult to explain to primary school pupils why science experiments work.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>18</td>
<td>I will typically be able to answer primary school pupils’ science questions.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>19</td>
<td>I wonder if I will have the necessary skills to teach science in primary school.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>Given a choice, I will not invite the principal to evaluate my science teaching.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>21</td>
<td>When a primary school pupil has difficulty understanding a science concept, I will usually be at a loss as to how to help the pupil understand it better.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>22</td>
<td>When teaching primary school science, I will usually welcome pupils’ questions.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>23</td>
<td>I do not know what to do to turn primary school pupils on to science.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>24</td>
<td>I do not feel I have the necessary skills to teach science in primary school.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>25</td>
<td>After I have taught a science concept once, I will feel more confident teaching it again.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>26</td>
<td>I find science a difficult topic to teach.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>27</td>
<td>I understand science concepts well enough to teach primary school science effectively.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>28</td>
<td>I know how to make primary school pupils interested in science.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>29</td>
<td>I feel anxious when teaching science content in primary school that I have not taught before.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>30</td>
<td>I wish I had a better understanding of the science concepts I will teach.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

The following questions relate directly to the GDE-P science unit:

<table>
<thead>
<tr>
<th></th>
<th>How confident are you NOW about teaching Science &amp; Technology?</th>
<th>Totally</th>
<th>Very</th>
<th>Some</th>
<th>Not</th>
<th>Not at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Which Content Strand(s) do you feel more confident in after completing the GDE-P science unit? Rank 1-5; 5=most confident</td>
<td>Biology _____ Chemistry _____ Earth &amp; Space _____ Physics___</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Did the modelling of science teaching strategies assist your confidence to teach primary science?</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>No</td>
</tr>
</tbody>
</table>

Tick all of the Instructional Strategies that you saw being used when science was being taught.

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transmission</td>
<td>Models</td>
<td>Interactive</td>
</tr>
<tr>
<td></td>
<td>Discovery</td>
<td>Constructivist</td>
<td>Conceptual Change</td>
</tr>
</tbody>
</table>

Please provide examples of techniques you observed:
<table>
<thead>
<tr>
<th>34.</th>
<th>Did you find the GDE-P science unit engaging? Tick those that apply</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>□ Yes, I was able to gather teaching resources</td>
</tr>
<tr>
<td></td>
<td>□ Yes, the tutor was very knowledgeable</td>
</tr>
<tr>
<td></td>
<td>□ Yes, I found the activities interesting</td>
</tr>
<tr>
<td></td>
<td>□ Yes, I enjoyed the delivery style of the tutor</td>
</tr>
<tr>
<td></td>
<td>□ No</td>
</tr>
</tbody>
</table>

Briefly explain your answer(s):
APPENDIX I

Interview Scripts for all Participant Groups

TUTOR SEMI-STRUCTURED INTERVIEW QUESTIONS

OPENING:

• Introduce myself.
• How long it will take approximately 30 mins.
• Ethics: This is a voluntary interview
  ○ Audio recorded – participant may leave if not agreed to
  ○ Interview will be ended at any point as requested by participant
  ○ **Confidentiality:** All data will be de-identified with the use of a pseudonym for reporting of data
• The discussion data will allow for supporting statements to the research questions and also to support the data obtained through the quantitative survey

• Could I have your name, and a pseudonym you would like me to use in the report?

**Proceed with the recording, if in agreement with audio recording.**

Before we start, how many tutorials of the GDE-P science unit did you teach, and over how many days?

**BACKGROUND DATA:**

1. What was your experience as a student with science classes in school?

2. What areas of science are you most passionate about? What sparked this interest?

3. In what way do you believe that your teachers may have had an influence on you becoming a teacher of science?
4. What is your teaching background? How could you best describe your teaching philosophy?

