Teaching Teachers: The Influences on the Primary Science Pedagogy of First Year Pre-Service Teachers at Two New Zealand Universities

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Abstract

This study investigated the influences of teacher educators and university coursework on the primary science pedagogy of first year pre-service teachers at two New Zealand universities. The mixed methods study employed a constructivist and an interpretivist lens and evaluated data collected from the Preferred and Actual (pre/post) course Constructivist Learning Environment Survey (CLES), syllabi analyses, and semi-structured interviews. These tools investigated if the primary science learning environments teacher educators created informed the pedagogical approaches of pre-service teachers and worked towards the effective pedagogy practices stated in *The New Zealand Curriculum*. Descriptive statistics for both universities indicated that pre-service teachers preferred to learn in a critical constructivist environment. Actual CLES results indicated where perceived constructivist principles were weak or strong. Paired-samples *t*-tests had significant findings (*p* < .05) for both universities with modest to large effect sizes. Completion of analyses on gender, age, ethnicity and science qualifications indicated if these groupings had any significant differences. ANOVA results had significant differences (*p* < .05) between two ethnic groups and independent-samples *t*-tests were significant (*p* < .05) for age at one university. Syllabi analyses indicated a difference in the number of pedagogies used in the courses (3 versus 1). Interviews revealed the pre-service teachers’ science attitudes improved, however, science teaching time while on practicum was limited. Pre-service teachers indicated they were confident to teach science and that their teacher educators influenced their potential teaching practices. The findings supported 4 of the 7 effective pedagogy approaches listed in the curriculum. The research results indicated the complexity of the learning environment and ways to monitor it should be an important part of reviewing teacher education.

*Keywords:* primary science, constructivism, pre-service teacher education, CLES, teacher educators, *The New Zealand Curriculum*
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*There is a single light of science, and to brighten it anywhere is to brighten it everywhere.*
Isaac Asimov

Let’s go brighten some lights!
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Key Abbreviations Used in the Study

As the field of education uses many abbreviations in its lexicon, this section is for referencing the meaning of the education abbreviations in this study.

*CLES*–Constructivist Learning Environment Survey

*CK*–Content knowledge

*ERO*–Education Review Office

*LISP*–Learning in Science Project at the University of Waikato

*NEMP*–The National Education Monitoring Project

*NoS*–The Nature of Science

*NZARE*–New Zealand Association of Research in Education

*NZCER*–New Zealand Council of Education Research

*PCK*–Pedagogical content knowledge

*PD*–Professional development

*TIMSS*–The International Trends in Mathematics and Science Study
Teaching Teachers: The Influences on the Primary Science Pedagogy of First Year Pre-Service Teachers at Two New Zealand Universities

Chapter 1–Background to Study

1.1 Some of the Challenges in Primary Science

Recent national reports emphasise a number of challenges facing the New Zealand educational system in primary and secondary school science (Bull, Gilbert, Barwick, Hipkins, & Baker, 2010; Education Review Office, 2012; Gluckman, 2011). The reports highlight effective science teaching practices in schools, however, they also note many issues regarding ineffective science planning and teaching especially at the primary school level. The challenges presented in the reports for primary school science are not new topics for discussions in New Zealand or in other countries (Ginns & Watters, 1995; Prenzel, Seidel, & Kobarg, 2012; Tobin, Briscoe, & Holman, 1990). Within the discussions of how to alleviate some of these challenges, teacher quality is often an identified issue and improvements in this area are one of the main proposed solutions to improve and achieve a quality primary school science education for students. The question then arises, how is a quality primary school teacher educated in science? A review of the literature reveals that teachers’ preparation for the classroom during their university education is a good indicator of how well they may eventually teach (Darling-Hammond, 1999; Education Review Office, 2010; Rice, 2003). Within teacher education preparation programmes, several influences need to be considered when evaluating future teacher quality. These are: the teacher educators who instruct during pre-service teacher education (Cochran-Smith, 2003); teacher educators’ and pre-service teachers’ perceptions of the classroom learning environment (Fraser, 2012); and, if the pre-service teachers practise teaching using the pedagogy learned during their coursework (Hudson & Skamp, 2002). Several of these influences are self-explanatory in how they may
affect pre-service teachers’ potential teaching quality but what is not well understood is the influence of the teacher educators, the individuals who teach the primary science education courses. Teacher educators create the classroom learning environments in which pre-service teachers experience science learning and teaching. How, then, do teacher educators and classroom learning environments contribute to the complicated educational picture of primary science teacher preparation? How is the university classroom learning environment understood by pre-service primary teachers? Does this learning environment influence how they may potentially teach primary science?

University teacher educators have an enormous task to complete with each cohort of primary pre-service teachers that begin teaching degree coursework. The teacher educators’ task is to develop the students into competent primary teachers with multiple curricula learning area expertise in a relatively short timeframe. Researchers indicate that the teacher education experienced by the pre-service teachers strongly correlates to later quality of teaching (Darling-Hammond, 1999; Kane, 2005a; Rice, 2003). Teacher educators develop the coursework and the learning environments in the university classroom that pre-service teachers experience. The learning environments created during coursework play a part in pre-service teachers’ understanding of teaching practice or pedagogy. Part of the learning environment experienced by pre-service teachers includes the pedagogic modelling that teacher educators use to demonstrate how the subject material should be taught, making explicit the teaching practice both practically and conceptually (Loughran & Berry, 2005). Modelling by teacher educators introduces the pre-service teachers to pedagogic practices and begins the pre-service teachers on the journey of becoming teachers.

In addition to teaching about pedagogy, teacher educators familiarise pre-service teachers with The New Zealand Curriculum (Ministry of Education, 2007) that underpins the learning areas taught in all primary and secondary classrooms. The New Zealand Curriculum
is a policy document that, “states succinctly what each learning area is about and how its learning is structured” (Ministry of Education, 2007, p. 4). Pre-service teachers need to understand this document and implement it successfully as it is, “a statement of official policy relating to teaching and learning in English-medium New Zealand schools” (Ministry of Education, 2007, p. 6). There is a large amount of information that teacher educators need to communicate to pre-service teachers who then need to understand, assimilate and apply it in the primary classroom. Teacher educators expect the material they teach in class to be understood by pre-service teachers, for university course time is limited and there is a large amount of content to cover.

As a new teacher educator, my interest lies in understanding how primary pre-service teachers understand the related aspects of the classroom learning environment and the modelling of pedagogy. In this thesis, I take this interest and develop it by studying what primary pre-service teachers understand from their university classroom learning environment and examine whether it matches the expectations of the teacher educator who teaches the course. This critical inquiry (Adler, 1993) into the practice of teaching teachers can be used to inform my own teaching practice and those of other teacher educators. As I want to increase my own pedagogic knowledge with the goal of improving the science experience for primary school children through the education of their future teachers, my thesis investigates what the research literature indicates teacher educators understand about how pre-service teachers construct knowledge from their classes.

Given the variety of education courses and pedagogic theories that primary pre-service teachers learn during their studies, I focus on one pedagogic theory and one subject learning area. Two factors determine the selection of the learning area to research: first, primary science is my teaching passion and second, international and national research indicates it is an area that is in need of research attention (Abell, Bryan, & Anderson, 1997; Appleton &
Kindt, 1999; Chamberlain & Caygill, 2012; Education Review Office, 2012; Jarrett, 1999; Palmer, 2002). The choice of which pedagogic theory to examine comes from The New Zealand Curriculum, as it contains two pages on effective pedagogies described as, “teaching approaches that consistently have a positive impact on student learning” (Ministry of Education, 2007, p. 34). As these teaching approaches are relatable to the principles of constructivism (Barker, 2008), this is deemed the pedagogic theory to investigate.

The purpose of this study is to investigate how both teacher educators and pre-service teachers understand the university primary science classroom learning environment. The study also explores if the perceptions of the classroom learning environment, held by teacher educators and pre-service teachers, are congruent or divergent. The aims of the research include identifying which aspects of teacher educators’ classroom practices have particular impacts on pre-service teachers’ pedagogical understandings of primary science. In addition, the study endeavours to identify if any other factors influence the pre-service teachers’ understandings of science pedagogy as well as the extent to which the environment is modelled, if at all, on The New Zealand Curriculum’s (Ministry of Education, 2007) effective pedagogy approaches.

1.2 Introduction to the Key Elements in the Study

Below is a brief introduction to the key elements of the research study. Introductions to the elements are in this background section while full development of the elements occurs in subsequent chapters of the thesis.

1.2.1 New Zealand’s primary pre-service education. In New Zealand, to become a primary teacher, an individual undertakes a qualification at an accredited institution. Kane (2005a) reports that such an institution is usually a university and there are six universities with Colleges or Faculties of Education that provide this type of qualification. There are a
total of 15 teacher education providers offering a range of study options (Teach NZ, 2012). Cameron and Baker (2004) indicate that the most common way for someone to enter primary teaching is through the completion of a 3 year undergraduate degree. Individuals who pursue this degree are pre-service teachers and they enrol in an initial teacher education (ITE) programme in order to graduate and become a provisionally registered teacher. Education coursework occurs within a College or Faculty of Education, which is equivalent to a department within a university. As part of the primary teacher education qualification, pre-service teachers must engage with The New Zealand Curriculum’s learning areas. Part of the role of a teacher educator is to teach education courses in The New Zealand Curriculum learning areas.

1.2.2 Who are teacher educators. Who teaches the teachers how to teach? This task in New Zealand is given to teacher educators who teach at a university’s College or Faculty of Education but who may teach courses in other departments in a university as well (Cameron & Baker, 2004). This study focuses only on teacher educators at university Colleges or Faculties of Education, though other types of institutions do have teacher educators leading education coursework. Usually teacher educators are successful classroom teachers holding leadership positions before taking up employment at a College or Faculty of Education (Russell & Chapman, 2001). Some individuals remain permanently in their role as teacher educators while others are on short-term contracts and return to their roles as classroom teachers (Cameron & Baker, 2004).

Even though teacher educators are an important aspect of teacher education, the research literature indicates they are often a neglected researched group in educational studies. Internationally and nationally, education researchers claim little research or attention has focused on the quality or expertise of teacher educators (Cameron & Baker, 2004; Northfield, 1998; Smith, 2005). Researchers highlight these issues in an Australian literature
review of 215 studies on teacher education that found only eight studies concerned with the background, knowledge and attitudes of teacher educators. The rest of the studies focused on pre-service teacher characteristics (Murray, Nuttall, & Mitchell, 2008). The quality and expertise of teacher educators are also given minimal attention, if mentioned at all, in a small-scale study of European policy documents on teacher education (Snoek, Swennen, & van der Klink, 2009). If one considers the influence teacher educators have on pre-service teachers, it is astonishing that more research has not investigated how teacher educators, “conceptualise the knowledge and understandings that they seek to develop in student teachers” (Cameron & Baker, 2004, p. 35).

As teacher educators are responsible for providing pre-service teachers with strong foundations of professional teaching knowledge, this thesis questions whether there are ways to measure how and to what extent this is accomplished and to what degree it is usefully measured. These issues are my motivation, to find a way to measure the interpreted interactions between teacher educators and pre-service teachers in the university classroom. I expect my findings to better inform my own teaching practice as well as that of other teacher educators.

1.2.3 Pre-service teachers and the primary teaching degree. To be a pre-service teacher in New Zealand, individuals enrol at a university in the College or Faculty of Education or other ITE provider and study towards a teaching qualification. For this study, the qualification studied is a primary school qualification that permits teaching of New Entrants to Year 8 pupils (5-12 year old children). Primary pre-service teachers choose between completing a traditional 3 year Bachelor of Teaching degree (B.Ed. Teaching) or a 4 year Bachelor degree with a specialisation in a curriculum learning area. There are other options available to obtain a primary teaching degree, however, these are not the focus of this study.
Published demographics of primary pre-service teachers in New Zealand are limited in the research literature. The located demographic data indicates that primary pre-service teachers vary in age with one third to about one half being in the 18-20 year old range. Males comprise only a small portion of this demographic with up to 80% of the pre-service teachers being female. Ethnicity also varies, but over half of pre-service teachers indicate their ethnicity as New Zealand European, sometimes referred to as Pākehā¹ (Cameron & Baker, 2004; Gray & Renwick, 1998; Lomas, 2004).

With published demographic data indicating a predominately young pre-service teacher cohort that has limited time to learn what is required to be a successful teacher, understanding what these individuals comprehend from their courses and potentially incorporate into their own teaching pedagogy, is important. Research that reveals what pre-service teachers understand from university coursework will elucidate where improvements to teacher education courses are required.

1.2.4 Constructivism and the challenge of a new curriculum. The New Zealand Ministry of Education introduced a substantially different curriculum in 2007 compared to previous curriculum documents (Benade, 2009). The 2007 curriculum now places educational goals within the context of a vision, principles, values, and key competencies as well as achievement objectives in each subject learning area. Rather than establishing endpoints focused on outcomes for the educational process, creating lifelong confident learners is now a major focus (Ministry of Education, 2007). Included in the curriculum is a new section that lists pedagogical approaches that teachers are encouraged to incorporate into their teaching practice based on evidence about pedagogy that impacts student learning

¹ Pākehā is a Māori word that indicates a New Zealander of European ancestry. Māori are the indigenous people of New Zealand (Te Aka Maori-Engligh Dictionary, 2012).
positively (Ministry of Education, 2007). This list of effective pedagogical approaches is closely aligned to the principles of social constructivist teaching and learning (Barker, 2008). Currently, constructivism is a major influence on elementary science teaching (Carlsen, 2007; Koch, 2006) and learning (Tobin & Tippins, 1993) as well as on other subject areas like mathematics (Lomas, 2004; Stoddart, Connell, Stofflett, & Peck, 1993). Primary teachers, however, may not understand how to implement this style of pedagogy as a stratified random sample study of 168 Ohio, United States teachers indicate (Czerniak & Lumpe, 1996). This study reveals that 81% of teachers surveyed believe constructivism is not necessary or unnecessary, 4% are undecided about it and only 14% report using methodologies consistent with constructivist theory every day to several times a week. Other researchers indicate that expecting primary teachers to teach competently using constructivism is difficult at best as few teachers will have experienced learning in this context when they were students (Appleton & Kindt, 2002). Even if constructivism is stated as being the pedagogical practice used at the university level, MacKinnon and Scarff-Seatte (1997) state that it is difficult to impart constructivist ideals to pre-service teachers due to a variety of constraints in education courses. The courses’ constraints listed in the study are: limited time to understand children’s science ideas/conceptions, limited time to build those ideas/conceptions into the lesson plans, as well as limited time required to understand the learning process and the failure to learn.

As constructivist pedagogic tenets are in the New Zealand national curriculum, learning to teach in a constructivist style requires education in this pedagogy at the pre-service level. Being introduced to a teaching method, however, does not guarantee its uptake into the pre-service teacher’s teaching repertoire (Mellado, 1998). Both national and international research studies focus on the assessment of primary teachers and their science pedagogy once they are in the classroom (Appleton, 2003; Ginns & Watters, 1999; Lewthwaite, 2005; Pickett & Fraser, 2002). These research studies lead to the questions, how are the pedagogies
understood in university classrooms during pre-service teacher education? How do teacher educators know if pre-service teachers interpret the curricula practices in the manner anticipated?

1.2.5 Classroom learning environments. In all educational institutions, teachers and students create a learning environment that can aid or deter learning. Universities also have created classroom learning environments and these influence teacher educators as well as pre-service teachers. Learning environments are defined as the, “social-psychological contexts or determinants of learning” (Fraser & Walberg, 1991, p. x). The learning environment is a mix of the social and emotional as well as the physical environment and includes everything from the attitudes of students and teachers and how teachers teach a subject, to how comfortable students feel to ask questions and control their own learning. As learning environments are created in the university setting and in the individual classroom, the learning environment of the university classroom is used for this study. The university classroom is where primary science learning and teaching is predominately concentrated for first year pre-service teachers. The classroom is also where the teacher educator creates the learning environment and has the most control over what occurs during the learning process of the course.

Studies show student achievement is better when the classroom learning environment fits or is preferred by the student (Dorman, 2002; Fraser, 2012; Fraser & Fisher, 1983; Martin-Dunlop & Fraser, 2012; Pickett & Fraser, 2002). Learning environment research has a rich history and shows, “consistent relationships between the nature of the classroom environment and various student cognitive and affective outcomes” (Taylor, Fraser, & White, 1994, p. 2). In addition to student outcomes, teachers’ perceptions of their classroom environments are often viewed more positively by them when compared to the students’ perceptions of the same classroom environments (Johnson & McClure, 2004; Taylor, et al., 1994). If teachers often view the learning environment more positively than their students,
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research that informs teachers’ practices is essential to enable closer alignment between the
two perspectives. A discussion of this point is in Chapter 2–Literature Review, Section 2.6.

1.3 Research Questions

Though there are many factors that influence the education process of teachers, the
purposes of this study are to investigate the university primary science classroom learning
environment and how teacher educators and pre-service teachers perceive or understand this
environment. The initial research question emerges from the desire to determine what
pedagogical elements pre-service teachers understand when in the university classroom
learning environment and to note if any changes in these perceptions occur over time.

1. How do pre-service primary teachers perceive the university classroom learning
environment created by the science teacher educator? Do these perceptions change
over the duration of the primary science course?

To identify if the pre-service teachers’ understanding match the desired outcome of the
courses, it is important to assess the courses’ structures and the learning environments that the
teacher educators create in the university classrooms during the primary science courses. This
question also reviews the extent to which the curriculum’s effective pedagogy approaches are
apparent in teacher educators’ practices.

2. What perceptions do science teacher educators have of the classroom learning
environments they created and/or modelled for pre-service primary teachers?

Once pre-service teachers and teacher educators evaluate the classroom learning
environment, the final intention of the research study is to indicate if any other aspects
influence how pre-service teachers may eventually teach primary science. As the study takes
place in the first year of the pre-service teachers’ degree, only the evaluation of these
influences is possible, as there is the potential that other unknown factors may still influence their future science teaching practices.

3. What aspects of teacher educators’ primary science courses appear to shape the pedagogical approaches the pre-service primary teachers may use when teaching primary science? Do other factors influence the shaping of these pedagogical approaches?

The design of the three questions reveals what is happening in the university classroom learning environments in varying degrees of detail. To capture the diversity of data that assists in addressing the research questions, the study uses different research methods to investigate the questions.

1.4 Research Methods

To respond to the research questions, this study uses a constructivist and an interpretivist lens to view the research questions. Constructivism suits this research as the study investigates how pre-service teachers make sense of the new teaching knowledge they encounter. In addition, constructivism is now an important part of the New Zealand curriculum document. To deepen the understanding of the data, an interpretivist lens focuses on the shared meaning and the different interpretations created within discourse and shared activities by individuals (Morehouse, 2012). The use of a mixed methods research methodology gathers a range of data for the study. Mixed methods is also a methodology often used in learning environment studies and has proven effective in those studies (Aldridge, Fraser, Taylor, & Chen, 2000; Fraser & Walberg, 1991; Pickett & Fraser, 2002; Tobin & Fraser, 1998). The research tools that best reveal what occurs in the classroom environment are from both the quantitative and qualitative research perspectives. To use the two perspectives’ tools, a mixed methodology is warranted. While briefly summarised here,
further discussion of the theoretical frameworks, methodologies and methods are in Chapter 3–Methodology.

For the first part of the study, the thesis uses a survey to achieve an overview of what kind of classroom learning environment the pre-service teachers preferred and eventually perceived when attending the primary science course. A psychometrically sound survey that measures perceptions of a constructivist learning environment is the Constructivist Learning Environment Survey (CLES), developed at Curtin University of Technology in Perth, Australia. The survey measures both teacher educators’ and pre-service teachers’ perceptions of a constructivist learning environment, of both the preferred and actual experiences (Taylor, et al., 1994). Researchers developed the CLES to enable researchers, as well as teacher educators, to evaluate constructivist teaching approaches in science classrooms and the extent to which such approaches are understood by students or pre-service teachers (Taylor, Dawson, & Fraser, 1995).

The second tool is a course syllabus analysis similar to those conducted in other studies of university courses (Harrington & Enochs, 2009; Skamp, 1988). The thesis analyses syllabi from the participating universities’ primary science courses to ascertain the composition of the courses and the consistency between teacher educators’ survey responses and the outline of the course presented to pre-service teachers. The syllabi also list the pedagogical approaches taught during the courses and then linkages to The New Zealand Curriculum’s effective pedagogy approaches are possible.

Semi-structured interviews with pre-service teachers are the third tool in the study. The interviews examine what aspects from their courses influence the pre-service teachers. The analysis codes their experiences of becoming primary teachers during the science course according to themes using the interpretivist method of analytic induction. Analytic induction
entails deliberately searching for evidence that confirms and/or disconfirms the ideas that emerge from the body of collected data. This evidence searching assists in identifying, “subtle shadings of distinctions” (Erickson, 1986, p. 145) in the learning environments.

Among the diverse research tools available to answer the research questions, the three tools briefly described are the most appropriate means to gather data relevant to the research questions and did so in the time available for the research project. The use of each method either builds on or delves into greater detail of the study and responds to the research questions. This format produces a solid investigation that can withstand the rigours of research validity and reliability issues. A more comprehensive discussion of these issues is in Chapter 3–Methodology, Sections 3.5 and 3.6.

### 1.5 Importance of the Study

Teachers are the key to a quality education as they are the link between curriculum, pedagogy, assessment and social and learning outcomes (Jones & Baker, 2005). There is a need for primary school teachers who can effectively develop these links in the learning area of science. It is difficult, however, to achieve a positive link for New Zealand primary students when many of their primary school teachers are uncomfortable with teaching science (Education Review Office, 2010, 2012; Lewthwaite, 2000). Researchers report that when teachers are uncomfortable with teaching a subject, their coping strategies can have a limiting effect on children’s learning (Harlen, 1997; Harlen & Holroyd, 1997; Newton & Newton, 2000). This limiting effect may be evident as Caygill (2008) indicates significantly less time is spent on teaching science topics in New Zealand primary classrooms than in 2002. In addition, The National Education Monitoring Project (NEMP) and The Trends in Mathematics and Science Study (TIMMS) primary science data indicate a lack of doing and understanding basic science concepts by New Zealand primary students (Caygill, 2008; Crooks, Smith, & Flockton, 2008). The most recent New Zealand TIMMS data from 2010/11
show Year 5 students (9 year olds) are indifferent to science and less engaged in science lessons at school (Chamberlain & Caygill, 2012). These conclusions raise the questions, what is happening to the study of science in primary classrooms? Are there teaching issues in primary science that are identifiable during pre-service teacher education programmes? If issues are identified, this knowledge may lead to improvements in future science teaching and learning in the primary classroom.

An important element in teacher education is the teacher educator who teaches the courses to pre-service teachers (Cochran-Smith, 2003). Teacher educators convey all aspects of The New Zealand Curriculum and its alignment to constructivist principles (Conner, Lancaster, & McGrath, 2008) to pre-service teachers. Therefore, teacher educators need to know which parts of the university classroom learning environment are influencing pre-service teachers. Teacher educators should not assume that the concepts taught and modelled during primary science coursework are understood, nor that in the future they will be integrated into the teaching pedagogy of the pre-service teachers once they are in a classroom situation (Mellado, 1998).

In New Zealand, research on pre-service teachers’ and beginning teachers’ understandings of how to teach science reviews: their confidence (Anderson, Bartholomew, & Moeed, 2009), content knowledge (Lewthwaite, 2000), views on teaching (Salter, 2000) and role-modelling/activities that promote good pedagogy (Hume, 2012). The New Zealand studies that research constructivism as presented or modelled by teacher educators are limited. The published literature includes one study involving a different learning area, namely mathematics (Lomas, 2004). In order to determine the existing familiarity with such pedagogical approaches and thus facilitate adoption of the most recent curriculum, it is necessary to assess the extent to which such approaches are communicated to and understood by pre-service teachers. Investigating how classroom learning environments are influencing
pre-service teachers’ pedagogical approaches will assist science teacher educators in the evaluation of the extent to which their science course designs are moving pre-service teachers towards being able to deliver the science curriculum through recommended pedagogy.

An investigation into the perceived environments will assist teacher educators in planning and modifying their teaching practices and understanding the impact that their course has on pre-service teachers’ perceptions and potential teaching behaviours. As 20 years of research into science education shows, making pedagogical changes is an extremely complex process and it must occur in an informed manner to be successful (Saleska, 2000). Hence, the compiled and analysed data will assist teacher educators to determine if the environment perceived is the one they intended to create. This research may also assist in the planning of future courses or when updating current ones. Though primary science is the focus, the findings of this study may be of interest to other learning areas of pre-service education to assist teacher educators in evaluating and monitoring pre-service teachers’ pedagogical understandings.

1.6 Key Terms Used in Study

The italicised words below define the key terms used throughout this thesis. Where a particular definition is applied to more than one word or term used in the research literature, the alternative word is also stated for clarity of understanding. The first italicised words in each paragraph are the words used in this study.

*Classroom learning environment* is the social, emotional and physical atmosphere created in a classroom where the roles and beliefs of the teacher and learners facilitate or inhibit learning (McRobbie & Tobin, 1997). For this study, the environment is the one that takes place in the university primary science classroom.
Constructivism is a teaching and learning theory. As a learning theory, it is defined as an active process where the learner makes sense or constructs knowledge by linking new ideas to past experiences and knowledge (Staver, 1998; Taber, 2010). As a teaching theory, the teacher elicits what the students know and then plans lessons that build on that knowledge or that challenge the old knowledge to generate a better understanding of the concept or topic (Richardson, 2003). Constructivism is also a research framework used in education, international relations, psychology, nursing, health sciences and management knowledge (Cottone, 2007; Mills, Bonner, & Francis, 2006; Petit & Huault, 2008). For these disciplines, constructivism is an alternative to positivism when used as a research framework.

Constructivist Learning Environment Survey (CLES) was developed by Peter Taylor and Barry Fraser at Curtin University of Technology in Perth, Australia (Taylor, et al., 1995). The survey enables researchers and teacher educators to evaluate constructivist teaching approaches in classrooms, including the extent to which these approaches are understood by their students. It contains 25 statements in a pre course and post course survey format that indicate if any constructivist aspects are preferred in the classroom learning environment and later if these aspects are noticed in that environment. The survey measures both the teacher’s and students’ perceptions of the classroom learning environment.

Interpretivism is a methodology framework that is concerned with understanding, “shared meaning and shared concepts that are created within discourse and activities that allow us to negotiate differences in meaning and interpretation” (Morehouse, 2012, p. 22). Interpretivism is usually a framework located within qualitative methods.

Mixed methods is a study design in which the researcher collects and analyses data by integrating and drawing inferences of the findings using quantitative as well as qualitative methods (Teddlie & Tashakkori, 2006).
The New Zealand Curriculum is the national curriculum document, disseminated by the Ministry of Education, that defines what each required subject learning area is, the structure of that area, the achievement objectives, and the outcomes for students in English medium schools for New Entrants to Year 13 (5-17 year olds) (Ministry of Education, 2007). Subject learning areas in the curriculum are English, The Arts (dance, drama, music, visual arts), Health and Physical Education, Languages, Mathematics and Statistics, Science, Social Sciences and Technology.

Pre-service teachers are students enrolled at one of six university Colleges or Faculties of Education working towards a primary teaching qualification to teach New Entrants to Year 8 students (5-12 year olds). For this study, the pre-service teacher students may be enrolled full or part-time but not by studying via a distance programme. The pre-service teachers in this study are in their first year of their undergraduate education degree. In the research literature, the words student teacher as well as education student are both used and have the same meaning.

Pre-service teacher education is defined as the initial education programme (ITE), undertaken to achieve a teaching degree. It includes the courses in pedagogy and subject learning areas as well as the teaching practicum in schools. The successful completion of the programme’s coursework allows a person to seek work as a provisionally registered teacher in New Zealand. Some studies use pre-service teacher education interchangeably with pre-service teacher training.

Primary science coursework is the university course or paper completed during pre-service primary teacher education that relates to the learning and teaching of science concepts, pedagogy and/or activities. Depending on how the university offers the coursework, it may be a stand-alone science course or an integrated course with other primary curriculum
learning areas. For this study, the course occurs during the first year of the primary teaching degree programme.

*Teacher educators* are defined as all people who teach the pre-service teacher education programme courses and include university staff that work conjointly with the education programme but are from other disciplines (Cameron & Baker, 2004). For this study, only teacher educators employed either full or part-time by a university are included even though other types of institutions employ teacher educators.

### 1.7 Overview of Thesis Chapters

Chapter 1–Introduction and background information on the research study. This chapter outlines the intentions of the study, the development of the research aims and questions as well as what future chapters discuss.

Chapter 2–Literature Review. It details the relevant background information on teacher educators and pre-service teachers in New Zealand. It contains a brief history of the New Zealand curriculum and how science developed as a curriculum area. The chapter also includes a review of constructivism as well as background information on the development of classroom learning environment studies in regards to the CLES. Finally, the chapter reviews how this research relates and adds to the knowledge of pre-service primary science education.

Chapter 3–Methodology. This chapter contains an overview of the methodology chosen for this study and the reasons behind those choices. The aims, research questions and hypotheses of the research are stated. Discussed in this section are the research tools used and the issues of validity/trustworthiness and reliability/dependability. The chapter also includes a brief discussion of the analysis techniques employed with the obtained data. The survey participants’ demographic information is located in this chapter.
Chapter 4–CLES Data Results. The CLES scale summary data is examined first for issues of validity. Next, statistical analysis of the CLES data reveals whether there is any evidence to support or refute the research questions. Paired-samples t-tests of individuals who completed both the Preferred and Actual surveys are analysed as well as comparisons of the CLES teacher educators’ results to their pre-service teachers’ results. To investigate teaching consistency, paired-samples t-tests with the different sections of pre-service teachers and, where possible, comparisons between different teacher educators are made. Demographic factors such as gender, ethnicity, science qualifications and age, group the data for analysis using independent-samples t-tests and ANOVAs. The use of demographic factors is to review if other variables influence the pre-service teachers’ perceptions of the classroom learning environment.

Chapter 5–Syllabi, Semi-Structured Interviews and Effective Pedagogy Approaches. This chapter contains a review of the courses’ syllabi that outlines the primary science course’s structure. A comparison of the syllabi results to the CLES data findings indicate if any alignment between the two exists. The use of analytic induction on the semi-structured interview data explores themes that emerge relating to the research questions. A discussion of the study’s data that supports the curriculum’s effective pedagogy approaches completes the chapter.

Chapter 6–Conclusions. This chapter discusses the major findings and what the wider implications are for teacher educators and primary science at the university level. Further areas for research are proposed and limitations to the study stated.

Following the references there are several appendices containing CLES forms, interview questions, permission forms for participants, graphs and statistical tables.
1.8 Summary

This chapter introduces the topic of the study and outlines, in brief, the background information that informs the research questions. Justification as to why this topic should be researched is outlined. Definitions of key words used in this study and the outline of the thesis chapters are presented.

The purpose of the research, to identify aspects of teacher educators’ classroom learning environments and practices that have particular impact on pre-service teachers’ pedagogical understandings in primary science, is described. The study aims to identify both the teacher educators’ perceptions of their classroom learning environment and the pre-service teachers. The extent to which the classroom learning environment is modelled, if at all, on The New Zealand Curriculum’s effective pedagogy approaches is considered relevant to review as it is a new part of the curriculum document. As the most recent curriculum’s effective pedagogy approaches are constructivist in nature (Barker, 2008), it is reasoned to be important to examine if there is an existing familiarity with, as well as the ability to adopt, these tenets by pre-service teachers. The aims lead to the three research questions regarding the extent to which teacher educators and pre-service teachers share perceptions of the classroom learning environment, if there are any changes in perceptions and what in the university course may influence the future pedagogy practices of pre-service teachers in primary science.
Chapter 2–Literature Review

The purpose of this chapter is to review the relevant literature in regards to the research questions posed in Chapter 1, Section 1.3, regarding teacher educators’ and pre-service teachers’ perceptions of the primary science classroom learning environment. Included in this chapter is literature on the New Zealand teacher education process, specifically detailing primary teaching, as this literature also informs the research questions posed earlier. In addition, this review contains relevant literature on the history of the New Zealand curriculum. The review looks at how in this document, the subject area of science changed over time, as it is important to understand how this change relates to science in the curriculum today.

This review begins in Section 2.1, which describes how the research literature was located, evaluated and selected for the literature review. In Section 2.2 the focus is on the background literature that is relevant to the topic of teacher educators, specifically exploring the issues of becoming university teacher educators and their teaching expertise. In Section 2.3 there is information regarding New Zealand’s primary teacher education programmes with an emphasis on primary science education, including the practicum. The section also examines the issues stated in the literature regarding primary school science teaching in New Zealand as well as internationally. Section 2.4 begins with a brief historical review of New Zealand’s curriculum documents, the development of science in the curriculum and a discussion of the current curriculum document, which contains information on the effective pedagogy approaches. Section 2.5 reviews constructivism and the literature surrounding it as a teaching and learning theory in primary science education. Finally, in Section 2.6, the background information on classroom learning environments and the Constructivist Learning
Environment Survey or CLES is presented. The literature review closes with a summary of the chapter.

2.1 How the Literature Was Selected for Inclusion

As this study is set in New Zealand, a discussion of the research literature within this context is throughout the chapter’s sections. Due to the limited number of relevant published studies, however, international literature is used to clarify or question the New Zealand research. As the international literature regarding the research topic is vast, the studies chosen for use in this review complemented or extended the literature located within the New Zealand context.

Literature was located by doing online searches using the key terms introduced in Chapter 1, i.e. teacher educator, pre-service teacher, constructivism, classroom learning environment and primary science. Databases used included, but were not limited to, Academic Search Complete, Google Scholar, ProQuest, ERIC (Education Resources Information Center), Te Puna (National Library of New Zealand), Ministry of Education and their online publishing websites, New Zealand Council of Educational Research (NZCER), and the Education Review Office (ERO). Time also was spent in the University of Otago’s libraries looking through archived materials and books that could not be found online. Almost all of the literature used in this review is from peer-reviewed journals, books, published anthologies, government reports and conference proceedings. The literature was selected is for its academic rigour or, in the case of government reports, included for the potential policy initiatives that may develop. The variety of chosen resources also developed a well-rounded understanding of the research topic. The use of items that were not peer-reviewed highlighted non-research study details. Studies older than 10 years provided historical background information, while all attempts were made to use the most recent
research studies available. In order to relate the research to the most current resources available, almost 50% of the studies cited are 10 years old or less.

The exclusion of literature in the topic area occurred when it did not have the research focus this study pursued. As the study’s focus is primary school science, the only use of secondary school science studies was when necessary, such as for showing the validation progression of the survey tool. Other areas of primary pre-service coursework (i.e. the arts, social sciences) also were not included as pedagogy and curriculum emphasis may not align with that in the primary science course. Foreign language articles were used when a translation in English was available.

Even though *The New Zealand Curriculum* is referenced in this research, curriculum development research studies were not used as this thesis looks specifically at the relationship between teacher educators, pre-service teachers and the constructivist learning environment created during the primary science coursework. As the New Zealand curriculum document now contains a section highlighting effective pedagogy approaches that can be linked to constructivist tenets, the curriculum document is used as the backdrop of why it is important pre-service teachers understand these pedagogy approaches. No other curriculum issues were considered in the literature review, as these go beyond the thesis’ focus.

### 2.2 Teacher Educator Research

Teacher educators, the individuals who teach pre-service teachers, are a relatively unexplored research area both nationally (Cameron & Baker, 2004) and internationally (Allen, 2003; Murray & Male, 2005; Northfield, 1998; Smith, 2005). It is a research field that is growing and various countries are initiating research into this area, as there is a need to better understand the role of the teacher educator within the teacher education profession (Berry & Loughran, 2012; Cochran-Smith, 2003; Korthagen, Loughran, & Lunenberg, 2005).
More published research is required on the many facets of teacher educators’ professional knowledge and how this knowledge is conveyed and understood by pre-service teachers.

2.2.1 Teacher educator expertise. Internationally, little research or attention has been given to the quality or expertise of teacher educators (Murray & Male, 2005; Northfield, 1998; Smith, 2005). Nationally, there are limited numbers of studies that investigate teacher educators’ professional communities, their experiences teaching in different education programmes, their underlying beliefs, and their professional development as teacher educators (Cameron & Baker, 2004; Whatman, 1997). Some countries such as the Netherlands and the United States have nationally stated standards for teacher educators’ professional knowledge whereas others, like England, do not (Murray & Male, 2005). The latter is the case in New Zealand as the New Zealand Teachers Council stated on their website that staff members who educate pre-service teachers only needed to, “bring knowledge of teacher education and have had personal experience of effective teaching in the particular sector” (New Zealand Teachers Council, 2010, para. 14). In the Teachers Council’s latest document for approval and review of ITE programmes it noted that the teachers of teachers should model teaching practices, create learning experiences that are powerful, link theory to practice, assess pre-service teachers’ progress, and support the pre-service teachers’ progress and understanding of practice (New Zealand Teachers Council, 2010). In addition to this lengthy list, as all Colleges of Education have merged with a university, expectations were now that teacher educators also conduct research and advance the knowledge in the field of education (Cameron & Baker, 2004).

With high stakes testing, standards and changing curriculum areas, teacher educators have to prepare pre-service teachers to competently manage change, as well as cope with an altering educational landscape. Cochran-Smith (2003) summarised several international studies that researched these issues. Her review reported that in the United States, teacher
educators have to prepare pre-service teachers to teach to new K-12 curriculum standards, to teach to the needs of a diverse student population and to have students pass high stakes tests. In addition, teacher educators have to conduct and publish research as well. In Australia she noted serious issues arose with reforms proposed in a national report on initial teacher education that teacher educators were supposed to enact, as it did not address the context and culture in which teacher educators actually work. In Norway, Cochran-Smith highlighted that teacher educators have to develop a culture of research as well as maintain a strong teaching tradition. In Israel, she reported on an experimental programme that brought teacher educators together to address the concern that their educational needs were being ignored. The analysis of studies from Cochran-Smith (2003) indicated that attention to what teacher educators know, and what structures are in place to support teacher educators when they are preparing pre-service teachers to meet the demands of teaching today, is required.

The role of preparing others to handle the changing demands of being a classroom teacher appears to be an important one and it raises the question of how one becomes a teacher educator. In New Zealand, teacher educators tend to be successful classroom teachers who held leadership positions at their schools before becoming teacher educators (Cameron & Baker, 2004; Russell & Chapman, 2001). Yet there is little New Zealand research that explores how teachers negotiate the transition from classroom teacher to university educator, nor teacher educators’ contributions to pre-service teachers’ learning (Cameron & Baker, 2004).

Of the international studies located, Murray and Male (2005) interviewed and gathered biographical data on 28 relatively new teacher educators. In their qualitative interpretive study set in England, they reported that teacher educators took 2-3 years before feeling comfortable with their new identity as teachers of teachers. Similar results to the research stated above were concluded in the few studies located in the New Zealand literature. A
study presented at the 1997 New Zealand Association of Research in Education (NZARE) Conference interviewed four individuals and asked them how they negotiated their transition from the secondary classroom to becoming teacher educators. The process was described as, “...a slow, often painful, and frequently haphazard one” (Whatman, 1997, p. 11). The only methods stated in this small-scale study were interviewing and coding for themes that exist in the research literature. While this study raised awareness of the difficulty individuals had with transitioning from teachers to teacher educators, it did not explore in any depth, how pre-service teachers understand teacher educators’ pedagogy and modelling during coursework.

Russell and Chapman (2001) examined the perceptions of 25 New Zealand teacher educators on short-term university contracts about their teaching experiences at university. In a qualitative study drawing on the interpretive paradigm, they used a predominately open-ended questionnaire to structure the interview questions. What the interviews with teacher educators revealed was that an induction programme into university culture and organisation would have assisted the new teacher educators to make a smooth transition to teach at the university level. The researchers did not assess the teachers’ pedagogical transition to teaching adults, but they stated that many of the teacher educators struggled when returning to teach in a primary or secondary classroom. There were varieties of reasons given as to why former teacher educators struggled returning to the classroom, such as, colleagues’ disinterest and that they felt unwanted back at school. However, several did say going back to teaching children was now difficult compared to teaching adults. On the positive side, those that did return to the classroom felt their pedagogy and understanding of research to improve practice increased dramatically.

Another New Zealand qualitative study, that used a socio-cognitive and a socio-cultural focus, interviewed and surveyed 27 early career primary teachers. These teachers stated that there was not any support for them to take their knowledge of teaching children and modify it
Researchers have worked on understanding how teachers know what to teach and then how to teach it. Shulman (1986) developed the knowledge of knowing how to teach and what to teach into the theoretical constructs of subject content knowledge (CK) and pedagogical content knowledge (PCK) to understand the knowledge that teachers acquire and use when teaching. Shulman suggested that teachers draw on these knowledge constructs when teaching. PCK includes, “an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons” (Shulman, 1986, p. 9). CK by contrast, is defined as the subject matter that is taught and the, “organization of the knowledge per se in the mind of the teacher” (Shulman, 1986, p. 9). Every subject area holds its own PCK in addition to its CK. Science PCK can then be seen as, “…the amalgam of a teacher’s pedagogy and understanding of (science) content such that it influences their teaching in ways that will best engender students’ (science) learning for understanding” (Loughran, Mulhall, & Berry, 2004, p. 371). As both of these constructs are seen as necessary for competent teaching (Loughran, et al., 2004; Shulman, 1986), teacher educators should begin to develop solid science CK and effective PCK in pre-service teachers.

Internationally there is little research on the knowledge and subject matter that teacher educators need to teach pre-service teachers in the CK and PCK they later need in the classroom (Cochran-Smith, 2003). A literature review of New Zealand studies into initial teacher education by Cameron and Baker (2004) recommended that more research was required into how teacher educators, “conceptualise the knowledge and understandings that
they seek to develop in student teachers” (p. 35). In a report reviewing the quality of New Zealand initial teacher education, Cameron (2004), asked how teacher educators explore whether pre-service teachers acquired the skills and knowledge deemed important for them to learn. A more recent government report into the state of Year 5-8 (9-12 year olds) primary science in New Zealand indicated that pre-service science teacher education programmes needed to be, “well-considered pre-service training that effectively prepares them [teachers] for teaching science” (Education Review Office, 2012, p. 22). The report did not suggest how to measure or observe effective preparation.

2.2.2 Teaching issues for teacher educators. Russell and Chapman’s (2001) qualitative interpretive New Zealand study, which interviewed short-term contract teacher educators, determined there is a reported lack of sufficient time for teacher educators to develop pre-service teachers’ depth of understanding on science topics otherwise known as science CK. This lack of time in science coursework during teacher education continues in New Zealand as indicated by the 2012 Ian Axford Fulbright report on public policy. The author synthesised science information on primary and secondary schools and tried to make sense of the policies that guide science delivery. He reported that some university science educators estimated that some primary pre-service teachers received as little as 8 hours of coursework in their bachelor degree programme and that 1 year postgraduate programmes were even less likely to have a science course component (Vannier, 2012). As pre-service science education has been indicated as a significant factor for schools being able to provide high quality science teaching and learning (Education Review Office, 2010), less science course time for pre-service teachers does not bode well for future science teaching in schools.

Even if teacher educators appear to have the time to educate pre-service teachers in how to teach science, there may still be difficulties encountered in the university classroom. Cannon (1997), citing Champagne and Klopfer’s 1984 review of cognitive psychology
research in science education, indicated that there is accumulating evidence that texts, lectures and experiments used in class by professors were often not interpreted by university students in the way these were intended. If there is trouble in the general university student body in interpreting science coursework, what does this mean for teacher educators who have pre-service teachers that are required to understand both CK and PCK?

Whether there appear to be constraints on developing science CK, questions remain on how to adequately develop PCK in pre-service courses. An Israeli research team reported that the PCK of interviewed classroom teachers and their mental models of PCK were not constructed from their pre-service education or from professional development courses (Strauss, 1993). The findings of the study indicated that PCK came from the teachers’ own experiences and beliefs of teaching and that their PCK was resistant to change. The study did not give an indication of the methodology or how many teachers the researchers interviewed.

Pre-service teachers have well-established conceptions about teaching by the time they enter their teacher education studies (Gunstone & Northfield, 1994). Researchers conducting a mixed methods study focused on 27 primary pre-service teachers in the western United States. The study found that many of the pre-service teachers’ teaching conceptions are based on their previous schooling, much of which was in a traditional didactic style–textbooks and lectures (Stofflett & Stoddart, 1994). This study concluded that unless pre-service teachers experience learning in a constructivist or conceptual change manner themselves, they would struggle to teach in this pedagogic style. While it appears possible to change pedagogy practices if pre-service teachers experience learning the way they are expected to teach science, this alone does not guarantee a change. Duit and Treagust’s (2003) analysis of 3 decades of conceptual change studies concluded that it is difficult to change teachers’ views on teaching and what they do in their everyday classroom practice. These difficult to change views are attributed to, in part, the theory-practice gap. The theory-practice gap is the
difference between using the pedagogic theory suggested by research results (theory) and what teachers actually do in the classroom (practice).