5. How would you describe your own confidence teaching science at primary, secondary and/or tertiary levels?

6. What type of teaching strategies would you employ to engage your students?

REFLECTION OF LEARNING EXPERIENCES AND GDE-P SCIENCE UNIT:

1. In general, how would you gauge the engagement of the students in your tutorials?

2. How would you describe your preservice teachers’ self-efficacy at the start of the unit?
   - Did this change towards the end?
     - If so, how did it change?
     - Give some examples to demonstrate any change.

3. You described some of your teaching strategies/style earlier.
   - Do you feel that they are consistent with how you have taught the tutorials?
   - Why or why not?
   - How do you feel that your strategies and style may have equipped your students with pedagogical skills and teaching strategies to teach primary science?

4. Thinking about the GDE-P science unit structure:
   - What factors would you identify which may have influenced the students’ self-efficacy?
   - Describe how you think that it has assisted the students’ science content knowledge?
   - Describe how it may have assisted the students’ pedagogical content knowledge?
5. In what ways would you think the unit could be improved to assist with students’ self-efficacy to teach primary science?

CONCLUSION OF INTERVIEW:

Thank you for participating in the interview as part of the research. As you have provided me with your name, I would be happy to forward the transcript to yourself for checking the accuracy of your responses. Would you like this?
LABORATORY TECHNICIAN SEMI-STRUCTURED INTERVIEW QUESTIONS

OPENING:
• Introduce myself.
• How long it will take approximately 30 mins.
• Ethics: This is a voluntary interview
  o Audio recorded – participant may leave if not agreed to
  o Interview will be ended at any point as requested by participant
  o Confidentiality: All data will be de-identified with the use of a pseudonym for reporting of data
• The discussion data will allow for supporting statements to the research questions and also to support the data obtained through the quantitative survey
• Could I have your name, and a pseudonym you would like me to use in the report?

Proceed with the recording, if in agreement with audio recording.

1. How long have you been involved in the delivery of the GDE (Primary) Science unit?
2. In what capacity have you been involved?
3. What changes have you experienced throughout the development of the unit?
4. How have these changes impacted your role?
5. Have you had any interaction with the unit’s students? If so, what kind of interaction has there been, and how often?
6. From your contact with the students what would be your perception of their attitudes and abilities with the unit?
7. Would you have any other observations of the unit that you could share?
CONCLUSION OF INTERVIEW:

Thank you for participating in the interview as part of the research. As you have provided me with your name, I would be happy to forward the transcript to yourself for checking the accuracy of your responses. Would you like this?
APPENDIX J

Preservice Teacher Focus Group Questions

These questions were used as prompts to guide the discussions. Groups were conducted at the beginning and towards the end of the intervention.

OPENING FOR EACH DISCUSSION GROUP:

- Introduce myself.
- How long it will take – 10 to 15mins.
- Ethics: This is a voluntary group discussion
  - Audio recorded – participants may leave if not agreed to
  - Participants may leave if feeling uncomfortable at any time
  - Confidentiality: All data will be de-identified with the use of a pseudonym for reporting of data
- The discussion data will allow for supporting statements to the research questions and also to support the data obtained through the quantitative survey
- Could I have your name, and pseudonym to use in the report?

If all agree then proceed with the recording

ICEBREAKER:

What have you done, career or education wise, prior to attending the GDE-P course?

QUESTIONS PRE INTERVENTION:

1. Thinking back to your own school experiences, how would you describe your own primary and secondary experiences of learning Science whilst at school?

2. With these experiences in mind, how do you feel that your Science learning experiences may have impacted how you would teach science to your future students?
   - What aspects?
3. How would you describe your confidence to teach science before starting the GDE-P science unit?
   ○ What do you think may have shaped this confidence level?

QUESTIONS POST INTERVENTION:

4. Now that you have completed the GDE-P science unit, how do you feel being a preservice teacher ready to go out to teach primary science?
   ○ How do you feel that the unit has assisted you with developing your content knowledge to teach primary science?
   ○ Tell me about how the unit may or may not have equipped you with the pedagogical skills/teaching strategies to teach primary science?