The familiarity with teaching in a didactic style led Carter to complete a meta-analysis of the learning to teach research in 1990. She indicated there are limited changes in pre-service teachers’ teaching conceptions after university coursework (Carter, 1990). Other researchers have questioned these findings and reported data that do show changes in pre-service teachers’ beliefs, but with long-term consistent support (Zeichner & Gore, 1990). A review of 93 empirical studies that focused on how beginning and pre-service teachers learn to teach (Wideen, Mayer-Smith & Moon, 1998), noted that traditional education programmes did little to change firmly held teaching beliefs by teachers. Programmes that did effect change were long term, systematic and built upon the teachers’ beliefs in a collaborative manner. Other researchers, employing a cognitive constructivist perspective within a case study methodology, used a single pre-service teacher and described that change in teacher’s or pre-service teacher’s beliefs did not always translate into a change of practice in the classroom (Bryan & Abell, 1999). This research participant indicated that to modify her teaching practice to align more closely with her beliefs would be a difficult and thought-provoking task.

Asoko (2000) and Loughran (2007) both reported that when first entering the classroom, pre-service teachers referred to how they were taught a subject, especially if they were not confident in CK or PCK. Many pre-service teachers, however, did not remember doing science in primary school and if they did, they remembered reading textbooks and answering questions (Smith, 2000). Smith (2000) reported in her research on pre-service primary teachers that even if pre-service teachers remembered doing hands-on activities they usually could not tell her what they learned during the hands-on activities. This study used
interviews, coursework and videotaped class sessions, but the article did not contain the methodology or number of pre-service teachers in the 2 year study.

Some researchers recommended that to change how teachers teach in the classroom, their epistemology, their knowledge on how science knowledge is constructed, and their views about science, would have to be transformed (Gil-Pérez et al., 2002). However, Smith reported that when this was the focus of the university education course, the pre-service teachers felt they were not receiving enough information on how to teach primary science. Rather, they felt that the teacher educator complicated their ideas on what science is and how to teach it (Smith, 2000), as many pre-service teachers wanted teacher educators to demonstrate activities they could use. Research indicated, however, that just using activities themselves was not enough. Thus, making sense of science for oneself is what is important, for making sense is a mental task, not just a physical hands-on one (Driver, Asoko, Leach, Scott, & Mortimer, 1994; Gunstone, 2000). A researcher in New Zealand, that used an action research design in a case study approach, reported using simulations and reflections to teach primary science CK and PCK. This approach helped the pre-service teachers use their course knowledge and change it into knowledge they could use when teaching (Hume, 2012). The study was with 11 pre-service teachers who took an optional second year course. The researcher did not specify whether the successful approach in the study could be applied to a first year course.

In addition to having pre-service teachers understand their own ideas in science, Connor, Lancaster and McGrath’s (2008) New Zealand survey study of 104 pre-service teachers, teacher educators and classroom teachers, stated that in good initial teacher education programmes, pedagogical modelling was important as was critical reflection. These points indicate there are many things for a teacher educator to do:
Making the tacit explicit, building the knowledge of science teaching and learning practices in ways that are accessible and useable by teacher educators and their student teachers is fundamental to a pedagogy of teacher education and is a meaningful response to the calls for science teacher education reform. (Berry & Loughran, 2012, p. 413)

If teacher educators are to create new knowledge in and about teaching (Smith, 2005) with their pre-service teachers, this leads to the question, what are pre-service teachers actually understanding from their pre-service science coursework? What, if any, pedagogy changes can teacher educators hope to achieve in the course time allocated for primary science in New Zealand?

### 2.3 Pre-Service Primary Teacher Education Programmes

In New Zealand, as in many countries, there is an increasing acknowledgement of the influential role that teacher education programmes play in enhancing the teaching skills of teachers (Cameron & Baker, 2004; Cochran-Smith, 2005; Northfield, 1998). To become a registered primary teacher in New Zealand, one spends several years studying at 1 of 15 teacher education providers (Teach NZ, 2012). These providers are a mix of private institutions, wānanga² and universities, which offer bachelor degrees in teaching or education in the primary sector. Even with this choice of institutions, 90% of individuals choose to study primary teaching at a university education provider (Kane, 2005a).

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² Wānanga are tertiary institutions that provide education in a Māori cultural context. This form of education was set up in 1989 in section 162 of the Education Act.
The educational process of studying to become a teacher is designed to prepare individuals to be successful and competent in the classroom (New Zealand Teachers Council, 2007). There are several ways in New Zealand to complete a teaching degree in primary education. One pathway is to enter the primary teaching programme already holding a degree and complete a 1 year graduate programme. Another pathway is a 3 or 4 year undergraduate programme for individuals who do not already hold a bachelor degree. After an individual graduates, the person applies for provisional registration. During the provisional registration period, 2 years of mentoring the beginning teacher by a fully registered teacher is required before the beginning teacher can gain full registration. This is in part to help beginning teachers remain in the teaching field during this difficult transition period as the reality of fulltime classroom teaching is encountered (Wong, 2004).

During the teacher education programme, pre-service primary teachers learn to teach the curriculum learning areas listed in The New Zealand Curriculum as well as learn education pedagogy. Which curriculum learning areas are covered by pre-service education depend on the education provider’s required courses, with science sometimes not being compulsory (Education Review Office, 2010). The New Zealand Curriculum contains eight learning areas with multiple sub-areas under each learning area. In addition to many curriculum learning areas and sub-areas, pre-service primary teachers also need to learn to teach at a variety of knowledge levels, listed as one through four that cover 5-12 year old children or school years 1 through 8. Preparing pre-service teachers to have, “multiple curriculum expertise” (Conner, et al., 2008, p. 3) is a challenge for teacher educators.

In New Zealand, Connor et al. (2008) described teacher education coursework as sessions that were usually delivered in small group settings. These groups engaged in interactive experiences, with individuals learning more from the small groups of peers rather than the teacher educator. This format changed at some institutions where large lectures are
currently used in addition to smaller group settings (University of Otago College of Education, 2011). As this is an intense learning time for pre-service teachers, knowing how the courses are affecting their content knowledge and pedagogical development are important. The Education Review Office (2010) report of science in Years 5-8 (9-12 year olds) contained recommendations that the providers of pre-service primary education, “should review the way science and other compulsory areas of the curriculum are taught in pre-service teacher education programmes” (p. 34) as concerns about science teaching in primary schools were noted.

2.3.1 Review of primary science education. In a review of initial teacher education, Cameron and Baker (2004) summarised several New Zealand studies of CK in mathematics, information and communication technology (ICT) and science among pre-service teachers in primary and secondary education. Even though the studies were not comprehensive enough to provide conclusive evidence, implications of the study were that pre-service teachers in the studies began teacher education without sufficient CK to support effective teaching in these areas. It was also noted that this area clearly needed further research; to review if graduating pre-service teachers were competent in teaching positively in the aforementioned subjects.

Pre-service teachers generally rely on the science CK they bring to the university classroom (Feiman-Nemser, 1990) as the coursework they take will more often focus on pedagogy, the how to teach, with most up-skilling on science content knowledge left to the pre-service teacher to develop at a later time (Lewthwaite, 2001). Stoddart, Connell, Stofflett and Peck (1993) had 49 pre-service primary teachers enrolled at a western United States university take a science content exam of 12 questions on the topic of the water cycle, a topic usually taught at the primary school level. On 10 of the 12 items, 60-90% of the pre-service teachers’ coded responses were naïve or scientifically naïve. Only two of the coded items
were considered as having a scientific understanding but then with only 64% and 45% of the respondents.

Even if the pre-service teacher is proactive and enrolls in other university science courses to improve CK, these have not been found to increase CK understanding, as the science courses are usually taught via lecture with predetermined laboratory outcomes so that students do not need to develop conceptual understandings of the subject (Stoddart, et al., 1993). This issue was noted in the above mentioned water cycle response study, as the pre-service teachers recently completed three prerequisite science courses before taking the science teaching methods course. Hence, with these issues and limited time to develop CK, concerns about pre-service teacher preparedness in the subject area of science arise.

Baker and Jones (2005) identified a similar concern regarding the adequacy of both CK and PCK in science among New Zealand classroom teachers citing an ERO report entitled In Time for the Future (Education Review Office, 2000). This report contained a number of strategies for improving the teaching of science in primary schools such as improving CK and science PCK of teachers. Additional ERO reports in 2010 and 2012 of Years 5-8 science suggested that issues of CK and PCK had not been resolved. Stated within the ERO 2010 report was, “In general teachers had not learnt about science as part of their pre-service education. Science was not a compulsory aspect of their training, despite being a compulsory part of the school curriculum” (Education Review Office, 2010, p. 11). After the release of the ERO 2010 report, the New Zealand Prime Minister’s Chief Science Advisor also recommended a review of pre-service primary science education courses as he saw education as a way to implement long-term changes in primary science teaching (Gluckman, 2011).

Following the ERO 2010 report, another commissioned report reviewed science in primary schools. The ERO 2012 Science Report again contained concerns regarding the
overall quality of science learning and teaching in Years 5-8 (Education Review Office, 2012). Within this report was a recommendation that the New Zealand Teachers Council, the professional and regulatory body for teachers, reviewed how pre-service teachers were educated in primary science. A timeframe was not in the report to specify when to complete the review or what indicated successfully meeting the goal of educating primary teachers in science.

Calls for improvement to teacher education preparation in the teaching of science were also apparent in the international literature and have been for many decades (Allen, 2003; Appleton & Symington, 1996; Cochran-Smith, 2005). Making improvements a reality, however, usually requires extra funding or entails additional resources from governments or universities; both institutions that already have many demands on limited resources.

2.3.2 Practicum experience. In addition to the issues of lack of science CK and PCK, other difficulties for New Zealand pre-service teachers are not observing science taught by experienced teachers or teaching it themselves while on practicum. O’Sullivan’s (2008) study of 28 third year primary pre-service teachers and Anderson et al.’s (2009) questionnaire study of 33 primary pre-service teachers mentioned these issues. However, it is not just a New Zealand problem. Marion, Hewson, Tabachnick and Blomker’s (1999) research on conceptual change teaching courses in the Midwest of the United States described that many of the pre-service teachers were not able to practise the science pedagogy they learned in class as the practicum school had them teach other curriculum areas during their placement. Varma, Volkmann and Hanuscin’s (2009) qualitative naturalistic inquiry study reported that 28% of the 40 pre-service primary teachers participating in their United States study indicated that their associate teachers were not teaching science during their practicum times. Not teaching science was due to other subjects’ priority over science, preparation time required for standardised tests, or their observation times did not coincide with a science class. In
Australia, a qualitative research study indicated that practising teachers who have little confidence to teach science, would be unlikely to have pre-service teachers on practicum teach it either and this would have the effect of, “perpetuating the problem into the next generation of primary teachers” (Kenny, 2010, p. 1268). To assist the next group of pre-service teachers to break this cycle, volunteer teachers in the study, worked with the pre-service teachers on science teaching for 6 weeks. Kenny (2010) concluded from reviewing the reflective journals of the pre-service teachers as well as data from the teachers and principals, this approach appeared to be an effective way to build pre-service teachers confidence in science.

Teaching science successfully while on school practicum was important as a United States study by Cantrell, Young and Moore (2003) reported. The researchers stated that preparing and teaching science had a positive effect on the pre-service teachers’ personal science teaching efficacy. Using the Science Teaching Efficacy Belief Instrument (STEBI) form, a larger statistical effect size was noted on pre-service teachers’ personal science efficacy when they had a successful science teaching time, with the highest effect size ($d = 0.80$) noted if the pre-service teachers were able to teach science more than 3 hours across the 3 weeks of practicum time. The researchers also noted that the personal teaching efficacy could plateau or stagnate, depending on the school culture in which the pre-service teachers were teaching.

In New Zealand, pre-service teachers may encounter a range of teaching situations during their school practicum experiences that can include a mismatch of expectations between their university coursework and the schools in which they are placed (Russell & Chapman, 2001). This issue was also reported in the international literature, as some primary teachers perceived that the university had no relevance in the world of teaching, which encouraged a gap between using the pedagogic theory suggested and what was actually used—
the theory-practice gap (Kenny, 2010; Russell & Chapman, 2001). Korthagen and Kessels’ (1999) review of research studies on developing new approaches to teacher education indicated that connecting theory to practice was often lacking in teacher education programmes. Rivero, Azcarate, Porland, Martin del Pozo, and Harres’s (2011) qualitative study of Spanish pre-service primary teachers reported that the pedagogical theory taught during coursework was interfered with by the pre-service teachers’ ideas on teaching. These ideas were: that students should learn what they are taught and that science holds true knowledge and should therefore be learned exactly (i.e. rote). If a pre-service teacher held the teaching ideas stated above, these ideas impeded understanding and implementing the pedagogy taught during science coursework.

Implementing the pedagogy learned at university can put pre-service teachers in a quandary. Do they teach what they learned or do what the school culture dictates? This learning to teach against the grain (Cochran-Smith, 1991) is a concern for teacher educators and difficult for pre-service teachers to overcome when they are novices and are coping with the fulltime responsibilities of a classroom (Loughran, Brown, & Doecke, 2001). As researchers have a good understanding of what happens once teachers are in the classroom, an investigation is warranted into what pre-service teachers understand of their primary science coursework before they have to potentially struggle with teaching against the grain.

2.3.3 Preparedness to teach primary science. What happens once pre-service teachers are beginning teachers, are in their own classrooms and reflect back on their university teacher preparation in science? Internationally there is a plethora of research on beginning primary teachers and their science teaching. These studies looked particularly at: teachers that taught effectively (Abell & Bryan, 1997; Appleton, 2003; Peterson & Tregast, 1998; Skamp & Mueller, 2001; Traianou, 2006), discourse processes in science (Kelly & Crawford, 1997; Newton & Newton, 2000), science literacy (Harlen, 2001; Holbrook &
Rannikmae, 2007), the teaching practices used with science (Appleton, 2003; Mellado, 1998), and conceptual change processes (Neale, Smith, & Johnson, 1990; Stofflett & Stoddart, 1994). There were few published studies about New Zealand’s primary science teaching preparation. Studies located with a New Zealand context showed that beginning teachers had mixed reviews on how well their teacher educators prepared them for the classroom. An early New Zealand research project by Gray and Renwick (1998) surveyed 402 first year primary teachers and asked them to rate their pre-service science education in the areas of planning, preparedness to teach, and preparedness to assess, among other items. The results showed that 59% felt well prepared to plan science, 53% felt well prepared to teach science and 47% to assess science. These results appeared to indicate that in the late 1990s, teacher educators were preparing almost half of their pre-service teachers well in science education, at least from the pre-service teachers’ point of view. However, an issue remained about how to improve the pre-service teachers that considered themselves poorly prepared in science: 11% to plan, 13% to teach and 18% to assess. As there were no identifiers in the study, the research did not indicate whether it was the same people who rated poorly over all three categories, or if it was a variety of individuals with strengths in one area but not in another.

As with other New Zealand research, this report relied on self-indicated data and only captured a moment at a particular time in the career of the beginning teachers. As such, it was not possible to assess relationships between education coursework and eventual teacher classroom performance.

In comparison, Lewthwaite (2000) reported that 45% of 36 surveyed New Zealand beginning primary teachers, listed inadequate preparation as a reason why they struggled with teaching science. Only 10% listed their pre-service training as very good and another 45% listed it as acceptable. In the same study, 41% of 122 surveyed teachers said their confidence to teach science was not a significant problem, 50% said it was somewhat of a problem and
1% said it was a serious problem. This research study used questionnaires and was completed by Central North Island primary and intermediate teachers including kura kaupapa Māori teachers.

Another New Zealand study used a structured set of questions to measure self-indicated CK in the different science subject strands that primary pre-service teachers would eventually teach in the classroom. In this study, Salter (2000) based his findings on the responses of 79 participants who had recently completed a 1 year teaching diploma programme. He found that pre-service teachers’ understanding varied, with a greater understanding of biological science CK relative to physical sciences CK. Yet, 33% of the pre-service teachers felt more confident in their ability to teach physical science than in their knowledge of this area.

Both of these New Zealand studies’ findings regarding preparation to teach science relied on the teachers’ ability to recall the conditions of their pre-service experience. These studies focused on the CK of pre-service teachers and did not indicate the potential consequences of the findings for the primary students learning science nor did they examine the classroom performance of the beginning teachers. Later research by Lewthwaite (2001) examined the implementation of the science curriculum in New Zealand classrooms by surveying 156 pre-service teachers. He reported 38% of pre-service teachers felt prepared to teach Years 1-8 (5-12 year olds) in science while 29% did not and 33% did not know. The study did not indicate what kind of learning environment there was in the university classroom or what kind of science teaching pedagogy the pre-service/beginning teachers experienced during their teacher education.

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3 Kura kaupapa schools are state accredited Māori language immersion schools where the philosophy and school practices reflect Māori cultural values.
Cameron, Berger, Lovett and Baker’s (2007b) socio-cultural study reviewed how a select group of New Zealand beginning teachers reflected on their teacher preparation. Of the 27 primary teachers interviewed and surveyed, most felt prepared or well prepared by their education programmes to begin teaching, with a number indicating there were areas in which they desired more preparation such as behaviour issues and dealing with parents. As this study’s participants were a specialised group of primary teachers, individuals marked as teachers of promise, it did not review how other beginning primary teachers reviewed their education coursework. This study was longitudinal and continued to follow these beginning teachers. In the next report, 2 years after the initial study, it was noted that only some of these teachers of promise were seeking professional development (PD) that would increase their own CK in subject areas where they identified they required development (Cameron, Berger, Lovett, & Baker, 2007a). There were varieties of reasons listed for this low PD use: lack of time, the school set the subject area for PD, or PD was internal or school based only. The PD offered to these teachers, focused strongly on literacy and numeracy in the primary sector, as PD in these areas had Ministry of Education funding. There was no mention of science PD in the study. When science PD was indicated in government reports, it reflected that New Zealand teachers received less PD in science than teachers in many other countries (Gluckman, 2011).

Anderson et al. (2009) asked New Zealand pre-service primary teachers near the end of their teacher education programme about their pre-service science coursework. The researchers used a questionnaire that contained selected and ranked responses, open-ended questions and a Likert scale. The study gave no indication of the scale, ranking or questions used on the questionnaire. Twenty-nine of 33 primary pre-service teachers felt well-prepared by their coursework and 30 out of 33 felt confident or very confident in their ability to teach science. Even though the majority of pre-service teachers in this study felt confident in their
ability to teach science, due to scheduling issues between the primary science course and school practicum, there were no requirements to teach the science lesson created during the science course. Some science teaching experience was achieved as two-thirds of the primary pre-service teachers reported they were able to teach science while on practicum (Anderson, et al., 2009). There was no indication whether the science teaching was only with small groups of students or with the whole class.

The above mentioned New Zealand studies suggested that pre-service teachers were feeling at least somewhat prepared to teach science in the classroom. Other research studies, discussed in the next section, indicated feeling prepared to teach did not seem to be translating into science being taught or understood by primary students. What is happening to science teaching at primary school if pre-service teachers are indicating they are prepared to teach it?

2.3.4 Having time for and confidence in primary science. Stating that one feels well prepared to teach is not the same as teaching science well, as the following recent national and international reports assessing New Zealand’s primary science highlight. Caygill’s (2008) review of New Zealand’s Year 5 (9-year olds) results in the International Trends in Mathematics and Science Study (TIMSS) indicated significantly less time was being spent on teaching science topics in New Zealand primary classrooms than in the past. There was no discussion in the report as to why less time was spent on teaching science. In the recent 2012 Ministry report on the TIMSS survey of 2010/11, 52 hours per year on average was reported as spent on science teaching in New Zealand Year 5 classrooms compared to 85 hours on average spent internationally (Chamberlain & Caygill, 2012).

A Ministry of Education Research Division Paper used information from the National Education Monitoring Project (NEMP), TIMSS and NZCER surveys to conclude, “the teaching of science at primary school is starting to wane” (Ministry of Education, 2009, p. 6)
and it has been that way for some time. The ERO 2010 Science Report noted the 13 schools studied indicated that science was less of a priority and this low priority was due to the emphasis being on, “numeracy, literacy, inquiry learning, assessment and ICT initiatives…” (Education Review Office, 2010, p. 8). The number of reported hours per year spent on science in the classroom was different in the ERO 2010 report compared to the 2007 TIMSS study (44 versus 60 hours). The ERO 2010 report discussed the variability noted in time spent teaching science between schools as some schools reported it was difficult to count the hours, as science was often integrated with other subjects and it was difficult to separate the science hours out. Also noted in the ERO 2010 report was that in the schools studied, the overall assessment of science was weak, even though the schools had strong literacy and numeracy assessment.

Not devoting much time to studying science was not the only issue reported. There was also a decline in the TIMSS 2006 Year 5 (9-year olds) student mean scores in science. These declined to 1994 levels, even though the preceding three cycles had an increase in scores (Caygill, Sturrock, & Chamberlain, 2007). In the 2010/11 TIMSS report, this trend continued with a decline in mean scores from the 2006 results, with life/earth sciences having the biggest decreases. This result was surprising as life/earth sciences have usually been areas of strength for Year 5 students (Chamberlain & Caygill, 2012). The decline in TIMSS 2010/11 Year 5 mean scores was consistent for ethnic groupings with Pākehā/European, Māori and Asian students having a decline in mean scores from 2006. Only Pasifika students slightly increased their mean scores from 2006, but not significantly. In addition to lower mean scores, Year 5 students held indifferent views to doing science, were not confident in it and were less engaged in their science lessons when compared to their international counterparts (Chamberlain & Caygill, 2012).

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4 Pasifika are people of Polynesian, Micronesian or Melanesian descent.
The New Zealand based NEMP tested and reported on Year 4 (8-year old) and Year 8
(12-year old) students in the curriculum learning areas. Reports in the different learning areas
run in a 4 year cycle and began in 1993. This project used randomly sampled school children
that were from across the country. The primary science survey data for 2007 contained the
information that Year 4 students indicated they did little science at school, increased from 8% in
1999 to 16% in 2007. In addition, Year 8 students with negative attitudes to science
increased from 15% in 1999 to 37% in 2007 (Crooks, et al., 2008).

In 2012, ERO undertook a large study of science after presentation of the results of the
ERO 2010 report. This report on science in Years 5 to 8 found that only 3 out of 100 schools
engaged in highly effective science education and only 24 more taught science effectively
(Education Review Office, 2012). To evaluate the programmes, reviewers with science
curriculum expertise observed lessons in classes, reviewed documents and spoke with school
faculty, trustees and students. The ERO 2012 report listed a range of issues around science in
Years 5-8: teachers’ lack of confidence to teach science, low science CK and PCK, and
flawed investigations and stand-alone lessons that did not clearly align to the curriculum.
Classes where these issues were found had a more teacher-directed approach versus a student-
directed approach or the teacher avoided teaching science (Education Review Office, 2012).
The report indicated that primary students were confused as to whether they were learning
science or technology, or due to poor science planning, they received repetition of science
topics. Since 2004, ERO has reviewed school programmes and during this time ERO stated
its reviewers have not found improvements in New Zealand primary science (Education

Internationally, many of the same issues noted in New Zealand’s primary schools are
also in the literature. Teachers’ lack of confidence to teach science (Watters & Ginns, 2000;
Yates & Goodrum, 1990), low CK and PCK in science (Summers, 1992; Yilmaz-Tuzun,
2008), little time spent on teaching science (Tilgner, 1990), and low priority compared to other subjects (Varma, et al., 2009) are all evident in the literature. For instance, some researchers concluded that beginning teachers’ low self-confidence in teaching science and their dislike of the topic were reasons why some students were not learning science (Smith & Jang, 2011; Tilgner, 1990). Other researchers indicated that teachers did not consider science as important or assigned it a low priority when compared to other subjects like literacy and numeracy (Appleton & Kindt, 1999, 2002; Roden, 2000). When given a low priority, then issues with scheduling time for science teaching arose. If science was not a regular part of the schedule, then it appeared not to be taught very often by the teacher (Patterson, 2011).

International researchers also reported that teachers not feeling confident or disliking science, could lead to the teachers not using recommended teaching strategies that were consistent with current science curricula (Appleton, 2002). Appleton (2003, 2006) indicated that teachers, especially beginning ones, would use strategies from other subjects to teach science. If they could not figure out a strategy to use from another subject, they would then most likely not teach science. Other researchers reported that pre-service teachers would rely on textbooks or transmitting science facts, which was often how they were taught science, to begin their own teaching in science (Stofflett & Stoddart, 1994; Tilgner, 1990), especially if they were not confident in CK or PCK (Asoko, 2000; Loughran, 2007). If teachers did not feel prepared in a subject area, they might neglect teaching it and focus on other curriculum areas in which they felt confident or comfortable to teach (Pickett & Fraser, 2002). They might even resort to teaching science the way they were taught even though they wanted to teach it using more effective pedagogical methods (Smith, 2000). Researchers reported that it was difficult to change teachers’ views on teaching and what they did in their everyday classroom practice (Duit & Treagust, 2003). This difficulty was documented for pre-service teachers as well (Rivero, et al., 2011).
Conversely, de Laat and Watters’ (1995) Australian study used a science self-efficacy survey, reported that primary teachers who felt confident about their ability to teach science did not depend exclusively on textbooks and prescriptive materials, were more creative and attempted to integrate science teaching, albeit focusing more on biology topics as these were seen as easier to teach. Some studies contained the conclusions that preparing beginning teachers with activities that work in science (Appleton, 2002) or that using small group problem solving activities (Jarvis, McKeon, & Taylor, 2005) might also increase their confidence to teach science. In addition, researchers concluded that providing opportunities to actually teach science with support from the mentoring teacher and teacher educator, might be effective in changing science attitudes, raising confidence in science and growth in PCK in pre-service teachers (Ginns & Watters, 1999; Kenny, 2010).

2.3.5 Effects of limited CK and PCK. When pre-service or practising teachers have limited science CK, there are issues that arise when teaching. For example, researchers concluded that some teachers held the same science misconceptions as their primary students or they might not be aware of their students' misconceptions and not be able to offer viable alternative explanations that the pupils would find helpful (Ginns & Watters, 1995). Furthermore, even if teachers learnt what conceptions or misconceptions students held, little to no training was given in what to do with this information (Magnusson, Krajcik, & Borko, 1999). Teachers who struggled with science might even give inappropriate science metaphors or analogies (Osborne & Simon, 1996). A number of researchers argued that good CK and understanding in primary science were important for an effective pedagogy to develop (Carter, Carre, & Bennett, 1993; Grossman, Wilson, & Shulman, 1989). Driver et al. (1994) stated, “If students are to adopt scientific ways of knowing, then intervention and negotiation with an authority, usually the teacher, is essential” (p. 11). This quote indicated that teachers needed science CK and PCK education in order to correct or guide students’ conceptions in
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science to achieve Driver’s statement. Kruger, Summer and Palacio (1990) study’s findings reflected this quote as they stated, “It is difficult to see how a teacher can give children appropriate experiences which enable them to acquire a progressive understanding of science concepts unless the teacher knows and understands what lies at the end of this conceptual development” (p. 395). The teaching strategies, however, that proved effective in creating positive changes in pre-service teachers tended to be time-consuming and needed to be conducted in small groups rather than large lectures. It appeared what was gained in self-confidence was lost by covering less science content. Self-confidence, however, should not be confused with competence in teaching science. Appleton (2003) pointed out unless pre-service teachers also increased their grasp of science CK, it could be argued that they would remain incompetent to teach the subject.

When teachers struggle with how to teach a subject, classroom dynamics are affected. Harlen’s (1997) 2 year Scottish study of primary teachers and science teaching reported that the discourse used in class tended to turn to a teacher-centred method when teachers struggled to teach a subject. Another phase of this study described that a teacher-centred format did not allow for questioning by students because then, teachers might not know how to respond (Harlen & Holroyd, 1997). Furthermore, even if teachers were sufficiently confident to respond to questions, many were not trained to ask students higher order taxonomic questions in science (Harlen & Holroyd, 1997). Not understanding science was a point made also in Newton and Newton’s study (2000), that without questioning and discourse by teachers, there was a lack of causal understanding in science. This issue was a problem because researchers reported that teachers who asked more critical thinking questions impart a better understanding of the nature of science to their students than did teachers who asked this type of question less frequently (Lederman, 2007; Treagust, 2007). With fact recall and lower level questioning, students viewed science as a static, one-right answer subject, not as the
dynamic changing process it really was (Appleton, 2003; Lederman, 1992). Jones and Baker (2005), in their New Zealand pedagogy literature review, suggested that teachers needed to develop a, “richer pedagogical content knowledge to draw on when teaching science” (p. 141). The literature indicated that when teachers were teaching science, most did want to challenge their students and get them thinking. They just did not know how to ask the right type of questions or felt confident to do so.

When the type of coping strategies listed above were the norm in the classroom, students' attainment was limited in science and it was also likely that pupils' attitudes towards science would be detrimentally affected (Harlen & Holroyd, 1997; Osborne & Simon, 1996). It might also lead to an enacted science curriculum that was fragmented and had activities that were unrelated and which might not help primary students progress their conceptual development in science (Appleton, 2003).

2.4 A New Curriculum

With New Zealand’s implementation of a new curriculum document in 2010, changes to the science learning area needed to be understood and enacted differently by teachers and pre-service teachers when compared to the previous curricula. The New Zealand Curriculum (Ministry of Education, 2007) introduced a substantially altered framework for primary and secondary education from that developed in the previous 1993 curriculum documents. The earlier curricula provided an outcomes-focused approach stating what knowledge and skills students were to have (Ministry of Education, 1993). The current curriculum places educational goals within the context of a vision, principles, values, key competencies and achievement objectives in each learning area. Rather than establishing endpoints for educational processes, creating lifelong, confident learners is a major focus (Ministry of Education, 2007). As the achievement objectives are no longer seen as endpoints and there are fewer of them than previously, how to interpret the revised objectives has led to
discussions of them being simplified. Barker (2008) challenged teachers to view the new achievement objects not as less prescribed curriculum content, but as a way to make interconnections between the learning areas more apparent. This curricular progression to develop connections between science and the other learning areas has been a lengthy journey with challenges encountered in the past that still hold true today.

2.4.1 New Zealand’s science curriculum history. Science has been part of the New Zealand curriculum since the Education Act of 1877 (Ewing, 1970). At this time, there was a focus on the scientific method that had students observe and draw conclusions about those observations (Austin, 2001). Problems arose for teachers with having to teach the scientific method that included: lack of CK and PCK by teachers, lack of time and equipment, and pressure on teachers to teach other topics that were seen as more important (Austin, 2001). In 1885, a reorganization of the curriculum was completed, with a reduction in the requirements of elementary (primary) science or the requirements were organised into agricultural knowledge. Some schools interpreted this change as being able to create a garden plot that then would fulfil the science curriculum requirement (Ewing, 1970). In 1904, a new curriculum had science delivered as nature study. This had students observing, drawing and taking nature walks and asking what, how and why questions for Standards One through Two (7-8 year olds) and nature study or elementary science, based on discovery through experiments, for Standards Three through Six (9-12 year olds) (Ewing, 1970). Smaller country schools still focused all standards on nature study and gardening. Opponents of the curriculum changes complained that too much content was to be taught and that not enough equipment and teacher training were available in science (Ewing, 1970). In 1913, a revised curriculum was set that changed nature study and elementary science into compulsory areas for Standard Three upwards (9 year olds and up), not an additional curriculum subject as it was previously. The revised curriculum completely removed nature study and elementary
science for the Standards below Three. During 1919 another revised syllabus was introduced that adapted to the national examinations and was more direct in the science curriculum’s requirements (Ewing, 1970). In 1929, the *Red Book*, a 223-page curriculum, placed nature study as a topic from school entry (5 year olds) up to Standard Four (10 year olds), and upper schooling levels had a shift to the more formal sciences of secondary school, especially chemistry and physics (Ewing, 1970).

Various curriculum documents in science were introduced throughout the following years, with emphasis on different scientific ideas: 1950-nature study and 1961-draft syllabus for general science in Forms I and II (11-12 year olds) but nature study still in lower primary levels (Ewing, 1970). In 1980, the development of *Science Syllabus: Primary to Standard Four* was to assist teachers in the implementation of science. Once again, primary teachers were seen to have too little CK in science and the development of science resource units that were released over time assisted with this issue (Lewthwaite, 2001). In 1988, a draft curriculum for the middle school years was developed following research done at Waikato University by the Learning in Science Project (LISP) (Lewthwaite, 2001). This research presented science teaching in a constructivist vein. In 1993, a new curriculum had science with six strands. Four were contextual (Making Sense of the Living World, Making Sense of the Physical World, Making Sense of the Material World, Making Sense of Planet Earth and Beyond) and included two integrating strands (Making Sense of the Nature of Science and Its Relationship to Technology, Developing Scientific Skills and Attitudes) (Ministry of Education, 1993). As with the other curriculum areas, science was in an individual book, which meant teachers had multiple curriculum books, one for each learning area. The 1993 science curriculum was seen as heavily influenced by the theory and tenets of constructivism (Lewthwaite, 2001; Matthews, 2000). After a review of the implementation of this document, the Education Review Office (ERO) found that teachers with low CK and low confidence in
science struggled to use this curriculum. The current curriculum document supersedes the 1993 science document and now covers all subject learning areas of the curriculum. The Ministry of Education released it in 2007 and schools were to fully implement it by the start of the 2010 school year. A discussion of the current curriculum’s divergent points from the previous 1993 document is in Section 2.4.

Often the politics and economic policies of the day were what drove past curriculum documents and the revisions. These forces also influenced the current document. In the past, political parties looked to the curriculum documents to educate individuals in ways that helped New Zealand become a world leader economically and to develop industrially (Ewing, 1970; Lewthwaite, 2001). Leadership and economics are still a focus of the curriculum today, to educate young people to be the future of the New Zealand economy especially in science and related areas. Yet, teachers today are still struggling with the issues of how to teach science, low science CK, not enough resources and time. These are the same issues encountered in 1877.

2.4.2 The New Zealand Curriculum and effective pedagogy approaches. In science, the current curriculum has an overarching strand called The Nature of Science (NoS) and under this are the four content strands–Living World, Planet Earth and Beyond, Physical World and Material World (Ministry of Education, 2007). The four content strands link to the science subjects of biology, astronomy/geology, physics and chemistry. Primary teachers are to teach all of these content areas using the unifying strand of the NoS to give, “students consistent messages on how science operates” (Education Review Office, 2010, p. 4). NoS, as an overarching strand in science, is a new concept for the curriculum. This thesis did not focus on the NoS strand individually as NoS could be a study in itself. Instead, the complete science strand is the focus as enacted through the pedagogical approaches in the curriculum.
The current curriculum has recommendations for achieving outcomes not stated in the previous document. As teaching is no longer the transmitting of facts from the teacher to the student, a different approach to teaching is required. The curriculum currently includes a list of effective pedagogical approaches that teachers are encouraged to incorporate into their own practice based on, “well-documented evidence about the kinds of teaching approaches that consistently have a positive impact on student learning” (Ministry of Education, 2007, p. 34). The studies used as evidence for the effective pedagogy approaches are not listed online or in the curriculum document. The characteristics of the effective pedagogy approaches—a supportive learning environment, reflective teaching, relevant and shared learning, making links from past learning to new, opportunities to learn, and inquiry—can be closely aligned to principles of social constructivism. For example, learning in a social context, connecting prior experiences to learning, co-constructing knowledge with others, and meeting the knowledge multiple times and in multiple ways (Driver, et al., 1994) are easily linked to constructivist terminology.

Attempts to underpin the science curriculum with constructivist principles have been criticised (Taber, 2010). Matthews (2003) stated that science educators were basing their pedagogy on a relativist and subjectivist base, and not thinking and critiquing where their Kuhnian interpretations were leading them. Aside from the philosophical debate, few primary teachers would have experienced constructivist learning as students; therefore expecting them to teach using these methods would be difficult at best (Appleton & Kindt, 2002). Learning to use this pedagogy requires education at the pre-service level. Conner et al. (2008) noted, “Initial teacher education programmes need to respond to these initiatives…” (p. 2). The initiatives referred to in the quote were the new curriculum document items, as well as Māori and Pasifika education strategies. Many New Zealand primary teachers did not appear to respond to the initiative nor to achieve the aims of the curriculum as they have
students memorise facts and follow recipe style step-by-step science experiments that required little thought or understanding of what happened (Hipkins & English, 2000, Education Review Office, 2010). The students’ hands might be involved but their minds were not engaged. As a result, research indicated New Zealand students often disliked science, did not see it as relevant in their daily lives and avoided taking science classes when at secondary school (Lewthwaite, 2000).

With a curriculum document influenced by constructivist tenets, researching what pre-service teachers understand of constructivism from their primary science course is warranted. As aspects of these constructivist tenets have improved students’ science outcomes, as evidenced in similar pedagogies researched at the University of Waikato with LISP (B. Bell, 2005; Hipkins, et al., 2002), pre-service teachers need to understand and know how the pedagogies support student learning. One way to begin to review what pre-service teachers know is to research what they experience at the pre-service level.

2.5 Constructivism

Use the word constructivism in education today and one will receive as many definitions of it as there are educators in the room. There are proponents of it as a theory for science pedagogy (Driver, et al., 1994; Staver, 1998; Tobin & Tippins, 1993) as well as opponents (Matthews, 2003) or even researchers who question its theoretical assumptions (Gil-Pérez, et al., 2002; Jenkins, 2000; Meyer, 2009). Constructivism, as a learning theory, has been in the literature for a number of decades (Matthews, 2000) but as a theory of teaching and practice more recently (Richardson, 2003). As constructivism develops from a learning theory to a teaching theory, agreed upon knowledge of what constitutes constructivist pedagogy is still in its embryonic stage (Richardson, 2003). Even though its pedagogy is still developing, constructivist influenced science curricula are prevalent in science education in the United States, England and New Zealand (Taber, 2010) as well as Spain, Israel, Canada.
and Australia (Matthews, 2000). To understand the history of constructivism and how it informs this thesis, the following issues are considered.

**2.5.1 Which type of constructivism?** For this study, constructivism is defined as active ways individuals construct meaning or build knowledge (Staver, 1998; Taber, 2010). This includes sense-making interactions between previous understandings and the new ideas and knowledge. Constructivism has a long history, but much of the current meaning given to it was attributed to Piaget’s work on developmental stages and Kuhn’s work on the historical development of science knowledge that together became known as Cognitive Change Theory (Carlsen, 2007). Another major contributor to help define constructivism was Ausubel. Ausubel’s (1962) theory of meaningful learning, which was prominent in educational research in the 1980s, stated that what learners know influenced their current learning foremost; it was up to the instructor to find out what this knowledge was and instruct in a manner that addressed this (Anderson, 2007; Carlsen, 2007; Saleska, 2000). Many of the ideas that constructivism developed from were derived from other academic research areas such as in the fields of cognitive psychology and information processing (Gunstone, 2000).

Posner wrote one of the most influential works on Conceptual Change Theory that proposed that some dissatisfaction with previous understandings had to occur and the new concept had to be acceptable to the learner before a conceptual change in the mind of the individual occurred (Posner, Strike, Hewson, & Gertzog, 1982). Posner’s work still is a major influence on the constructivist field today (Gunstone, 2000). As researchers noticed that society and the environment around the individual influenced learning as well, constructivism was further amended to include the influences of the social constructs of society and called social constructivism (Richardson, 2003). Within social constructivism, Vygotsky’s (1962) work stressed how language and social interactions were important to learning. In social constructivism, students take an active part in a community of learners that
construct knowledge into a community of practice. Later constructivism was linked to Habermas’ critical theory and critical constructivism began to appear in the literature to address the issues of those social constructs that constrained a constructivist learning environment (Taylor, 1998). The constraints may be teacher or student created such as the accepted socio-cultural roles of teacher/student (knowledge provider/passive receiver), myths of science as cold and objective, and that science is created of facts that are delivered and to be known (Taylor, et al., 1995; Taylor, 1998). Eventually radical constructivism was added to the debate to address the ideas of constructivism’s epistemology and how constructivism addressed truth (von Glaserfeld, 1989). This epistemology caused problems for some researchers when the idea of no reality outside the individual could exist, only constructed truths (Townsend, 2008). Von Glaserfeld (1999) wrote about constructivism as a specific worldview, not a theory of learning but a theory of knowing. Matthews (2000) counted 18 different varieties of constructivism in the education literature. As the theorists argued what constructivism is or is not, what was agreed upon was that constructivism had become an integral piece of the pedagogic mainstream (Meyer, 2009). Entering the philosophical exchange regarding the epistemology of constructivism is beyond the scope of this thesis. However, for this study, I wanted to concentrate on how a theory of learning juxtaposes to a theory of teaching that pre-service teachers can then implement in the primary science classroom. Even the critics of constructivism recognised the value of constructivism for use as a science pedagogic philosophy to support good practice (Staver, 1998).

As this thesis’ design specifically looked at science education, the key studies that focused on improving science education in the classroom using a constructivist lens were reviewed. A large portion of constructivist work came from Rosalind Driver’s research in England (Gunstone, 2000) looking at how children made sense of the science they learnt and alternative or misconceptions they held about science phenomena (Driver, et al., 1994). Her
pioneering work set other research into motion such as at the University of Waikato where work by Roger Osborne focused on children’s science understandings and learning (Osborne & Freyberg, 1985). This research, called the Learning in Science Project (LISP), is continued by Beverly Bell and began focusing on teacher development in science (Bell, 1998). The findings from these studies still influence curricula and science education research studies both internationally and nationally.

The constructivist pedagogies that developed from studies such as those listed above have the following characteristics. They:

1. Are student-centred and respect students’ backgrounds and beliefs.
2. Explore knowledge through communicating with the purpose of having a shared and agreed upon understanding.
3. Use a variety of forms (conversation, texts, websites, etc) to introduce formal and informal knowledge into the knowledge exploration.
4. Have tasks that students engage in to change, add, challenge and determine their understandings and beliefs about the knowledge.
5. Develop students’ own understandings of their learning process (metawareness) (Richardson, 2003).

As the definition of what constructivism is and how it is applied in research continues to develop, Richardson’s (2003) summary of constructivist pedagogy suited this thesis’ lens as it stated constructivism was:

…the creation of classroom environments, activities and methods that are grounded in a constructivist theory of learning, with goals that focus on individual students developing deep understandings in the subject matter of interest and habits of mind that aid in future learning. (p. 1627)
2.5.2 Influencing teaching and learning. As stated previously, constructivism is a major influence on elementary science teaching (Carlsen, 2007; Koch, 2006) and learning (Tobin & Tippins, 1993). Most constructivist studies, however, concentrate on the self-confidence of teachers (Appleton, 2003; Appleton & Kindt, 1999), beliefs and attitudes (Beck, Czerniak, & Lumpe, 2000; Palmer, 2002), and pedagogical reflections (Abell, et al., 1997; Patterson, 2011). In New Zealand, the studies located that researched primary science teachers review their confidence (Anderson, et al., 2009), content knowledge (Lewthwaite, 2000), views on teaching (Salter, 2000) and authentic activity models (Hume, 2012). Only one study in New Zealand researched pre-service teachers’ understanding of the constructivist classroom environment and it is in the subject of mathematics (Lomas, 2004).

Richardson (2003) noted that there was not a step-by-step constructivist model that pre-service teachers could learn and then implement in their classrooms. This idea was indicated also in Driver et al.’s (1994) earlier work, that no pedagogical rules emerged from constructivist learning theory, but that important ideas of how teachers could mediate science learning with students had. Driver et al. (1994) stated this process was dialogic; the teacher introduced to students the new ideas and the required tools to understand the science. Next, the teacher evaluated what the students made sense of and helped them to negotiate further understanding. Unfortunately, Driver’s findings could sometimes be misunderstood as one pre-service teacher noted that a science background was not needed in order to teach science because with constructivism, the teacher would just let their students figure things out for themselves (MacKinnon & Scarff-Seatter, 1997).

Many pre-service teachers encounter constructivism for the first time in their education courses. University courses, including education courses, can be taught in a transmission style so pre-service teachers have constructivist theory delivered via a lecture. They are then supposed to go out and implement the theory they have learned. Smith (2005) reported that
Israeli novice teachers expected their teacher educators to model what they were teaching and if they did not, a gap between theory and practice was indicated. Teacher educators realised they had to conduct their own classes in a constructivist style to, “increase the legitimacy of the theory among teacher education students, and to help students develop deep understandings of the teaching process” (Richardson, 2003, p. 1627). However, what the pre-service teachers understand from courses taught in this manner is not well documented. In a case study from the United States using primary teachers enrolled in a 2 year masters programme, Kroll (2004) reported that the theory of constructivism, by itself was different from commonsense ideas. It could be confusing and even ignored by teachers even when it was taught in an engaging format (Kroll, 2004). The masters programme students struggled to, “integrate their growing personal theoretical understandings with their developing teaching practice” (Kroll, 2004, p. 216).

Studies conducted on teachers’ abilities to enact pedagogy indicate that it is not straightforward to have pre-service teachers implement constructivism, even if modelled. In a New Zealand study that used both qualitative and quantitative methods, Lomas (2004) stated that mathematics teacher educators who did not model the constructivist practices they were promoting, had the potential to limit the changes they sought to have the primary pre-service teachers enact. Patterson (2011) reported in a small scale case study of United Kingdom primary pre-service teachers who were able to learn in a constructivist context, that the pre-service teachers would not necessarily be able to translate this context into their own constructivist-informed pedagogy. Many of the constraints to implementing the pedagogy were school related (i.e. limited science teaching time, school culture) while others were due to lack of experience in questioning and science CK. The constraints listed in the study were pre-service teacher reported and not externally reviewed for accuracy.
Constraints to implementing constructivism were also evident in a Turkish study of 300 pre-service science teachers from two public universities using the DASTT-C test (Draw-A-Scientist-Teacher-Test-Checklist) where pre-service teachers draw and explain teacher and student roles. Even though constructivism was addressed during the courses, it was not incorporated into the mental models and drawings by the pre-service science teachers, even though this was an aim of the teaching curriculum (Tartar, Feyzioglu, Buldur, & Akpinar, 2012). Skamp and Mueller (2001) described constraints to constructivism in a study of Canadian primary pre-service teachers of what made a good science teacher. Even though the teacher educator emphasised constructivism, pre-service teachers did not voice changes towards a constructivist approach during interviews, as they retained some of their own teaching conceptions.