5. Thinking about the different pedagogical and teaching strategies that were modelled during the learning experiences. Could you identify and describe the modelling of teaching strategies to teach a scientific concept in your tutorial class?
   ○ How did these experiences affect your confidence to teach primary science? Why?
   ○ From the tutorial learning experiences, what strategies would you consider using in your future primary classroom?

6. What suggestions do you have that may assist in improving the GDE-P science unit to better suit the needs of future preservice primary teachers?
   ○ Further teaching of content areas: Biological, chemical, physical, Earth & space sciences, and sustainability?
   ○ Explicit modelling of teaching strategies, including differentiation for students’ learning?
   ○ Explicit instruction on pedagogical styles?
CONCLUSION OF DISCUSSION:

Thank you for participating in the focus group discussion. As you have provided me with your name, I would be happy to forward the transcript to yourself for checking the accuracy of your responses. Please let me know if you would like to peruse the transcript.
APPENDIX K

Tutorial checklist

This list allowed tutors to reflect on teaching strategies and pedagogies used during the weekly tutorial sessions. Tutors were asked to provide specific examples of activities performed or generalised examples of strategies used and in what week they used these strategies through a tick in the relevant week.

TUTORIAL PEDAGOGY & TEACHING STRATEGIES CHECKLIST

<table>
<thead>
<tr>
<th>Pedagogy/Strategy</th>
<th>Examples</th>
<th>Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture style (Y/N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student-centred (Y/N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flipped Classroom (Y/N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiential Learning (Y/N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brainstorming</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case study</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Debates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Questioning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Simulations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical thinking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Role play</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: eg: humour,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>team teaching</td>
<td></td>
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</tbody>
</table>
APPENDIX L

Tukey HSD post Hoc multiple comparisons

The following tables indicate the full descriptive statistics for the Tukey HSD post Hoc test for comparing pre and post intervention Personal Science Teaching Efficacy Beliefs (PSTE) means.

### Tukey HSD post Hoc multiple comparisons pre intervention PSTE means

<table>
<thead>
<tr>
<th>(I) type of learner</th>
<th>(J) type of learner</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fearful</td>
<td>Disinterested</td>
<td>-1.72</td>
<td>1.306</td>
<td>.680</td>
<td>-5.32 - 1.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Successful</td>
<td>-5.93*</td>
<td>1.355</td>
<td>.000</td>
<td>-9.66 - 2.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td>-5.75*</td>
<td>1.186</td>
<td>.000</td>
<td>-9.01 - 2.48</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Not clearly identifiable</td>
<td>-3.84*</td>
<td>1.231</td>
<td>.017</td>
<td>-7.23 - .45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disinterested</td>
<td>Fearful</td>
<td>1.72</td>
<td>1.306</td>
<td>.680</td>
<td>-1.87 - 5.32</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Successful</td>
<td>-4.21*</td>
<td>1.193</td>
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<tr>
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<td>1.051</td>
<td>.261</td>
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</tr>
<tr>
<td>Successful</td>
<td>Fearful</td>
<td>5.93*</td>
<td>1.355</td>
<td>.000</td>
<td>2.20 - 9.66</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Disinterested</td>
<td>4.21*</td>
<td>1.193</td>
<td>.005</td>
<td>.93 - 7.50</td>
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<td></td>
</tr>
<tr>
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<td>-1.90</td>
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</table>

**Note**: Based on observable means. The error term is Mean Square (Error) – 18.242

* The mean difference is significant at this level
Tukey HSD post Hoc multiple comparisons post intervention PSTE means

<table>
<thead>
<tr>
<th>(I) type of learner</th>
<th>(J) type of learner</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
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<td>.794</td>
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</table>

Note Based on observable means. The error term is Mean Square (Error) – 18.242

* The mean difference is significant at this level
APPENDIX M

Descriptive Statistics for Self-Efficacy constructs

The following tables demonstrate pre and post intervention descriptive statistics for each of the self-efficacy constructs, Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE), of the preservice teachers in each tutor cohort. Data was obtained from Science Teaching Efficacy Beliefs Instrument (STEBI-B) administered pre and post intervention.