Even if pre-service teachers can translate theory into practice, other constraints of implementing practice arise. Savasci and Berlin (2012), in their inductive analytic study in the Midwest of the United States used four experienced teachers from two schools, described the various levels of constructivist pedagogy used in the classrooms. The teachers’ own beliefs of the students’ abilities and behaviours often influenced the use of pedagogy when implementing constructivist practices. If the teachers did not believe the students’ abilities or behaviours were good enough, they reverted to teacher-centred teaching practices even though they espoused constructivist ideals. In another United States study by Haney, Lumpe and Czernaik (2003) completed on the role of beliefs in educational settings, 72 high school teachers, administrators, parents and students answered single open-ended responses on science learning environments using the BALE (Beliefs About Learning Environments) survey instrument. The researchers reported that constructivism was not a pervasive belief of the teachers and even less understood by parents and students. Administrators, however, had a more positive view of constructivism than teachers did. Results from this study noted
support by administrators for teachers using constructivist practices reinforced the teachers’ belief of the practice. Not understanding the use of constructivism held by parents and students, however, might constrain teachers in using this pedagogy.

The studies mentioned above contain recent research findings. Earlier research completed on conceptual change and teachers have the same result findings—teachers revert to old teaching habits and do not implement best practice even with support. As an example, in an earlier United States study, Neale, Smith and Johnson (1990) researched eight primary teachers and the extent the teachers were able to implement a conceptual change science unit. Using interviews, written evaluations and videotaped lessons from a 4 week summer institute programme, a noted positive outcome was teachers learned to consider children’s science ideas when teaching. It was also noted, that the time and the amount of effort required by the teachers to construct the knowledge needed to teach in this manner, hindered the implementation of the pedagogy.

In the United States, Gibson and Van Strat (2001) reported that 14 pre-service teachers who attended university mathematics and science courses taught in a constructivist style as well as in a traditional lecture/note-taking style, rated the constructivist courses as having a positive impact on their attitudes and beliefs when compared to those subjects taught in the traditional format. The courses were over a 3 year period and looked at how the pre-service teachers responded to the different teaching styles over time. The data collection was via questionnaires, tests on conceptual understanding, focus groups, interviews and journals. Stofflett and Stoddart (1994) reported on their United States study where 27 pre-service teachers who experienced learning in a constructivist style, understood the science content better and were more likely to use this pedagogy when teaching. Plourde and Alawiye (2003) randomly selected 90 of the 511 pre-service teachers they surveyed using a Student Attitudes questionnaire to explore the effect of a constructivist learning model on the pre-service
teachers beliefs and the future potential practical application of constructivism in their own classrooms. The relationship had a high positive correlation \((r = .76)\) between pre-service teachers’ constructivist knowledge and the future belief that one day they could apply it. As their knowledge regarding constructivism increased, so did their belief that they would be able to apply it.

The research studies presented above appear to have positive aspects for pre-service teachers; to learn in a constructivist style and a greater possibility of then implementing it when teaching. The questions remain of what is happening in New Zealand primary science education courses? Do pre-service teachers experience learning in a constructivist environment and do they actually notice this?

2.6 Influences of Classroom Learning Environments

Teacher educators are, in part, able to influence the classroom learning environment that pre-service teachers experience. This environment in turn, has an influence on the pre-service teachers and potentially how they create the learning environment when teaching in their own classrooms (Johnson & McClure, 2004; Nix, Fraser, & Ledbetter, 2005). As teaching skills develop during teacher education programmes, research that indicates areas of value as well as areas of improvement for teaching and programming is vital. The classroom learning environment, which is under the teacher educator’s control, has been shown to influence the learning outcomes achieved by pre-service teachers (Harrington & Enochs, 2009; Martin-Dunlop & Fraser, 2012). Information that could improve learning outcomes, is particularly relevant to teacher educators, as constraints over the amount of course time given to primary science have been noted in New Zealand (Russell & Chapman, 2001; Vannier, 2012).
McRobbie and Tobin (1997) defined the classroom learning environment as, “consisting of learners' beliefs about their roles as learners, beliefs about the roles of others in facilitating and inhibiting learning, and beliefs about the extent to which the social and physical milieu constrain learning” (p. 194). In brief, it is the perceptions of the classroom that the teacher and students have and share including the relationships the teacher and students share on a day-to-day basis. For this study, the classroom environment reflects the teacher educators’ pedagogical approaches taught and modelled for pre-service teachers during the primary science courses.

The research area of learning environments has a lengthy history which is summarised well by Fraser (2007, 2012) in several of his publications. Learning environment research stemmed from early social psychology work and one of the earliest recorded research studies was Thomas’ 1920s work in the United States on classroom climate or, “recording explicit classroom phenomena rather than the psychological meaning of events” (Dorman, 2002). Lewin added to Thomas’ research findings in 1936 with his field theory that defined behaviour as a function of the person and the environment (Lewin, 1936). Lewin’s seminal work in educational environments recognised that personal characteristics and the interaction with the environment were strong indicators of human behaviour (Fraser, 1998). Murray extended this work in 1938 to include a needs-press theory–needs are the important determinants of behaviour within the subject and according to Murray, “the press of an object is what it can do to the subject–the power it has to affect the well-being of the subject in one way or another” (Murray, 1938, p. 121). Stern, in 1970, furthered the needs-press theory to include the degree to which the person-environment is congruent and how this relates to student outcomes (Dorman, 2002). This was the basis for the person-environment fit tools used today with a preferred and actual environment assessment that was then related to student outcomes (Fraser, 1998).
In the 1960s, Walberg and Moos independently developed their work in classroom psychosocial environment perceptions from Lewin’s research, and these developed into major research programmes (Fraser, 1998). From Moos and Walberg’s research, two other programmes emerged, one in the Netherlands with Theo Wubbels focusing on the interactions between teachers and students in the classroom and the other in Australia looking at student-centred classrooms (Fraser, 2012). The Australian work developed other research instruments to measure specific parts of the classroom environment: Science Laboratory Environment Inventory (SLEI), What is Happening in this Class? (WIHIC), and the Constructivist Learning Environment Survey (CLES). The work of these researchers over the past several decades led to the development of a variety of widely applicable surveys and questionnaires that researchers could use to evaluate students’ perceptions of classroom environments (Pickett & Fraser, 2002). These survey instruments have been trialled and found to be valid and robust as well as to be a cost effective way to investigate classroom research questions (Martin-Dunlop & Fraser, 2012). In addition to being cost effective, understanding the perceptions of the classroom environment, from the viewpoint of the participants, can yield a wealth of information that an outside observer or researcher may not notice (Pickett & Fraser, 2002). It became apparent that using a survey designed for measuring the classroom learning environment responds to this thesis’ proposed questions of what pre-service teachers understand during their primary science coursework.

2.6.1 CLES. As constructivism is a pedagogical focus in primary science coursework in New Zealand, the CLES is a survey that can illuminate what pre-service teachers understand during their university coursework. Pre-service teachers are still regarded as students in the primary science coursework environment. Studies show student achievement is better when the classroom learning environment fits or is preferred by the student (Fraser & Fisher, 1983; Lizzio, Wilson, & Simons, 2002). Measuring what students (pre-service
teachers) perceive of the coursework is important as teachers’ (teacher educators’) perceptions of their classroom environments are often more positive than their students (pre-service teachers) (Johnson & McClure, 2004). Information that informs practice to help the two views come more into alignment is useful as the belief systems of the teacher and student are powerful forces that shape the learning environment (McRobbie & Tobin, 1997). Investigating what their belief systems are and how these are understood in the context of the classroom learning environment is a step in the direction of informed change for the university primary science classroom.

The classroom learning environment tool in this study, the CLES, provides a format to understand if a constructivist pedagogical structure is used and perceived by both the teacher educators and pre-service teachers. The version of the survey form in this study has a Preferred form that is concerned with goals and value orientations and measures the ideal classroom environment preferred by both the pre-service teachers and teacher educators (Fraser, 2012). The Actual form measures what is perceived during the experience. The wording of the forms is in the personal so individuals filling out the survey think of their own personal experience, not that of the entire class (Fraser, 2012). The wording is similar for both surveys, but for the Preferred version statements start with *In this class I wish*... and the Actual form uses *In this class I*.... For complete examples of the survey forms in this study, refer to Appendix A.

Classroom environment research that used the CLES took place in a variety of countries and with a range of educational levels. The CLES was used in Australia with Year 7–9 science students (Aldridge, et al., 2000; Taylor, Fraser, & Fisher, 1997), in the United States with primary through secondary pre-service and in-service science teachers (Beck, et al., 2000; Harrington & Enochs, 2009; Johnson & McClure, 2004; Nix, et al., 2005), first year university science students and their lecturers in the United States (Cannon, 1997), in the
United States with Year 9–12 science students (Dryden & Fraser, 1998), in Taiwan and Korea with intermediate and high school students (Aldridge, et al., 2000; Lee & Fraser, 2001) and in South Africa with Grade 4–9 classes (Fraser, 2012). All the researchers in the above studies reported that the students surveyed preferred to learn in a constructivist classroom environment, but what the students actually encountered in their environments varied greatly from study to study. In all of the studies recently mentioned, the CLES was found to be valid and reliable. A discussion of the validity and reliability of the CLES for this study is in Chapter 3–Methodology.

The number of classroom environment studies that focus on primary science coursework for pre-service teachers is somewhat limited (Martin-Dunlop & Fraser, 2012). In New Zealand, only one study used the CLES to monitor constructivist learning environments at the university level (Lomas, 2004). Lomas (2004) researched how pre-service teachers understood teacher educators’ constructivist aligned pedagogy practices in the mathematics course when the course’s aims were constructivist. What the researcher reports was that the pre-service teachers perceived constructivism in the course’s environment though there were some variations between classes and between teacher educators (Lomas, 2004). This study informed the teacher educators’ constructivist practices. The CLES then indicated the alignment between teacher educators’ and pre-service teachers’ perceptions of the constructivist environment. As little has been studied about pre-service primary teacher science classroom learning environments within the New Zealand context, there appears to be a need for research that covers this area. As the CLES measures a constructivist environment, this can also assist teacher educators in monitoring the perceived understandings of the effective pedagogy approaches in the curriculum document, as the approaches are also constructivist in nature.
2.7 Summary

As the literature review indicated, little research has been published on New Zealand teacher educators’ primary science classroom learning environments and how pre-service teachers perceive the environment. This is a gap in the research knowledge of teacher education in New Zealand. The majority of studies done in New Zealand reported on how beginning teachers assessed their pre-service primary science education preparation. In the New Zealand studies located they usually did not state the pedagogy nor course structure of how the pre-service teachers were prepared to teach primary science. As many teacher education programmes now state the use of modelling pedagogy practices for pre-service teachers, it is important to understand, “how the situation is interpreted and understood by the student-teachers” (Loughran, 2002, p. 148) and not assume that it is being understood as stated on the syllabus. Research showed that classroom learning environments experienced by university students from all academic areas, including education, influenced their learning outcomes (Lizzio, et al., 2002) and for pre-service teachers, potential teaching pedagogy practice uptake (Johnson & McClure, 2004; Lomas, 2004). Investigating how classroom learning environments develop pre-service teachers’ pedagogical approaches will assist science teacher educators in evaluating how their science course designs move pre-service teachers towards being able to deliver the New Zealand science curriculum through the document’s recommended effective pedagogy approaches. A study understanding the perceptions of classroom constructivist pedagogy by pre-service teachers proved useful for teacher educators teaching a mathematics course for pre-service teachers in Auckland (Lomas, 2004). As published investigations into the perceptions of classroom learning environments during the primary science course in New Zealand are not evident, this thesis assists teacher educators in planning and modifying their teaching practices and understand
the impact their course has on pre-service teachers’ perceptions and potential teaching behaviours.

As *The New Zealand Curriculum* contains a list of effective pedagogy approaches whose tenets align with constructivism, what pre-service teachers understand of constructivism and if they will utilise it in their own classrooms should be researched. As it is probable pre-service teachers will have little recognized experience of constructivism in their own primary and high school science classes, expecting them to implement this pedagogy is likely to be difficult (Appleton & Kindt, 2002). Other issues that have been identified in the literature that impede primary science teaching, such as, being confident to teach science (Appleton & Kindt, 1999; Harlen & Holroyd, 1997), and having time to teach science while on practicum (Anderson et al. 2009; O’Sullivan, 2008) have been well documented. As international and national studies revealed the diminishing quantity and quality of New Zealand primary school science, (Caygill, et al., 2007; Chamberlain & Caygill, 2012; Crooks, et al., 2008; Education Review Office, 2012; Vannier, 2012) the need for research into what is being understood in university primary science coursework by pre-service teachers is highlighted. With the current curriculum imbued with constructivist tenets and many primary teachers not feeling confident to teach science, questions regarding what pre-service teachers understand of their university primary science coursework in regards to constructivism, should be researched.

This chapter reviewed issues of science in the primary school as well as at the teacher education level. One issue highlighted was teacher education preparation. A research study into teacher education preparation indicated that if a teacher did not feel prepared or did not like science, he or she might avoid teaching the topic (Olson & Appleton, 2006). This avoidance to teach science appears to be borne out by three recent New Zealand studies of primary school science. Caygill’s (2008) study indicated significantly less time was being
spent on teaching science topics in New Zealand primary classrooms as well as that current NEMP and TIMMS primary science data indicated a lack of doing and understanding basic science concepts by New Zealand primary students (Chamberlain & Caygill, 2012; Crooks, et al., 2008). These results highlight that research is required in the area of pre-service teachers’ understandings of their primary science preparation to better mitigate science avoidance in future primary classrooms.

As studies from decades of science education have shown, making pedagogical changes is an extremely complex process and it must occur in an informed manner to be successful (Saleska, 2000). Jones and Baker (2005), commenting on the summary of Hipkins et al.’s (2002) New Zealand literature review on pedagogy, indicated that future policy directives were needed in professional development and pre-service teacher education. Amongst the suggested directives, two points reflected the research questions posed in this study. Teachers need a deeper understanding of science CK (Appleton, 2003) and PCK (Jones & Baker, 2005) to use when teaching and teachers need time to develop their teaching conceptual frameworks. The reported short length of some pre-service science education programmes (Vannier, 2012), however, does not allow for this development. Using the data compiled and analysed from this thesis to make informed decisions on how best to prepare first year pre-service teachers to teach science may be the next step in the on-going process of improving teacher preparation programmes.
Chapter 3–Methodology

The purpose of this chapter is to describe and justify the methodology used in this research study. First, in Section 3.1, the aims of the study are stated followed by the research questions that develop from these aims. Following this in Section 3.2 is a discussion of the theoretical framework drawn on to consider the research questions. Next, Section 3.3 contains a review of the methods selected for use and descriptions of the three research instruments employed. In Section 3.4 the administration, data collection and analysis processes used in this study are described. A discussion of the issues around the data’s validity and reliability are in Section 3.5 and Section 3.6. The ethical considerations that required attention within the research framework are in Section 3.7. A description of the participants in the study and a table displaying their self-identified demographic data are in Section 3.8. In the final Section 3.9 is a summary of the Methodology chapter.

3.1 Research Aims and Questions

After synthesising the relevant literature in Chapter 2, a research gap was apparent. This knowledge gap concerns how the university classroom learning environment, created by teacher educators, is understood by first year pre-service teachers as they learn primary science teaching pedagogy in New Zealand. The classroom learning environment experienced by pre-service teachers should contain influences of New Zealand’s curriculum document, as demonstrated through the effective pedagogy approaches. The effective pedagogy approaches are constructivist in nature and constructivism is a major teaching influence in primary science. The points above developed into the aims of this thesis. The aims seek to:
1. Identify aspects of teacher educators’ classroom practices which have particular impact on pre-service teachers’ potential pedagogical practices in primary science.

2. Identify how pre-service teachers perceive characteristics of the learning environment that teacher educators develop in the classroom during the primary science course.

3. Identify teacher educators’ perceptions of their classroom learning environment and the extent to which it is modelled, if at all, on The New Zealand Curriculum’s effective pedagogy approaches.

4. Investigate if the teacher educators’ perceptions, when aligned to the pre-service teachers’, are congruent.

5. Investigate if there is a relationship between pre-service teachers’ understandings and potential teaching behaviours of the primary science classroom environment and demographic factors of gender, ethnicity, age and prior level of science education.

From these aims, the following research questions evolve:

1. How do pre-service primary teachers perceive the university classroom learning environments created by science teacher educators? Do these perceptions change over the duration of the primary science course?

2. What perceptions do science teacher educators have of the classroom learning environments they created and/or modelled for pre-service primary teachers?

3. What aspects of the teacher educators’ primary science course appear to shape the pedagogical approaches the pre-service teachers may use when teaching primary science? Do other factors influence the shaping of the pedagogical approaches?
In an attempt to frame these questions within a research paradigm, a review of several theoretical frameworks took place. The desired lens will frame this project in light of what teacher educators are expected to achieve in the university classroom and what is considered by some academics as the current good science teaching practice. Good science teaching practice is important and has the following characteristics: students’ ideas are elicited, addressed and linked to learning, the science context is meaningful and can link to students’ lives, students are engaged in thinking and considering others’ ideas, learning is scaffolded and the Nature of Science (NoS) is made apparent (Carr et al., 1994; Hipkins, et al., 2002). In addition to using best practice pedagogy, teacher educators are informed by The New Zealand Curriculum and its list of effective pedagogy approaches. Teacher educators should educate pre-service teachers in these effective pedagogy approaches, as pre-service teachers should become familiar with these techniques before entering the teaching workforce. Finding a theoretical framework to view these issues through is a challenge. Though there are many frameworks to choose from in educational research, the questions asked in this study are best framed using the methodology described below.

3.2 The Theoretical Framework Selected

A current influence on primary science education is a concept called constructivism. Constructivism, in its simplest form, is described as learning that is an active process of building knowledge by thinking individuals (Staver, 1998; Taber, 2010). As stated in Chapter 2, the definition of constructivism has evolved over time as researchers work on understanding the complex process of learning. As additional meanings augment the basic definition, descriptors to the word clarify which form constructivism takes. For example, as researchers began to understand how individuals changed their ideas and how social factors influenced the mean-making process, social constructivism developed (Richardson, 2003). When debates on constructivism’s epistemology and how it addressed truth ensued, then the
phrase radical constructivism appeared in the literature (von Glaserfeld, 1989). Later when concerns developed over the social constructs that constrained learning and how the issues of equality were perceived, critical constructivism emerged (Taylor, et al., 1995). While there are many variations discussed in the literature, all with a range of meanings, the basic tenet of all these variations remains the same; that the knowledge is made sense of by the learner (Taber, 2010). For a more in-depth evaluation of constructivism and how it is reflected in this study, refer to Section 2.5 in Chapter 2–Literature Review.

In addition to a variety of types of constructivism, there is also an extensive debate among academics about whether constructivism is a theory of learning and/or a theory of teaching (Matthews, 2000; Staver, 1998). When referred to as a learning theory, constructivism is defined as the individual making sense of knowledge. As this thesis’ research takes place in a university environment, where the pre-service teacher learns about the teaching profession from an experienced teacher, the social aspects of learning also need to be taken into account. Thus this knowledge is:

constructed when individuals engage socially in talk and activities about shared problems or tasks. Making meaning is thus a dialogic process involving persons-in-conversation, and learning is seen as the process by which individuals are introduced to a culture by more skilled members. (Driver, et al., 1994, p. 7)

Constructivism is also defined as a teaching theory. When it is used in this context, it can be understood as classroom goals that focus on students’ abilities to develop deep understandings in subjects through the grounding of activities, environments and teaching methods in a constructivist theory of learning (Richardson, 2003, p. 1627).

As the debate continues about whether constructivism is a theory of learning or teaching or can be used as both, what is agreed upon by educational researchers, is that
constructivism currently is a major influence on elementary science teaching (Carlsen, 2007; Koch, 2006) and learning (Tobin & Tippins, 1993) in Western education systems. As the tenets of constructivism are one of the main teaching and learning strategies that pre-service teachers encounter when learning to teach primary science, teacher educators have the responsibility to teach about this concept. For this study then, the definition of constructivism is how the pre-service teachers make sense of the primary science pedagogy teacher educators teach and what influences and constraints to this learning are noted.

In addition to constructivism being a major influence in science education, *The New Zealand Curriculum* includes a list of effective pedagogy derived from evidence-based teaching approaches that have consistent positive impacts on student learning (Ministry of Education, 2007). This list of seven teaching approaches is grounded within a social-constructivist paradigm that is following on from the earlier *Science in the New Zealand Curriculum* (Ministry of Education, 1993) that promoted this approach (Anderson, et al., 2009, B. Bell, 2005). As constructivist influences are prevalent in the science curriculum document, using constructivism as this study’s research framework to view pre-service teacher education is a viable option.

As stated above, constructivism is usually associated with learning theories, nevertheless, Carlsen (2007) located constructivism clearly within educational research approaches. He stated that it, “has largely supplanted CCT [Cognitive Change Theory] in the science education research vernacular, despite the problem of its many different meanings” (p. 60). CCT developed out of Piaget’s work on developmental stages and Kuhn’s work on the historical development of science knowledge and was prominent in educational research in the 1980s (Anderson, 2007). Even though in education, constructivist theory appears most prominently as an approach to teaching and learning, it is also used as a research framework in international relations, management knowledge, health sciences, psychology and nursing
studies for many years (see the research of Cottone, 2007; Mills, et al., 2006; Petit & Huault, 2008). For these disciplines, constructivism provides an alternative to positivism as a research framework. Guba and Lincoln (1989) stated that constructivist theory rejected the experimental approaches employed in science and replaced them with a hermeneutic/dialectic process that, “takes full advantage, and account, of the observer/observed interaction to create a constructed reality that is as informed and sophisticated as it can be made at a particular point in time” (p. 44).

Using a constructivist research process hinges on having an awareness of the social context of the university education environment as well as the social expectations placed on pre-service teachers and teacher educators. The teaching degree programme has the expectation that a primary pre-service teacher will be able to teach science after successfully completing the coursework. The teacher educators have the expectations that primary pre-service teachers understand the subject matter taught. The pre-service teachers expect that they will be able to teach science after the coursework. It should be noted that pre-service teachers bring different understandings and experiences to the university classroom; they also understand differently what is experienced during coursework. Due to these differences, consideration to the individuals’ interpretations of the phenomena, experienced by all involved in the study not just the researcher’s observations, is necessary. Furthermore, a constructivist framework for this study is a practical application of the research questions as the study is set within the learning environment of the university classroom and the perceptions of that environment by the individuals who experience it.

In the area of learning environment studies, “the constructs regarded as having most salience in a learning environment reflect the theoretical frameworks used by a participant to give meaning to what is experienced” (Tobin & Fraser, 1998, p. 624). As pre-service teachers are making sense of, or constructing meaning, while in the university classroom environment
by interacting with both the teacher educator and peers and engaging in discursive practices (e.g. writing, talking, thinking, reading), a constructivist methodology frames this study well. Within this perspective, learning, “occurs within constantly evolving communities in which the practices of participants are shaped by social structures, relations of power and the nature of the activities in which learners engage” (Tobin & Fraser, 1998, p. 626).

In addition to a constructivist framework, it is desired to view the study through an additional lens to deepen the understanding of the analysed data. The selection of interpretivism is to alter the viewpoint of the research questions, but in a manner complementary to constructivism. This does not cause tensions between the frameworks as interpretivism, for this study, is defined as a process, “whereby a knower (the inquirer as subject) gains knowledge about an object (the meaning of human action)” (Schwandt, 2000, p. 194). It can be seen as seeking to, “understand shared meaning and shared concepts that are created within discourse and activities that allow us to negotiate differences in meaning and interpretation” (Morehouse, 2012, p. 22). As well, interpretive research is concerned with, “the specifics of meaning and of action in social life that takes place in concrete scenes of face-to-face interaction” (Erickson, 1986, p. 131). The interpretive framework complements the constructivist lens to develop a more in-depth understanding of what occurs in the university classroom.

It is not the view of this thesis that paradigms are rigid categories that do not intersect. This position is taken from Kuhn who suggested that rigid paradigm boundaries were not required (Creswell, 2010; Kuhn, 1970). Researchers often return to Kuhn’s work as it is regarded as the seminal work in paradigm debates. Kuhn defined paradigms as information shared within a community of practice (Kuhn, 1970). The shared practice of this thesis research takes place within the education community where constructivism is a major influence. As education is a social process where meaning is derived during discourse and
activities, the lens of interpretivism is important as well. This thesis endeavours to make sense of the research questions using these two frameworks. In tandem, the frameworks review the data, to understand what the perceptions are of the learning environment in the university classroom.

One way to get the best out of the two frameworks and move beyond a rigid single paradigm stance is to employ research tools from both the quantitative and qualitative research traditions. Neither approach has priority over the other; but the two methods collaborate as each area’s expertise comes to the fore. This type of research is called mixed methods and it suits this study. Mixed methods can purposefully use more than one framework lens through collecting different types of information, combining the use of different methods, and, “…the maintenance of different philosophical assumptions about social phenomena and our ability to know them, and the inclusion of diverse values and interests” (Greene, 2001, p. 251). This study researches the social phenomena of pre-service education in the university classroom. Some researchers believe this phenomena can not be fully understood by employing only one method (Teddlie & Tashakkori, 2003) hence, a mixed methods approach is taken to answer the research questions. The use of mixed methods is to complement each other and develop a rich data set that details the perceptions in the university classroom by teacher educators and pre-service teachers. As this study is, in part, researched within the field of learning environments, it is a recommended practice in this research field to use methods from both the quantitative and qualitative frameworks to capitalise on the potentials of each tradition and that the study benefits from the range of approaches taken (Fraser & Walberg, 1991; Tobin & Fraser, 1998).

A mixed methods approach is further warranted in this research situation as a variety of data sources and analyses are needed to, “understand complex multifaceted institutions or realities” (Teddlie & Tashakkori, 2003, p. 16). It is a conscious decision to, “go back and
forth between qualitative interpretation and quantitative analysis” to be, “explicitly seen as yielding important insights concerning the phenomena under study” (Rocco et al., 2003, pp. 596-597). Using mixed methods, “draw from the strengths and minimize the weaknesses of both in a single research study…” (Johnson & Onwuegbuzie, 2004, pp. 14-15). It also allows the researcher to delve further into the data to enhance the research findings (Onwuegbuzie et al., 2007).

For this research, a coordinated mixed methods design is used, which is defined by Greene (2001) as having methods that are planned and implemented as, “discrete, separable sets of activities” and that these methods, “remain distinguishable throughout the inquiry” (p. 255). Keeping the methods separate is in part possible due to the posed research questions and how to best answer them. Onwuegbuzie and Johnson (2006), leaders in mixed methods research, define this study’s framework as a basic concurrent mixed methods design as the following conditions hold:

(a) both the quantitative and qualitative data are collected separately at approximately the same point in time, (b) neither the quantitative nor qualitative data analysis builds on the other during the data analysis stage, and (c) the results from each type of analysis are not consolidated at the data interpretation stage, until both sets of data have been collected and analyzed separately, and (d) after collection and interpretation of data from the quantitative and qualitative components, a metainference is drawn which integrates the inferences made from the separate quantitative and qualitative data and findings. (p. 53)

Even though the name given to the method may change, the basic tenets remain the same in the study; quantitative and qualitative methods are used together, but as separate
entities, to gather, analyse, report and infer the research data. The study uses two lenses to view the research questions and the use of three sets of data are to reinforce or refute the other data results.

As mixed methods methodology is becoming acceptable by researchers from either methodology perspective, the language used to describe and define its parameters is in flux. Terms from both the quantitative and qualitative approaches hold specific meaning and using terms from these perspectives can imbue an undesired understanding to terms. As the language of mixed methods develops and is debated by academics, it is a type of research that is slowly being accepted by other academic fields (Creswell, 2010). As it can incorporate multiple ways of understanding the research questions, mixed methods methodology:

rests on the assumptions that each of our ways of knowing offers a meaningful and legitimate view of what we are striving to know and, therefore, that incorporating multiple ways of knowing will enable us to know better and more fully. (Greene, 2001, p. 251)

3.3 Methods Descriptions

An important part of a mixed methods study is to have the research questions drive the methods chosen (Tashakkori & Teddlie, 1998). The questions focus on understanding the social phenomena in the university classroom and the tools chosen have to solicit this information from the study’s participants. As educational research has a rich history with quantitative research (Duit & Treagust, 1998; Roulston, Legette, Deloach, & Pitman, 2005) there are many tried and validated tools available within this methodological practice. As research in education has now extended to include more qualitative studies (Roulston, et al., 2005), qualitative tools that are equally as useful for the research process are now used within educational studies. This study’s design is to have a distinct quantitative phase and then a
separate qualitative phase so tools from both methods are selected. This intermethod mixing, the using of two or more methods either concurrently or sequentially (Johnson & Turner, 2003), is also sometimes referred to as method triangulation (Denzin, 1989). A discussion of triangulation, in relation to the study’s data and methods, is below in Section 3.5.

The research questions are set in a social context, as this is where the individuals derive meaning (Appleton, 2007; Koch, 2006). To measure as many individuals’ perceptions of the classroom context as possible, the use of quantitative methods to gather as many data points for indicating trends, is required (Creswell, 2005). Research questions one and two, as stated in Section 3.1, are designed to be primarily quantitative in nature to indicate the groups’ overall perceptions of the classroom environment. The use of quantitative methods for these questions provide background information of what happens in each university’s primary science classroom using a, “‘coarse grain size’ of analysis” (Tobin & Fraser, 1998, p. 627). This part of the study design is to gain an overview of classroom learning environments across the studied universities. To gain this overview, the use of paper and pen surveys obtain the research data. Fraser and Walberg (1991) state this method is more economical to use than classroom observations and it measures the pooled judgements of all participants who are in a class rather than just the recorded observations of a single observer’s perceptions.

In addition to using the surveys when investigating questions one and two, an analysis of the courses’ syllabi provide a data set that indicate the goals and over-all composition of the courses. This analysis is both quantitative and qualitative in nature as it looks at the official outline of how the courses are structured. This provides background descriptive information of what types of classroom environments teacher educators are supposed to create, a qualitative data point. This descriptive information is matched later to the surveys’ results.
Research question three is qualitative in nature and is researched using semi-structured interview questions, a qualitative tool. The qualitative part of the study develops in detail, finer points of the study using a, ““fine grain size’ of analysis” (Tobin & Fraser, 1998, p. 627). This portion stresses the social experience and how it is given meaning (Denzin & Lincoln, 2003). Semi-structured interviews allow the interviewer to follow a set question schedule but then follow-up with further questions to any statement made by the person interviewed. Then the interviews are transcribed, analysed and related back to the surveys and syllabi data. In addition, question three is researched by using the survey demographic data to indicate if demographic factors influence perceptions of the classroom learning environment.

Using tools from the two methodologies complement each other and provide the information to create a richer understanding of how pre-service teachers’ pedagogical approaches to the teaching of primary science develop and how the classroom learning environments, created by teacher educators, shape that development. The interpretation of the findings is integrated as well, for in the discussion chapter both results (quantitative) and inferences (qualitative) are used to make sense of the data collected.

3.3.1 CLES-Constructivist learning environment survey. A good survey instrument can be a quick and inexpensive way to collect data, especially to get a base-line measure of what is happening (J. Bell, 2005). The Constructivist Learning Environment Survey (CLES) developed by Peter Taylor and Barry Fraser at Curtin University of Technology in Perth, Australia, is used for part of the quantitative portion of the study. The development of the CLES enables teacher researchers to evaluate constructivist teaching approaches in science classrooms and the extent to which these approaches are understood by their students (Taylor, et al., 1995). Researchers can make use of the CLES to, “monitor the effectiveness of preservice/inservice attempts to change teaching/learning styles to a more constructivistic
approach . . . to reflect on and improve classroom environments” (Fraser & Walberg, 1991, p. 21). The survey measures both the teacher educator’s and pre-service teachers’ perceptions of the classroom learning environment. A survey that measures perceptions is chosen rather than observing classrooms in session as researchers indicate that, “students’ perceptions, because they are the determinants of student behavior more so than the real situation can be more important than observed behaviors” (Fraser & Walberg, 1991, p. 4). As the CLES is a quantitative tool, hypotheses are developed for the potential outcomes from the study. The research hypotheses are:

Null (H₀)–Pre-service teachers perception of critical constructivist learning environments will not be affected by the teacher educator’s primary science course. This H₀ is supported by conclusions reached in studies that suggested teacher education courses had little effect on changing pre-service teachers ideas on teaching (Carter, 1990).

Alternative (H₁)–Pre-service teachers perceptions of critical constructivist learning environments will be affected by the teacher educator’s primary science course. This H₁ is supported by the pedagogy focus taught in the primary science courses as listed on the syllabi (i.e. constructivism) and research studies done in other countries with pre-service teachers (Gibson & Van Strat, 2001; Harrington & Enochs, 2009; Nix, et al., 2005).

The CLES’ format is a pre course survey and a post course survey that each contains 25 statements. The pre course survey measures the preferred or ideal learning environment and the post course surveys measures the actual perceived learning environment of pre-service teachers and teacher educators. The surveys measure five key elements of a critical
constructivist learning environment. Below is a detailed description of each CLES scale block and the critical constructivist element it measures.

- **Scale 1–Personal Relevance (PR)–** the relevance of science outside of the classroom. Focuses on how pre-service teachers see the relevance of university science to their out-of-university experiences. These are everyday experiences that are used as a meaningful context for the development of scientific knowledge.

- **Scale 2–Uncertainty (UC)–** the ability for students to experience the evolving nature of science. Appraises what opportunities are created for pre-service teachers to experience scientific knowledge as being from inquiry driven theories that use human experiences and that are influenced by cultural and social values.

- **Scale 3–Critical Voice (CV)–** students’ ability to question the teacher’s plans and methods. Measures the classroom’s social climate to see if pre-service teachers feel it is all right and even beneficial to question the teacher educator’s teaching plans and methods and express any concerns they may have about their own learning.

- **Scale 4–Shared Control (SC)–** the amount of control students have over the total learning environment. Reviews the amount of control pre-service teachers have over the total learning environment such as sharing control with the teacher educator to set goals, learning activities and assessment criteria.

- **Scale 5–Shared Negotiation (SN)–** students’ ability to explain and develop their ideas with other students. Assesses the opportunities there are for pre-service teachers to explain and develop their science ideas with other pre-service teachers and to reflect on the validity of their own and others’ ideas (Fraser, 1998; Taylor, et al., 1995).

The surveys’ 25 statements are grouped into five key element blocks, rather than being mixed together throughout the survey. The wording of the statements is identical on both the Preferred and Actual survey formats except for the beginning of each phrase. The Preferred
learning environment survey (pre survey) statements begin, *In my Primary Science class I wish that* and the Actual learning environment survey (post survey) statements begin, *In this class*. A 5-point Likert Scale uses the categories *almost always, often, sometimes, seldom* and *almost never* to rate the desired frequency or perceived frequency of occurrences of each statement.

To maintain the anonymity of the universities, each is assigned a letter to represent the name. Teacher educators have the letter of the university they teach at and if there is more than one teacher educator, a number follows the letter (e.g. A1). No other meaning should be inferred as the letter and number combinations only differentiate between individuals and universities.

The survey portion of the study aims to provide an overview of the perceptions of the university classroom learning environment. The surveys indicate if pre-service teachers desire to learn in, and then notice, a constructivist learning environment during their primary science coursework. As constructivism is reflected in the national curriculum document and is an influence in science pedagogy, it should be experienced at the pre-service level if it is to be implemented in the future by pre-service teachers (Plourde & Alawiye, 2003).

### 3.3.2 Syllabi Analysis

In order to gain further insight into the teacher educators’ structure of their classroom learning environments, the syllabus from each course in the study is requested. The syllabus analysis is the second quantitative and first qualitative method employed that provides a background description of the espoused curriculum in the university classroom during the course. Skamp (1988) employed this type of analysis on New South Wales’ 3 year teaching diplomas to create a broad picture of what happened across the state as well as detailing information about individual campuses. Using syllabi in research is useful as these are official documents that state the goals for the courses and encourage consistency
in teaching from one year to the next as different teacher educators deliver the course content (Harrington & Enochs, 2009). In the literature though, researchers noted that course objectives did not necessarily translate directly into course instruction (Harrington & Enochs, 2009) nor were the teaching objectives necessarily understood as intended by pre-service teachers (Skamp & Mueller, 2001).

The syllabus from each course is collected and analysed to understand the stated composition of the course by reviewing items such as the aims and objectives, required readings, assignments, course hours and amount of science teaching time in primary schools. A review of the wording of syllabus items, in light of the CLES’ five scales, notes if constructivist principles are apparent in the syllabus. Teacher educators are asked to clarify vague statements of the listed course content. If the teacher educators report any changes to the syllabus during the course, these are taken into account during the analysis.

3.3.3 Semi-structured interviews. For the main qualitative portion of the research, semi-structured interviews are conducted. Interviews are the best tool to elicit pre-service teachers understandings of Shulman’s (1986) theoretical constructs of pedagogical content knowledge (PCK). PCK is generally seen as a combination of general pedagogical knowledge and subject matter knowledge (Gess-Newsome, 1999). Content knowledge or CK by contrast, is defined as the subject matter that is taught and how it is organised in the teacher’s mind (Shulman, 1986). Teacher educators need both knowledge types to develop in pre-service teachers as teachers draw on these knowledge constructs to know what to teach and how to teach it. As the CLES and syllabi analyses evaluate the larger idea of the learning environments that are understood by pre-service teachers, this part of the study evaluates what pedagogy individuals understand from the course and if it relates to constructivism and the effective pedagogy approaches from The New Zealand Curriculum document.
The interview questions developed by reviewing qualitative portions of the research literature that evaluated constructivist learning environments. In addition, questions asked in other CLES studies (Aldridge et al, 2000; Saleska, 2000; Lomas, 2004) were evaluated for potential use. Once a list of 25 possible questions evolved, the list was filtered through the research questions asked in this study. The list was narrowed to 15 questions and grouped into four sections entitled: *Understanding the Course, Effective Pedagogy/Constructivism, Beliefs* and *Personal*. The questions selected reveal a more in-depth understanding of what pre-service teachers experience during their university course and the influences on their future science pedagogy.

The scheduled interviews are conducted outside of university coursework time and take between 20-30 minutes to complete with each individual. Even though there is an interview protocol, the interviewer asks follow-up questions if an item needs clarification or is deemed of interest to pursue further. All interviews are conducted soon after the pre-service teachers complete their primary science coursework. As the only individuals interviewed are those who indicate their willingness to participate, the desired sampling of male/female, age ranges and different ethnicities is not guaranteed. Interviews occur in one of three ways; either in person at the university the pre-service teacher attends or via distance using the telephone or with the Internet using the communication programme Skype. Telephone interviews are audio taped using a Sony Cassette-corder TCM-200DV on a TDK Normal Position Type I cassette tape. Internet and in-person interviews use Audacity software (v1.2) on a MacBook computer. All transcriptions of interviews are verbatim and then are coded for emerging themes.
3.4 Administration, Data Collection and Analysis

I received permission from two universities to study their primary science course. I did request permission from the six universities that provide ITE for primary education, but was only granted access to the two ITE providers.

3.4.1 CLES. Permission was granted from the CLES creators to use their survey for this research. Dr. Peter Taylor emailed the surveys in a Word Document format on 2 November 2009, so that the wording could be tailored to fit the research format and a demographic data section inserted on the first page (P. Taylor, personal communication, November 2, 2009). The emailed permission is in Appendix A. The demographic data section solicits personal details as well as an indication of the schooling level of last formal science course completed by the participant. The use of these details is as grouping identifiers for analysing any perception differences between older/younger, male/female, more science/less science and Pākehā/Māori/Pasifika/other ethnicities of the pre-service teachers.

The administration of the Preferred CLES was during the first 2 weeks of the primary science course and the administration of the Actual CLES was just before completion of the course. In negotiation with the teacher educators of the courses, the second to last class was used to administer the Actual CLES as a larger potential survey pool was available compared to the last class session that some pre-service teachers did not attend. This survey schedule was for both universities to be consistent in the administration of the surveys. A written instruction letter was read to the participants before beginning so that instructions on taking the surveys were consistent, even if different individuals administered the surveys. The written instructions are in Appendix A.

I received help in administering the CLES as the two universities that agreed to be in the study had classes that convened at the same time and I could not be at two universities at
the same time administering the surveys. I administered the Actual CLES in person to the university I was not able to attend for the Preferred CLES. To maintain consistency I also read aloud the written instructions at the universities I administered the surveys.

The entry of the survey data is into an Excel spreadsheet and checked for errors before analysing with IBM SPSS v.19 software for descriptive information, frequencies, means and standard deviations. Examination of the summary means of the five scales is to indicate if teacher educators’ perceptions differ from the perceptions of the pre-service teachers they teach. For one university, a comparison of scale summary means is possible between teacher educators, as this university has more than one teacher educator for the primary science course. This comparison is to indicate if the teaching of the course is consistent between different individuals. For the other university with one teacher educator, a comparison between classes to check for teaching consistency is completed.

Social demographics are analysed to look for any factors that may influence pre-service teachers’ pedagogical understandings in science. Scale summary means comparisons for gender, ethnicity, age and year level of science are completed. ANOVA, independent-samples \( t \)-tests and paired-samples \( t \)-tests for these demographical factors are also completed. Some statistical tests cannot be completed for both universities, as not all demographic data qualifiers are identified for each institution. Detailed information on the statistical tests completed on the CLES data is in Chapter 4–CLES Data Results.

To validate the surveys, Cronbach’s alpha reliability tests are completed on the five scale categories. This test ensures that each item within a scale is measuring the same concept and correlates to the other scale items in the block. Cronbach’s alpha (\( \alpha \)) ranges from 0 (no relationship) to 1 (perfect relationship). An alpha of .7 or above is desired as this score is seen as acceptable for research purposes (Muijs, 2011).
In using a multi-scale surveying instrument, it is important that each scale measures independently of the other scales to provide a measure of unique construct. Spearman’s rho ($r_s$) checks for the correlations of the scales. This calculation is chosen for the scales, as the numbers to mark the survey are ordinal and rankings (1-5) (Muijs, 2011). Spearman’s rho is measured from -1 to +1, with -1 meaning a perfect negative correlation, +1 a perfect positive correlation and 0 shows no relationship. Complete validity information for the surveys is in Chapter 4–CLES Data Results, Section 4.2.

3.4.2 Syllabi. Syllabi in paper format are obtained from the teacher educators who teach the primary science courses. With each syllabus, the course objectives and content outline are analysed for course conceptual structures, organisation of course, length and level of course, and teaching and assessment procedures utilised. This analysis is then compared to the surveys’ data and semi-structured interviews to see if students understand the course constructs the way the constructs are stated. Analyses of the syllabi are also to evaluate if the effective pedagogy approaches from *The New Zealand Curriculum* are apparent or if other pedagogies influence the course.

A comparison of the syllabi contents to the five scales of the CLES is completed. This comparison indicates if the espoused curriculum in the university classroom aligns to critical constructivist characteristics as defined by the CLES. A review of the courses’ constructivist alignment are sought, whether the courses are constructivist in nature or if they are partial or non-constructivist based courses.

The syllabi analyses reveal quantitatively how many times items link to the CLES as well as other details. Qualitatively, the analyses reveal what the intended learning environments are and how these develop over the duration of the courses’ sessions. Together
the two methods assist in developing an understanding of what occurs in the university primary science classrooms.

3.4.3 Semi-structured interviews. For the semi-structured interviews, participants who indicated interest, were contacted via email or phone and an agreed upon date was set for the interview. If the participant did not respond to the first phone or email message, two other requests, sent a week apart, queried a response from the individual. After the third try, contact ceased, as the participant was deemed no longer interested and the name removed from the interview list. I conducted all interviews and transcribed the majority of these with only four transcriptions outsourced due to time constraints.

The transcripts are reviewed multiple times for themes that emerge by a process called analytic induction (Erickson, 1986). Analytic induction is from the interpretive lens of qualitative research. This process looks at how to uncover the ways that the actions and choices of all members in the classroom constitute the enacted curriculum (Erickson, 1986). Using analytic induction is a way to sift through the interview data, with the coding of general themes done first. One of the themes the coded transcribed interviews reveal is an indication of how the primary science course affects and/or potentially affects pre-service teachers’ pedagogy. The review of the interview data confirms or contests the survey and syllabi data results. After coding for general themes, each general theme is then analysed again until a more detailed pattern emerges. Analysing of the interview data into detailed groupings is achieved by the fourth distillation. Support for the detailed themes that emerges from the data is with quotes by the participants. The themes are then linked, when possible, to the CLES’ five scales and the syllabi data to formulate an overall understanding of what teacher educators teach and pre-service teachers perceive in the primary science course. A discussion of these results is in Chapter 5, Section 5.2. A copy of the semi-structured interview questions used in the study is in Appendix B.
3.5 Validity and Trustworthiness

To achieve knowledge claims in a research study, validity is regarded as a way to evaluate the, “degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of interpretations and actions on the basis of test scores” (Messick, 1995, p. 741). Validity is the term used by quantitative researchers when considering if the construct that one wants to measure, is being measured (Muijs, 2011). Lincoln and Guba (1985), from the qualitative perspective, use trustworthiness when considering if the research is well done and if the findings are worthy of attention. Many new terms have developed that try to define and address validity issues in a mixed methods study and that are acceptable to both qualitative and quantitative researchers. To address validity for quantitative researchers or trustworthiness for qualitative researchers, the term legitimation, coined by Onwuegbuzie and Johnson (2006), aims to use language that is not from one perspective or the other. Legitimation addresses issues that arise when working in a mixed methods study and how to compensate for these to make the study as robust as possible. As the decision on which perspective’s language or words to use for mixed methods is still in its infancy and being debated by the academic community (Creswell, 2010), the decision is made to use the terms validity and trustworthiness as appropriate to the method type used in this study. This decision is in part due to the unresolved issue of language use with mixed methods. Using both words is clearer and more useful for readers to understand than limiting it to one method’s perspective language.