Descriptive Statistics for self-efficacy construct: PSTE

<table>
<thead>
<tr>
<th>Tutor</th>
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<th>N</th>
<th>M</th>
<th>SD</th>
<th>Min</th>
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### Descriptive Statistics for self-efficacy construct: STOE

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</table>
APPENDIX N

STEM Assessment as per unit plan for the preservice teachers in this unit

Preservice teachers were given this assessment to be completed in pairs outside of tutorial time at the University. The timeframe for completion was 6 weeks.

ASSESSMENT ONE: STEM INVESTIGATION (40%)
3000 Words and Photographs

Part A (30 Marks) for the investigation write-up: Due... Part B (10 Marks) for peer presentation: Due in class Week 6
Turnitin Rubrics 1 & 2 will be discussed in class with your tutor

STEM stands for Science, Technology, Engineering and Mathematics. The first assessment is designed to enhance your STEM investigation skills to support primary science teaching.

Prior knowledge: It is assumed that you have completed some physical science at a lower secondary level.

Collaborative work: At the end of the first seminar please choose a peer, and receive the investigation topic from the tutor.

If you are unable to work with a peer please speak to your tutor about an individual project.

Blackboard: Use Blackboard to assist with the preparation of the investigation and other support

Turnitin: Please submit an individual assignment, but also indicate: whom you worked with on the first page of your assignment; provide the tutorial/seminar time (your class), and the name of your tutor/lecturer.

Graduate Attributes:
The ability to work in teams.
Critical appraisal skills.

Topic Allocation
You will be allocated one of the five STEM investigations during Week 1.
The full details of your topic will also be found on Blackboard.
Do some preliminary reading and online research on the topic and plan the investigation with your partner during Week 2.
Exchange emails addresses and telephone numbers.
Subsequently, with your partner you will conduct pilot study to work out any technical limits. The pilot study will appear in...
your Appendix 1.

Your formal report (30%) will be submitted through Turnitin/Blackboard: . . . .

Your 10-minute peer presentation (10%) will occur in class Week 6. If you do not attend you will not receive marks for the presentation of your STEM project.

You will be allocated one of the five STEM projects: Solar ovens, Meteorites, Water Rockets, Mouse-trap Cars & Battery Cars (Try and use recycled materials where possible)

<table>
<thead>
<tr>
<th>STEM TOPICS AND ONLINE LINKS (40%)</th>
<th>SCIENCE CONCEPTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 Construct and investigate a simple solar oven during Perth’s winter. You are not expected to cook a meal! o You need to construct a solar oven and use some basic appreciation of the location of the sun to maximise the temperature of the oven. o It is important that you identify the variables associated with the oven. o You will need to trial your oven at the same time each day and record the temperatures. Some of the following links should help: <a href="http://www.timeanddate.com/sun/australia/perth?month=8">http://www.timeanddate.com/sun/australia/perth?month=8</a> <a href="http://www.education.com/science-fair/article/design-solar-cooker/">http://www.education.com/science-fair/article/design-solar-cooker/</a> <a href="http://www.hometrainingtools.com/a/build-a-solar-oven-project">http://www.hometrainingtools.com/a/build-a-solar-oven-project</a> <a href="http://www.nasa.gov/pdf/435855main_BuildaSolarOven_6to8.pdf">http://www.nasa.gov/pdf/435855main_BuildaSolarOven_6to8.pdf</a></td>
<td>Earth Space Science/Physical Sciences</td>
</tr>
<tr>
<td>2.0 Construct and investigate dropping hand made meteorites onto soft surface and measuring the size/depth of the crater. • Go Online and find a site that explores meteorites. • Use the diagram provided on Blackboard to orientate the investigation. • You drop the same meteorite from different heights. • Or you can drop meteorites with the same volume and different masses from the same height and measure the craters. Some of the following links should help: <a href="http://solarsystem.nasa.gov/planets/meteors">http://solarsystem.nasa.gov/planets/meteors</a> <a href="http://www.lpi.usra.edu/science/kring/epo_web/meteorites/craters.html">http://www.lpi.usra.edu/science/kring/epo_web/meteorites/craters.html</a> <a href="https://www.youtube.com/watch?v=kMBQJrwKcU">https://www.youtube.com/watch?v=kMBQJrwKcU</a> <a href="http://www.sciencebuddies.org/science-fairprojects/project_ideas/Astro_p010.shtml#makeityourown">http://www.sciencebuddies.org/science-fairprojects/project_ideas/Astro_p010.shtml#makeityourown</a></td>
<td>Earth Space Science/Physical Sciences</td>
</tr>
</tbody>
</table>
### 3.0 Constructing a water rocket and recording the distance it travels:

- You will go Online and find a site that will demonstrate how to build your water rocket (NB there is a diagram on Blackboard).
- After you build your rocket you will identify variables that you could test.
- How high does your rocket travel with different volumes of water?
- How will you measure the height?
- Can you measure the pressure inside your rocket?
- Can you design a release mechanism for your rocket?
- Try and use as many recycled materials as possible.

Some of the following links should help:
- [https://www.youtube.com/watch?v=1t663D_gErg](https://www.youtube.com/watch?v=1t663D_gErg)
- [http://www.npl.co.uk/upload/pdf/wr_booklet_print.pdf](http://www.npl.co.uk/upload/pdf/wr_booklet_print.pdf)
- [http://www.uswaterrockets.com/construction_&_tutorials/cable_tie_launcher/torial.htm](http://www.uswaterrockets.com/construction_&_tutorials/cable_tie_launcher/torial.htm)

### 4.0 Construct and investigate a mouse-trap powered car:

- You will go Online and find a site that will demonstrate how to build your mousetrap-powered car.
- After you build your car you will identify variables that you could test.
- You could test your car to perform (e.g., over different surfaces, or time taken to travel a specific distance, or change the diameter of the wheels to see how the car performs.)
- Try and use as many recycled materials as possible.

Some of the following links should help:
- [https://www.google.com.au/?gfe_rd=cr&ei=BDd2VX6MNPu8weG0bWoCw&gws_rd=ssl#q=mousetrap+car](https://www.google.com.au/?gfe_rd=cr&ei=BDd2VX6MNPu8weG0bWoCw&gws_rd=ssl#q=mousetrap+car)
- [https://www.youtube.com/watch?v=XZ23q0QXPx0](https://www.youtube.com/watch?v=XZ23q0QXPx0)
- [http://www.wikihow.com/Adapt-a-Mousetrap-Car-for-Distanc](http://www.wikihow.com/Adapt-a-Mousetrap-Car-for-Distanc)

### 5.0 Construct and investigate a battery powered car:

- You will go Online and find a site that will demonstrate how to build your car.
- After you build your car you will identify variables that you could test.
- You could test your car to perform (e.g., over different surfaces, or time taken to travel a specific distance, or change the diameter of the wheels to see how the car performs.)
- Try and use as many recycled materials as possible.

Some of the following links should help:
Make sure that you research appropriate literature to support your initial hypothesis.
• Other literature and online material should flow back into your interpretation of results,
as well as your evaluation.
• Formal APA 6th edition referencing protocols apply (NB marks will be deducted for inappropriate work).
• Appendices: Keep a working diary of notes, pilot investigation, measurements and photographs in an appendix section (scan your rough notes that relate to your pilot).
• Appendices and references will not be part of your word count.
• Provide photographs with a caption and the photographer’s name.