For this study, validity in part is, “the extent to which scores generated by an instrument measure the characteristic or variable they are intended to measure for a specific population” (Onwuegbuzie, et al., 2007, p. 116). The use of a survey for part of this study is to evaluate the viewpoints of as many individuals from a specific population. This evaluation is to understand how the individuals collectively view the university classroom learning
environment. The survey assists in addressing interpretive validity, how accurately the researcher portrays the views of the participants (Johnson & Turner, 2003). The use of all participants’ viewpoints from the survey data created a group viewpoint as few outliers, or extreme scores, are present to affect scale summary means. To review the frequency and low level of outliers from the survey data for both the Preferred and Actual CLES at each university, see Appendix C and D. The CLES is used for its, “satisfactory internal consistency and factorial validity” (Taylor, et al., 1997, p. 7). The first version of the CLES was indicated to be psychometrically sound and used in a number of studies and countries (Taylor, et al., 1994). In response to a noted weakness in its theoretical framework, the creators revised it and incorporated a critical constructivist framework (Taylor, et al., 1994). Since this change, the CLES has been trialled and found robust in a variety of classroom learning environment settings and for a variety of student ages (Aldridge, et al., 2000; Johnson & McClure, 2004; Lee & Fraser, 2001). More recently it was used to evaluate classes at the tertiary level in the USA (Cannon, 1995; Johnson & McClure, 2000; Saleska, 2000) and New Zealand (Lomas, 2004) and found valid, robust and useful in providing information about constructivist classroom learning environments. Its content, criterion and construct validity are strong and proven in the above cited studies (Fraser, 2012).

To address the qualitative term of trustworthiness, the use of semi-structured interviews and syllabi analyses in conjunction with the surveys help measure the same phenomena via method triangulation a term suggested by Denzin (1989). To achieve triangulation, high levels of confidence are required in the data; this confidence is gained by using many forms of data to confirm the findings of the research. It is a plan of action that uses multiple methods when researching and helps alleviate the deficiencies that may occur when using just one method (Denzin, 1989). The questions designed for the semi-structured interviews are to complement and clarify the survey information as well as the science teaching content listed
on the syllabi. The use of these questions also expands the data collection to include the experiences and observations pre-service teachers have with primary science during the academic year.

As the syllabi details are in the most part, interpreted and not observed, there is a possibility of low interpretive validity. Maxwell (1992) defines interpretive validity as the extent that an interpretation or understanding of an event represents the meaning given to it by the individuals. As the teacher educators who lead the courses are questioned about the items on the syllabi, this validity issue is minimised as much as possible.

In addition to triangulation, the mixed methodology used in the study increases the validity of constructs. By using mixed methods in a complementarity of design, to, “elaborate, enhance, illustrate, or clarify results” this increases the, “interpretability, meaningfulness, and validity of constructs” by counteracting method biases that are inherent and, “capitalizing on method strengths” (Greene, 2001, p. 253).

This mixed methods thesis strives to make:

knowledge claims that are grounded in the lives of the participants studied, that have some generality to other participants and other contexts, that offer both contextual understanding and structural explanation, and that isolate factors of particular significance while also integrating the whole. (Greene, 2001, p. 254)

3.6 Reliability and Dependability

Using a mixed methods approach means the researcher has to consider reliability from both traditions. Quantitative researchers refer to the reliability or the, “degree to which a measurement can be replicated; that is, do repeated measurements of the same phenomenon produce consistent results from one time to the next” (Hunter & Brewer, 2003, p. 581). Qualitative researchers refer to the dependability of the data (Lincoln & Guba, 1985).
The reliability and dependability of this research’s data has several checks. As far as is possible, the personal information is checked with individual participants to ensure its accuracy. Personal details are requested for both the Preferred and Actual CLES and these are checked against each other for accuracy and consistency before being separated from the survey forms. As some personal information and survey data are still incomplete, the information supplied is utilised as much as possible and missing data noted in the statistical software programme so that it can be compensated for when computing the statistics. The CLES has Cronbach’s alpha run for internal consistency on scale blocks, as the number of variables in each category is low (5), the measure’s sensitivity to higher number of items should be minimised and a false relationship avoided (Muijs, 2011). As this checks on the internal consistency of the scale blocks, a scale correlation matrix is used to measure how independent the scores of each scale are. Spearman’s rho measures the correlation coefficient to ensure these are in acceptable research ranges.

Non-response is always an issue for a researcher. To address this issue, the survey used is well structured and of a high quality so that participants take the time to fill it out. Administration of the survey is scheduled for the end of a class session. This tactic attempts to minimise participants forgetting to complete it and post it back. As individuals take the survey in the university classroom, this location also minimises distractions that may influence scoring. As the whole class receives the survey at the same time, perceived anonymity by participants is potentially strong. As the survey is closed-ended, there is a low dross rate, or low collection of unrelated research question material, which keeps the participants focus on the information sought.

Issues with type I and type II errors have to be considered as statistical analyses are completed on the survey data. Type I errors arise when the null hypothesis is rejected but it is true and type II errors are when the null hypothesis is not rejected and it is false (Muijs,
2011). To minimise type I errors, statistical analyses are run on the data collected on the five scale blocks of the CLES, rather than on individual questions. To further minimise type I errors significance values of $p > .05$ are used. Significance tests and effect sizes are computed with all data results that demonstrated a significant result. To minimise type I and type II errors, this study uses as large a sample size as is possible. This sample size decreases the influence of any outlier scoring. These tactics do not eliminate the errors from occurring, but the use of these strategies minimise the errors as much as possible.

The syllabi are collected during administration of the Actual CLES and any additions or changes noted. Neither university indicated any changes to their course syllabus; hence, it is considered consistently applied throughout the year and guides what happens in the university classroom. This data point, the syllabus, should be reliable. Each syllabus is also grounded in the setting of the university and portrays what is important to teach during the course. Whether or not the teacher educator follows the syllabus’ structure, is not measured. It is assumed that the teacher educator follows the syllabus as written. A weakness with using a course syllabus for analysis is that not everything is noted in detail on it. A general class overview is usually given, as this provides flexibility in planning for the teacher educators.

For the semi-structured interviews, as stated previously, three attempts at contacting the individuals were made. If after the third attempt to make contact and there was no response, further attempts were abandoned. This protocol was necessary with three participants who originally indicated they would be interviewed but who never replied to further contact efforts. Abandoning contact after three attempts was so that the participant did not feel required or forced to do an interview and potentially give inaccurate answers to the interview questions and so the individuals did not feel harassed. Perceived anonymity by participants might feel low as the interviews were recorded and interviews were done individually. To mitigate this, participants were reminded that their anonymity would be maintained.
Participants chose the time of the interview to minimise any feelings of being rushed. This also allowed them to think about the responses they gave. A reminder was given to the participant at the start of the interview that they could refuse to answer any question. Several individuals sent email additions or clarifications of their interviews. This extra information was of their volition and not prompted by the researcher. The additional information was included in the analysis portion of the semi-structured interviews.

The transcription of the semi-structured interviews was verbatim. If any words or phrases were unintelligible, another social science researcher familiar with interviewing techniques, listened and made sense of the section. If the meaning was still not discerned, a line was left in the transcript to indicate that word or words were missing due to not being able to interpret what was said. This issue occurred on three transcripts, in five different places in the interviews, with the maximum of 10 words not understood.

Through the use of three sources of data to triangulate the findings, this research endeavoured to create a study that was reliable. Nevertheless, it acknowledged the limitations that the data and research contained.

3.7 Ethical Considerations

The granting of research permission came from the University of Otago after completion of the ethics approval process. As the University’s ethics approval process is robust, proof of how this study mitigated any possible ethical issues was required before the research began. In addition, the Māori research approval process was successfully completed for this study. Once approval was granted from the home research university, approval from the six universities to conduct research with their pre-service teachers and teacher educators had to be gained. This approval often required three or more levels of acceptance (School,
Department, Coordinator, and Lecturer) before any research could commence. All concerns from each level had to be addressed before research work began.

All participants received an approved information sheet and a signed consent form was obtained to indicate their understanding of and willingness to participate in the study for both survey forms. The information sheet stated the purpose of the information gathered, what use would be made of it, the individual’s right to see or correct personal information and the participant’s right to withdraw at any time from the study without consequences. Copies of these sheets are located in Appendix E. The information and consent processes were repeated before beginning interviews, to reiterate their rights as research participants. As many of the interviews were done via distance, not face-to-face, distance participants were read the consent form and verbally agreed to the interview process. Interview participants were aware that they would not be able to be identified by any of their comments used in the thesis.

Personal data was collected, but this information was on a separate sheet from the survey data responses so it could be separated from the survey to maintain anonymity of participants from their respective surveys. No harm was foreseen with the study nor was any reported by participants and anonymity of the individuals and the participating universities was upheld as stated in the ethics approval process. A copy of the personal data sheet used with the surveys is located in Appendix A.

To minimise time taken from the researched courses, the surveys were done at the end of a class session, and interviews conducted outside of course time. If I was not able to administer the survey for a course, the teacher educators who taught the studied courses distributed and returned the surveys. Completed survey forms were sealed in envelopes and posted to or retrieved by me. Otherwise, I distributed and collected the surveys. No written comments regarding the course were required on any survey form.
As teacher educators for the primary science courses administered one part of the
CLES survey for me, their roles as leaders could lead to issues of influencing the research
participants. To counteract this potential influence, the Actual survey and interviews occurred
after course marks/results were completed. The Preferred survey would not influence the
course as it only measured what the pre-service teachers wished to experience in a learning
environment. Individuals understood that participating or not participating in the study would
have no effect on their course mark for the term. Participants also understood that teacher
educators could request the class analysis of the data, but that no individual answers would be
given out or discerned from the class data section as a whole.

The University of Otago’s data storage procedures of archiving original material for 5
years and storing it at the College of Education were followed. After the required storage
time commitment, the principal researcher will destroy personal information and any specific
identifying information from the data.

3.8 Background on Participants

Participants for this study were sought from the six universities in New Zealand with
teacher education programmes-Auckland, Waikato, Victoria, Massey, Canterbury, and Otago
as 90% of primary educated teachers graduated from one of these six universities (Kane,
2005b). As it was not expected all six universities would grant permission to study their
primary science education programmes, consideration was given to this and it was desired to
have at least two universities participate. Each university had multiple individuals that had to
grant permission before the teacher educator, who taught the primary science course, was
asked to participate. The permission letters sent to the universities are located in Appendix E.
Permission from all department levels was achieved for two of the universities. This met the
study’s participation goal of at least two universities participating. A combined total of 239
Preferred surveys and 221 Actual course surveys were completed from the two universities
using a sample of convenience. As all the primary science courses studied were face-to-face courses, there were no distance students recruited. All participants were 18 years or older and given consent forms and information sheets detailing the study and how the data was used. Copies of the study’s information and consent forms are located in Appendix E.

Participants’ self-reported demographics collected on both forms of the CLES are in Table 1. To maintain the anonymity of the universities, each has a letter to stand for its’ name (e.g. University A) and no other meaning should be inferred. The demographics displayed in Table 1 are similar to past studies undertaken on New Zealand’s teacher education programmes with the greatest number of pre-service teachers being female, Pākehā, and 18-20 year olds (Cameron & Baker, 2004; Gray & Renwick, 1998; Ministry of Education, 1997).
Table 1

Participants’ Self-Identified Demographic Data from CLES

<table>
<thead>
<tr>
<th></th>
<th>University A</th>
<th></th>
<th>University B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preferred</td>
<td>Actual</td>
<td>Preferred</td>
<td>Actual</td>
</tr>
<tr>
<td></td>
<td>surveys</td>
<td>surveys</td>
<td>surveys</td>
<td>surveys</td>
</tr>
<tr>
<td>Total surveys</td>
<td>68</td>
<td>70</td>
<td>171</td>
<td>151</td>
</tr>
<tr>
<td>Female</td>
<td>60</td>
<td>63</td>
<td>130</td>
<td>113</td>
</tr>
<tr>
<td>Male</td>
<td>7</td>
<td>7</td>
<td>36</td>
<td>25</td>
</tr>
<tr>
<td>No response to gender</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>NZ/Pākehā</td>
<td>51</td>
<td>55</td>
<td>102</td>
<td>79</td>
</tr>
<tr>
<td>Māori</td>
<td>7</td>
<td>9</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Pasifika(^a)</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Other(^b)</td>
<td>7</td>
<td>2</td>
<td>44</td>
<td>41</td>
</tr>
<tr>
<td>No response to ethnicity</td>
<td>3</td>
<td>4</td>
<td>13</td>
<td>24</td>
</tr>
<tr>
<td>18-20 years</td>
<td>56</td>
<td>52</td>
<td>109</td>
<td>81</td>
</tr>
<tr>
<td>21-23 years</td>
<td>7</td>
<td>13</td>
<td>41</td>
<td>44</td>
</tr>
<tr>
<td>24-27 years</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>28-30 years</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>30 + years</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>No response to age</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>17</td>
</tr>
</tbody>
</table>

Science level attained

<table>
<thead>
<tr>
<th></th>
<th>University A</th>
<th></th>
<th>University B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preferred</td>
<td>Actual</td>
<td>Preferred</td>
<td>Actual</td>
</tr>
<tr>
<td></td>
<td>surveys</td>
<td>surveys</td>
<td>surveys</td>
<td>surveys</td>
</tr>
<tr>
<td>Year 10</td>
<td>6</td>
<td>5</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Year 11</td>
<td>20</td>
<td>21</td>
<td>31</td>
<td>23</td>
</tr>
<tr>
<td>Year 12</td>
<td>19</td>
<td>13</td>
<td>29</td>
<td>19</td>
</tr>
<tr>
<td>Year 13</td>
<td>20</td>
<td>27</td>
<td>68</td>
<td>67</td>
</tr>
<tr>
<td>Above high school</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>No response to science</td>
<td>3</td>
<td>3</td>
<td>28</td>
<td>39</td>
</tr>
</tbody>
</table>

\(^a\) Stated Pasifika ethnicities are Fijian, Samoan, Tokelauan, Tongan. \(^b\) Other self-indicated ethnicities are Bidayuh, Canadian, Chinese, English/British, Filipino, Indian, Malaysian, South African.
As pre-service primary teachers were asked to complete a Preferred and later an Actual survey, approximately 69% of participants from University A completed both surveys (48 of 70) and 59% of participants completed both surveys (101 of 171) from University B. If a pre-service teacher did not complete the name section of the personal details portion of the survey each time, the surveys could not be matched for a comparison. Participation numbers between Preferred and Actual surveys were never expected to be the same as participation did vary due to individuals transferring into or exiting the course, or choosing to complete one survey but not the other.

Teacher educators from the two universities who taught the primary science courses were asked to complete the CLES. There were three teacher educators who could complete the surveys and the two teacher educators from University B completed the Preferred survey form. University A’s teacher educator did not complete the CLES. Teacher educators were not asked to complete the Actual survey, as they had already given of their classroom time and as only one university completed the Preferred survey, a comparison between the universities teacher educators could not be completed.

For the semi-structured interviews, all 14 individuals who volunteered from the two universities completed interviews; two were males, 12 were females. University A had three participants and University B had 11 participants. Most of the interview participants were in the 18-20 years old category, self-identified as NZ/Pākehā, and completed secondary school science courses in Year 13. Further interview participant demographic details are in Table 11 in Chapter 5, Section 5.2 Semi-structured Interviews.

Teacher educators were not interviewed except to clarify syllabi items. As teacher educators were occupied with pre-service teachers’ school placement observations when semi-structured interviews took place, time was not available for interviews. The scores of
the teacher educators’ Preferred CLES were used to indicate their practices when these were available as well as syllabi items and pre-service teachers’ comments from semi-structured interviews.

3.9 Summary

This chapter sought to explain the mixed methodology and methods used in the study. The two lenses used to frame the study’s questions were explained and justified as reasonable choices for this research. The three research tools employed to gather data were explained and verified in their use. Research hypotheses were stated for the quantitative portion of the study. The processes of data collection and the quantitative and qualitative analyses used on the data were discussed in detail. Finally, the important aspects of validity/trustworthiness, reliability/dependability and ethical considerations and how these were handled for the study were discussed; paying attention to the issues that could arise when using mixed methods. By paying attention to these research aspects, it was desired that the study’s results and conclusions would be regarded as useful and informative in pre-service teacher education.
Chapter 4–CLES Data Results

This chapter presents the results of the CLES that investigated the three research questions posed in Chapters 1 and 3. These questions seek to identify the perceptions of the classroom learning environment held by pre-service teachers and teacher educators. Unless otherwise stated, the results for both universities are in each section. In Section 4.1 is a brief review of the CLES and how to interpret the scoring of the scales. Section 4.2 discusses the validity results for the CLES scales by using the statistical tests of Cronbach’s alpha as well as scale correlations with Spearman’s rho to measure how independent the scores of each of the CLES scales are. The descriptive summary statistics for the five scale blocks of the Preferred and Actual CLES for pre-service teachers are in Section 4.3. Section 4.4 discusses the results from the paired-samples t-tests of individuals who completed both the Preferred and Actual surveys. Descriptive statistic scale summary means of University B teacher educators’ CLES when compared to their pre-service teachers’ CLES means are in Section 4.5. Section 4.6 presents the paired-samples t-tests that compares the different classes of University A’s pre-service teachers. In addition, this section also contains the paired-samples t-test results comparing University B teacher educators’ classes, to review for teaching consistency across the primary science classes. In Section 4.7 are the results of the independent-samples t-tests completed on the demographic data of gender, ethnicity and age. ANOVAs, used with ethnic groups as well as level of science qualification data, investigate if these factors have an influence on how pre-service teachers perceive the classroom learning environment. Section 4.8 concludes with a summary of the findings from this chapter.

Only CLES results are in this chapter. A discussion of the CLES results and how these linked to the other data findings is in Chapter 5–Syllabi, Semi-Structured Interviews and Effective Pedagogy Approaches. Descriptive statistics are included in each section of
Chapter 4, even if significant results are not indicated by the statistical test. The descriptive statistics specify the preferred and perceived classroom learning environment by pre-service teachers as these give a summary of indicated alignment to constructivist principles.

4.1 CLES and Scoring Descriptions

To investigate research question one regarding how pre-service primary teachers perceive the university classroom learning environment and research question two on the perceptions science teacher educators have of the classroom learning environment, the study required overviews of pre-service teachers’ and teacher educators’ preferred and then perceived classroom learning environments. The Constructivist Learning Environment Survey (CLES) (Taylor, et al., 1994) collected data from participants at both universities at the same point in the education process; the Preferred survey during the first 2 weeks of the course and the Actual survey during the second to last week of the primary science course. The Preferred survey gave a baseline measurement to compare to pre-service teachers’ Actual survey marks to investigate how they perceived the classroom learning environment. The Preferred and Actual survey comparisons noted changes in perceptions by pre-service teachers.

As described in Chapter 3 the CLES’ format, both Preferred and Actual versions, groups the 25 survey statements into five category blocks or scales that measure key elements of a critical constructivist classroom learning environment: Personal Relevance (PR), Uncertainty (UC) Critical Voice (CV), Shared Control (SC), Student Negotiation (SN) (Taylor, et al., 1995). For a detailed description of the five scales, refer to Chapter 3, Section 3.3.1. The scale number and two letter abbreviations are used throughout the rest of the thesis when referring to the scales (i.e. Scale 1–PR).
The CLES’ statements use a 5-point Likert Scale. Scores are 1-Almost Never, 2-Seldom, 3-Sometimes, 4-Often, 5-Almost Always. As the CLES uses a 1 to 5 Likert Scale to score items, each scale category of five items has a range of possible scores from 5 to 25. Using the scale summary means, an indication of the strength of alignment with a critical constructivist environment can be established—5-little alignment, 10-weak alignment, 15-moderate alignment, 20-moderately strong alignment, 25-strong alignment to constructivism. The establishment of the strength of alignment for each scale is by equally dividing the range of scores into categories following the original divisions of the CLES scales. The scale subdivision ranges are following on from the CLES mathematics study completed at the University of Auckland (Lomas, 2009). Discretion is advised with the cut-off points of the alignment scales, as these are guides and no ideal mean score is designed to be obtained (Cannon, 1995; Taylor & Fraser, 1991). The higher the number, however, the more closely aligned the desired or actual learning environments are to critical constructivist principles. Furthermore the lower the number, less of an alignment to those principles is indicated.