**What you need to include:**

**Part A: 3000 Words (30%)**

A-1 (10 Marks)
Your initial Hypothesis: (I.e., what you think will happen based on your own experience).

Literature Review (including Online):
• You minimum scientific understanding of science standard is that of lower secondary.
• The background scientific knowledge for your STEM investigation should come from
  a minimum of three referenced sources of information (one page maximum).
• Include all online links that you used for the construction of your STEM investigation.

Independent, dependent and control variables including:
• How you will be changing the Independent Variable and measuring the Dependent Variable.
• Identify what you will control.
• Also include its location with possible environmental influences that may impact your
trials (e.g., cloud cover, rain, wind etc).

A-2 (10 Marks)
Methodology (Plan & Conduct):
• An explanation of how you will design conduct your investigation.
• Include an accurate list of equipment used to perform this investigation.
• Use of photographs to provide visual evidence of the engineering and construction (i.e., materials technologies used – glue, recycled wheel etc).
• If applicable, what are the control group and the experimental group doing in terms of testing your hypothesis?

A-3 (10 Marks)
Data Analysis & Evaluation
! There should be appropriate tables to collect data (i.e., the tabulation of independent and dependent variables).
! There should be evidence of a minimum of five trials with some variations of independent variable investigated.
! Graphing should be appropriate to the data that is collected, and should follow correct graphing protocol (see Australian Bureau of Statistics link).

Discussion:
• Discuss what you found out from your STEM investigation.
• The discussion should explain whether your data will either support or disprove your hypothesis.
• You will need to include an explanation of the importance of fair testing.
• Briefly state how this STEM investigation is linked to sustainability.

Conclusions:
• Did your data support your initial literature review (i.e., what you had expected to happen)?
• Demonstrate the evidence drawn on the literature.

Evaluation of your investigation:
• Reflection upon any problems (avoidable or random errors) encountered.
• How could you improve on your STEM investigation should it be repeated?
<table>
<thead>
<tr>
<th>COMPONENTS OF THE INVESTIGATION</th>
<th>MARK ALLOCATION</th>
</tr>
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<tbody>
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<td>PART A</td>
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<tr>
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</tr>
<tr>
<td>Name 2 ________________________</td>
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<tr>
<td>Academic standards – APA 6th style apply. Marks can be lost for inappropriate standards across A1, A2 &amp; A3.</td>
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<tr>
<td><strong>A-1 Questioning &amp; Predicting</strong></td>
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<tr>
<td>• Initial hypothesis</td>
<td>N_C_CR_D_HD /10</td>
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<tr>
<td>• Literature review &amp; WWW research</td>
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<tr>
<td>• Identification of variables</td>
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<tr>
<td><strong>A-2 Planning &amp; Conducting</strong></td>
<td>N_C_CR_D_HD /10</td>
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<tr>
<td>• Methodology &amp; Design</td>
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<td>• Construction of project</td>
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<td>• Visual evidence of the processes</td>
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<tr>
<td><strong>A-3 Data Analysis &amp; Evaluation</strong></td>
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<tr>
<td>• Data Collection (e.g., tables and graphs)</td>
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<tr>
<td>• Discussion and Conclusion</td>
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<tr>
<td>• Evaluation of the investigation</td>
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<td>• References and Appendices</td>
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<td>Name 2 ________________________</td>
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<td><strong>Peer Presentation:</strong></td>
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<tr>
<td>• 10 minute poster presentation (A2 Max)</td>
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<tr>
<td>• Brief video of the working model (2 Mins)</td>
<td>YES/NO (5% Max)</td>
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<tr>
<td>• Complete and working STEM model</td>
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<tr>
<td>• Participation in Week 6</td>
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<tr>
<td>• (NB if you do not turn up you do not receive marks for presentation (i.e., minus 5%).)</td>
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<tr>
<td>• Coherent presentation (5 marks)</td>
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*Comments:*

Academic standards – APA 6th style
NB marks can be lost for inappropriate standards