4.2 CLES Validation—Cronbach’s Alpha Scores and Scale Correlations

To validate the internal consistency of the CLES’ five scales, the use of Cronbach’s alpha (α) measured each of the five scale blocks for both the Preferred and Actual surveys. Cronbach’s alpha above .7 is usually considered acceptable for research purposes (Muijs, 2011) and is considered acceptable for learning environment research (Fraser, 1986 as cited in Taylor, et al. 1995). As displayed in Table 2, all scale categories achieved Cronbach’s alpha of .7 or higher for both universities on the pre-service teachers’ Preferred and Actual surveys. The alphas ranged from .77 to .94. These findings aligned with internal consistency findings from the CLES creators that had alphas of .72 to .91 (Taylor, et al., 1995).
Table 2

Cronbach’s Alpha (α) Scores for CLES

<table>
<thead>
<tr>
<th>Scale</th>
<th>University A</th>
<th></th>
<th>University B</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Preferred survey</td>
<td>Actual survey</td>
<td>Preferred survey</td>
<td>Actual survey</td>
</tr>
<tr>
<td>Scale 1–PR</td>
<td>n 65</td>
<td>.88</td>
<td>68</td>
<td>.84</td>
</tr>
<tr>
<td></td>
<td>α</td>
<td>.88</td>
<td>.84</td>
<td>.86</td>
</tr>
<tr>
<td>Scale 2–UC</td>
<td>n 68</td>
<td>.77</td>
<td>70</td>
<td>.81</td>
</tr>
<tr>
<td></td>
<td>α</td>
<td>.78</td>
<td>.81</td>
<td>.81</td>
</tr>
<tr>
<td>Scale 3–CV</td>
<td>n 67</td>
<td>.88</td>
<td>70</td>
<td>.86</td>
</tr>
<tr>
<td></td>
<td>α</td>
<td>.94</td>
<td>.92</td>
<td></td>
</tr>
<tr>
<td>Scale 4–SC</td>
<td>n 66</td>
<td>.91</td>
<td>70</td>
<td>.89</td>
</tr>
<tr>
<td></td>
<td>α</td>
<td>.84</td>
<td>.94</td>
<td></td>
</tr>
<tr>
<td>Scale 5–SN</td>
<td>n 65</td>
<td>.94</td>
<td>70</td>
<td>.91</td>
</tr>
<tr>
<td></td>
<td>α</td>
<td>.94</td>
<td>.89</td>
<td></td>
</tr>
</tbody>
</table>

A scale correlation matrix that used Spearman’s rho ($r_s$) calculated how independent the scores of each scale were. These scores could range from a perfect negative correlation of $-1$, through no correlation of 0, to $+1$ being a perfect positive correlation (Muijs, 2011). As shown in Table 3, results for this study ranged from .05 to .57. Overall, it appeared that the CLES scales had a satisfactory degree of independence, even though there was some overlap between scales when measuring classroom learning environment aspects. These results were in accord with what the creators of the CLES noted with their scores of $.17$ to $.38$, as well as, other studies that used the CLES (Kim, Fisher, & Fraser, 1999; Lee & Fraser, 2001; Nix, et al., 2005; Taylor, et al., 1997).
Table 3

*Correlations of CLES Scales Using Spearman’s rho ($r_s$)*

<table>
<thead>
<tr>
<th>Scale 1–PR</th>
<th>Scale 2–UC</th>
<th>Scale 3–CV</th>
<th>Scale 4–SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>University A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preferred survey ($n = 62$)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale 2–UC</td>
<td>.43</td>
<td>–</td>
<td>.37</td>
</tr>
<tr>
<td>Scale 3–CV</td>
<td>.12</td>
<td>.37</td>
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<td>Scale 5–SN</td>
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<td>.57</td>
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<td>University B</td>
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4.3 CLES Descriptive Statistics for University A and University B

Descriptive statistics for pre-service teachers at each of the two universities who participated in one or both surveys were calculated. As indicated by the Preferred survey
scale summary means displayed in Table 4, pre-service teachers at University A would prefer a classroom learning environment that was moderately to strongly aligned to critical constructivist principles. For University A, Scale 4–SC had the lowest summary means of the five scales \( (M = 15.24, SD = 4.41) \) and Scale 5–SN had the highest summary means \( (M = 18.98, SD = 5.04) \) on the Preferred survey.

On the Actual survey there was a decline in four of the five scale summary means when compared to the scale summary means of the Preferred survey. At University A, the constructivist principles perceived by pre-service teachers were less than the constructivist principles they preferred to experience except for Scale 5–SN which increased from the Preferred to the Actual survey \( (M = 18.98, SD = 5.04 \text{ to } M = 20.60, SD = 4.19) \). Overall, the lower summary means on the Actual survey indicated less of an alignment with constructivist principles when compared to the Preferred survey’s summary means. Viewed on its own, however, the Actual survey indicated a moderate alignment with constructivist principles rather than a weak alignment, except for Scale 4–SC \( (M = 9.37, SD = 3.20) \). As these were only the pre-service teachers perceptions, the results did not indicate whether the teacher educator created a learning environment with constructivist features or rather that, the pre-service teachers did not perceive the learning environment to have such features.

University B had scale summary means in the moderate alignment to constructivism and above, for all scales on the Preferred survey. University B also had Scale 4–SC the lowest \( (M = 17.18, SD = 4.08) \) and Scale 5–SN the highest \( (M = 20.57, SD = 3.73) \). As with University A, the scale summary means indicated pre-service teachers preferred to learn in a classroom learning environment that had critical constructivist principles.

For University B’s pre-service teachers, four of the five Actual survey scales were higher than the Preferred survey except for Scale 4–SC that decreased \( (M = 17.18, SD = 4.08 \)}
to $M = 14.04, SD = 4.90$. Scale 5–SN remained the highest summary means for University B ($M = 22.53, SD = 2.91$). Most of the survey results for University B indicated a strong fit between the preferred and perceived constructivist principles experienced in the university primary science classroom learning environment. If this fit would translate into potential future constructivist pedagogy used by the pre-service teachers was not discernable from this data alone. The data, however, suggested the pre-service teachers preferred to learn in this environment and noticed some of the constructivist tenets in their primary science classroom.

Table 4

*Descriptive Statistics for CLES Scales*

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<td>163</td>
<td>20.57</td>
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4.4 Preferred versus Actual CLES Comparisons

In addition to scale summary means of all individuals who completed the Preferred and Actual surveys, a comparison between pre-service teachers who were identified as completing both surveys, was made. In this way, the Preferred surveys of the pre-service teachers were compared to their Actual surveys and individual changes noted. This analysis tested the null hypothesis that pre-service teachers’ perceptions of critical constructivist learning environments will not be affected by the teacher educator’s primary science course. Paired-samples $t$-tests compared identified pre-service teachers’ preferred to their perceived classroom learning environment surveys. For both universities the value of $p < .05$ indicated significance. If there was a significant relationship indicated, then effect size, using Cohen’s $d$, was calculated. Cohen’s $d$ revealed if the relationship was strong or weak. The guidelines used to indicate the relationship strength are: $0–0.20 =$ weak effect; $0.21–0.50 =$ modest effect; $0.50–1.00 =$ moderate effect; $> 1.00 =$ strong effect (Muijs, 2011).

As displayed in Table 5, significant differences between the Preferred and Actual surveys were indicated for two of the five scales for University A: Scale 3–CV and Scale 4–SC. Four of the five scales for University B were significant: Scale 2–UC, Scale 3–CV, Scale 4–SC and Scale 5–SN. Direction also differed between the two universities as University A’s scale summary means decreased for four of the five scales from the Preferred to the Actual survey. University B’s scale summary means increased on four of the five scales from the Preferred to the Actual survey. Effect sizes were calculated and ranged from modest to large effects ($d = 0.36–1.52$).
Table 5

*Paired-Samples t-Tests CLES Results*

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<td>3.67</td>
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<td>3.00</td>
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</table>

**Note.** Significant *p < .05* are bolded.

These results indicated that pre-service teachers noticed elements of a critical constructivist learning environment that teacher educators created in the university classroom.
The statistically significant findings rejected the null hypothesis, that pre-service teachers’ perceptions of critical constructivist learning environments will not be affected by the teacher educators’ primary science course. The null hypothesis was rejected on four of the five scales for University B and two of the five scales for University A. Scale 1–PR rejected the alternate hypothesis for both universities.

To the extent that participating pre-service teachers would implement elements of a constructivist learning environment in their future classroom environments addresses an issue beyond the scope of this study. Portions of the constructivist learning environment and practices perceived by the pre-service teachers, however, have the potential to influence their own teaching. A further discussion of these issues is in Chapter 5, Section 5.2.

4.5 CLES Score Comparisons for Teacher Educators and Pre-service Teachers

Teacher educators completed the Teacher Educator form of the CLES for the Preferred survey. As two of the three teacher educators completed the Preferred survey, both from the same university, these scores were compared to the pre-service teachers they taught. Teacher educators were not requested to complete Actual surveys due to only one university completing the Preferred survey and the amount of time the teacher educators from both universities had already provided for pre-service teachers’ class surveys.

The wording of statements on the CLES for the teacher educators is similar to the pre-service teacher’s Preferred survey but the emphasis is on what the teacher educator wishes his/her pre-service teachers to learn in his/her classroom. For example, statement one of the teacher educator’s Preferred survey is worded, *In my Primary Science Education class I wish that students learned about the world outside of the university*, whereas the pre-service teacher’s Preferred survey is worded, *In my Primary Science class I wish I learned about the world outside of the university*. Copies of the CLES forms are in Appendix A.
As displayed in Figure 1, the two teacher educators at University B appeared theoretically aligned to teach using critical constructivist principles as all scales were in the moderate alignment and above. This result meant if pre-service teachers attended the class of the other teacher educator at University B, their experiences of a constructivist learning environment would be similar. The results indicated some variations between the teacher educators with the largest variations on Scale 2–UC and Scale 5–SN. An important note for this comparison is the one-on-one sample size used. The results also did not indicate the overall pedagogical stance of University B’s education department faculty.

![Figure 1. Comparison of University B teacher educators' Preferred CLES scale summary means.](image)

The teacher educators’ Preferred survey scale summary means were compared to the Preferred survey scale summary means of the groups of pre-service teachers they taught. As shown in Figure 2, the teacher educators’ CLES summary means indicated they preferred to create a learning environment that was more strongly aligned with critical constructivist principles than their pre-service teachers’ preferences on Scale 1–PR, Scale 2–UC and Scale 3–CV. This result was also apparent for Teacher Educator B2 on Scale 2–UC and Scale 5–
SN. Teacher Educator B1 summary means were lower on Scale 4–SC and Scale 5–SN than the pre-service teachers Teacher Educator B1 taught.

![Graph showing comparison of preferred CLES scale summary means for University B’s teacher educators and the pre-service teachers they taught.](image)

*Figure 2. Comparison of Preferred CLES scale summary means for University B’s teacher educators and the pre-service teachers they taught.*

An overview of the two graphs indicated that teacher educators from University B would ideally create a classroom learning environment based on critical constructivist elements and that their pre-service teachers preferred to learn in this environment. The graphs also addressed research question two on teacher educators’ perceptions of the classroom learning environment. As pre-service teachers identified they preferred to learn in this environment, researchers indicated that learning outcomes for the pre-service teachers should be positively influenced if the teacher educators succeeded in creating and if the pre-service teachers perceived such an environment (Lizzio, et al., 2002). As two teacher educators taught the same course at University B, similar pedagogic practices would be important to maintain consistency for the pre-service teachers and in the interpreted syllabus.
4.6 Comparing Classes and Teacher Educators to Their Sections

The different class sections of the primary science course were analysed to review for consistency between the different classes’ understandings of the classroom learning environments as well as consistency between teacher educators. This data also addressed research question one. As University A had one teacher educator for all sections surveyed, no comparisons between teacher educators could be completed, only comparisons between the primary science class sections. At University B, there were two teacher educators and their class sections were analysed to review for similarities and/or differences between the two teacher educators’ classroom learning environments. Paired-samples t-tests, with the Preferred and Actual survey data of class sections, were completed. An indication of significant results was set at $p < .05$.

For University A, the Preferred scale summary means for all classes were above 15 or moderate alignment, except for Scale 4–SC that had two classes with summary means below 15. Why this scale’s summary means were lower for two classes on the Preferred survey was not discernible from the results. Actual scale summary means were 15 and above on three scales (Scale 1–PR, Scale 2–UC, Scale 5–SN) and below 15 on Scale 4–SC. Scale 3–CV had two classes’ means above 15 and one below 15.

As shown in Table 6, at University A there were five significant differences between classes taught by the same teacher educator. The indication of significance was on three scales (Scale 3–CV, Scale 4–SC, Scale 5–SN) but only one scale held significance for all three classes (Scale 4–SC). The other two scales were significant for one of the three classes only. Direction differed for the significant scales, as Scale 3–CV and Scale 4–SC decreased and Scale 5–SN increased. The effect sizes ranged from moderate to strong ($d = 0.78–2.64$).
Table 6

*Paired-Samples t-Tests CLES Results by Class Sections for University A*

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</table>

*Note.* Significant $p < .05$ are bolded.

In Table 7, the results of the paired-samples $t$-tests for all classes taught by each of the two teacher educators at University B are displayed. The indication of significance was set at $p < .05$. Preferred scale summary means, for both teacher educators’ class sections, were
above 15 or moderate alignment. On the Actual survey, scale summary means were 18 or higher except for Scale 4–SC. This scale’s means were below 15 for both teacher educators.

Both teacher educators’ class sections did not have significant results for Scale 1–PR. Their classes indicated significance on Scale 2–UC, Scale 4–SC and Scale 5–SN. On Scale 3–CV Teacher Educator-B2’s classes did have a significant result whereas Teacher Educator-B1’s classes did not. Direction was the same for both teacher educators with increased summary means on Scale 2–UC and Scale 5–SN and decreased on Scale 4–SC. For Teacher Educator-B2, on Scale 3–CV the direction had an increase of summary means. Effect sizes for the significant scales ranged from modest to strong (d = 0.46–1.15).
Table 7

**Paired-Samples t-Tests CLES Results by Class Sections for University B**

<table>
<thead>
<tr>
<th>Scale</th>
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<th>Actual</th>
<th>B2-Preferred</th>
<th>Actual</th>
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<td>B1-Preferred</td>
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<td>B2-Preferred</td>
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<td>23.11</td>
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*Note. Significant p < .05 are bolded.*

Pre-service teachers’ perceptions of the classroom learning environments featured similarities between the two teacher educators at University B. The similar environments would be beneficial for pre-service teachers that might have to change classes.
or make-up a class due to absences. It also would prove useful for the teacher educators to compare how pre-service teachers understood the classroom learning environments and where the teacher educators aligned with each other to keep the course and syllabus consistent.

As unequal numbers of pre-service teachers completed both surveys for teacher educators, caution is advised in interpreting the statistical differences. Nevertheless, the information to review where the two teacher educators’ classroom learning environments were perceived as similar as well as different is useful.

4.7 Demographic Data Comparisons

Self-reported demographic data was used as parameters to analyse the survey data and to indicate if any differences in perceiving a constructivist environment were noted. This data addressed research question one, which questions how pre-service teachers understand the classroom environment. It also investigated part of research question three, if other factors may influence the pedagogical approaches of pre-service teachers.

4.7.1 Gender comparisons. Gender was selected to compare data. For both participating universities, the number of female versus male respondents was highly weighted in favour of females. A low male population enrolled in the primary teaching course was not unusual (Cameron, 2004; Gray & Renwick, 1998) and was not an indicator of unwillingness to participate in the study.

Descriptive statistics on the Preferred CLES for University A, indicated that females had five of the five scale summary means and males had four of the five scale summary means in the moderate alignment for constructivist principles, or above a 15. On Scale 4–SC males’ summary means were just below 15 ($M = 14.00, SD = 4.40$). On the Actual CLES, four of the five scales had summary means for both genders in the moderate alignment for constructivist principles, or above 15. Scale 4–SC was below 10 or weak alignment for both
females and males, respectively ($M = 9.40, SD = 3.18$ and $M = 9.14, SD = 3.72$). On the Actual CLES, the direction of the scale summary means for both genders decreased when compared to their Preferred CLES scale summary means except for females on Scale 5–SN that increased ($M = 19.05, SD = 4.86$ to $M = 20.68, SD = 4.33$).

For University B, both genders had the five scale summary means 15 or above on the Preferred survey. Direction of the scale summary means increased for both genders except for Scale 4–SC that decreased for both from the Preferred to Actual survey. All scale summary means were in the moderate alignment to constructivist principles or higher except for Scale 4–SC on the Actual survey (Females $M = 13.98, SD = 4.69$; Males $M = 14.92, SD = 5.47$).

To determine whether gender had an effect on classroom learning environment perceptions, independent-samples $t$-tests were completed. No indications of significant differences were on any of the Preferred or Actual survey scales for either university (all $p$’s > .05). Appendix F contains Table F15 with complete details of the independent-samples $t$-tests for both universities.

4.7.2 Ethnicity comparisons. Ethnicity was also considered as a factor that might influence how pre-service teachers perceived the classroom learning environment. Demographic data indicated that there were various ethnic groups represented at the two universities. Pākehā and Māori pre-service teachers’ data was selected to analyse. Just as with gender comparisons, the same issue of number of participants arose, as the number of Māori respondents was low. Low participation numbers could bring into question the reliability of the statistical information but the statistical tests used in this study were robust and could cope with educational research that did not always have robust numbers (Muijs, 2011).
First, descriptive statistics of scale summary means were calculated for Pākehā and Māori. For University A, Pākehā and Māori pre-service teachers both had summary means on the five scales of the Preferred survey above 15 or a preferred classroom learning environment to be no less than moderately aligned to constructivist principles. Scale 4–SC had the lowest summary means for both groups and Scale 5–SN had the highest.

For University A’s Actual survey, Māori pre-service teachers had summary means for five of the five scales lower than their Preferred survey scale summary means. Two scales were below 15, Scale 3–CV ($M = 12.67$, $SD = 3.97$) and Scale 4–SC ($M = 8.33$, $SD = 2.96$). Pākehā pre-service teachers had summary means for four of the five scales lower than their Preferred survey scale summary means. One scale was below 15, Scale 4–SC ($M = 9.36$, $SD = 3.05$). The scale that increased for Pākehā pre-service teachers was Scale 5–SN ($M = 20.78$, $SD = 3.95$).

For University B, all five scale summary means on the Preferred survey were above 15 for both ethnicities or a preferred classroom learning environment moderately aligned to constructivist principles. For the Actual survey, Scale 4–SC was scored below 15 by both groups of pre-service teachers (Māori $M = 12.75$, $SD = 5.37$, Pākehā $M = 12.92$, $SD = 4.39$) and other scales were above 15. When reviewing both surveys for University B, scale summary means increased on three of the five scales for Māori and four of the five scales for Pākehā pre-service teachers. Scale 5–SN had summary means higher than 20, meaning pre-service teachers perceived a strong alignment to constructivist principles in the classroom learning environment on that scale (Pākehā $M = 22.44$, $SD = 3.01$; Māori $M = 23.50$, $SD = 2.38$).

Independent-samples $t$-tests on the two groups’ data from the two surveys were completed for both universities. An indication of significance was $p < .05$. A significant
Effect of ethnicity was indicated for University A’s Actual survey for Scale 3–CV, \( t(62) = 2.11, p = .04 \). Pākehā pre-service teachers perceived that the classroom learning environment was moderately aligned to constructivist principles \((M = 16.47, SD = 5.16)\) and Māori pre-service teachers perceived a weak alignment \((M = 12.67, SD = 3.97)\). Effect size was calculated at \( d = 0.83 \), a moderate effect. All other scale comparisons for both universities were not statistically significant (all \( p \)'s > .05). Displayed in Appendix G, Table G16 are complete results from the independent-samples \( t \)-tests for Pākehā and Māori pre-service teachers for both universities.

As well as having an identified Māori pre-service teacher population, University B had other self-identified populations of ethnic groups of pre-service teachers. University A had limited participants from other ethnic groups and no comparisons were completed. The decision to complete statistical tests on survey data using University B’s ethnic participants was made. Some ethnic groups had low participation numbers (2-27 individuals) and results should not be considered as representative of the ethnicity as a whole. The identified ethnicities analysed were Māori, Malaysian, Samoan, Chinese, Indian and Tongan.

Descriptive statistics on the Preferred survey scale summary means had all but one ethnic group scoring all scales higher than 15 or that they preferred to learn in a classroom environment that was moderately aligned to constructivist principles. The exception was for Chinese pre-service teachers on Scale 4–SC \((M = 14.67, SD = 5.51)\).

As Tongan pre-service teachers did not complete the Actual survey, no comparison was made for this group on this survey. The remaining ethnicities Actual survey scale summary means had four of the five scales in the 15 or above level. The scale that decreased was Scale 4–SC. Māori and Indian pre-service teachers’ summary means for this scale were \( M = 12.92, SD = 5.37 \) and \( M = 14.67, SD = 3.51 \), Samoans’ summary mean was \( M = 15, SD = 3.61 \), and
Malaysians decreased but were above 15 (\(M = 17.40, SD = 4.61\)). Chinese pre-service teachers slightly increased their summary means for Scale 4–SC (\(M = 14.67, SD = 5.51\) to \(M = 15.00, SD = 4.76\)). The range of Actual survey summary means on Scale 4–SC had two groups indicating the classroom learning environment was weakly aligned to constructivist principles while two groups viewed it as moderately aligned. Even though these summary means should not be generalised to all ethnic groups due to low participation numbers, teacher educators who teach in ethnically diverse institutions should note that ethnicity might frame how a pre-service teacher perceives the classroom environment.

A one-way ANOVA test was completed on the survey scale summary means of ethnic groups from University B. Pākehā pre-service teachers were not included in this analysis as the number of participants in this group was much larger than in the other ethnic groups.

The ANOVA indicated that the desired or preferred learning environment was significant, \(F(6,40) = 3.24, p = .01\) on Scale 5–SN on the Preferred survey. Partial eta squared was .33, which was a modest effect. The values of eta squared vary from zero to one. A number closer to one suggests a larger effect. The use of a post hoc analysis of least significant difference (LSD) determined where the differences occurred. This test showed that Malaysians (\(M = 22.07, SD = 2.88\)) viewed the classroom learning environment more positively than Chinese (\(M = 16.67, SD = 4.62, p = .01\)) and Māori pre-service teachers (\(M = 18.58, SD = 5.39, p = .03\)). Samoans (\(M = 23.50, SD = 0.71\)) also viewed the classroom environment more positively than Chinese pre-service teachers (\(M = 16.67, SD = 4.62, p = .03\)) on this scale. No other effects were noted between ethnic groups (all \(p’s > .05\)). Appendix H contains full results of the ANOVA test for University B in Table H17.

As there were a number of self-identified Malaysian pre-service teachers at University B, an independent-samples \(t\)-test for Malaysian and Pākehā pre-service teachers was
completed. University A did not have an ethnic population of Malaysian pre-service teachers for a comparison of this nature. Both ethnic groups’ direction increased for four of the five scales from the Preferred to the Actual survey. On the Actual survey, Scale 4–SC decreased for both groups. Malaysian pre-service teachers scale summary means for the classroom learning environment were higher for critical constructivist principles than their Pākehā counterparts on all five scale summary means for both the Preferred and Actual surveys.

Independent-samples t-tests on the two groups were calculated. An indication of significance was set at $p < .05$. Significance was indicated for Pākehā and Malaysian pre-service teachers on four of the five scales. Significant results for the ethnicities of Pākehā and Malaysian occurred on Scale 1–PR, Scale 2–UC, and Scale 4–SC on both the Preferred and Actual surveys and for Scale 5–SN on the Preferred survey. All other comparisons were not statistically significant (all $p$’s > .05).

Effect sizes were calculated for the three significant scales and these ranged from $d = 0.52–1.00$, which indicated a moderate to strong effect. The results suggested that being a Malaysian pre-service teacher influenced their perceptions of a critical constructivist classroom learning environment more positively compared to Pākehā pre-service teachers’ perceptions. Table 8 displays complete details for this test.
Table 8

*Independent-Samples t-Tests CLES Results for Pākehā and Malaysian Pre-Service Teachers for University B*

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<th>Actual–Pākehā</th>
<th>Actual–Malaysian</th>
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<th>SD</th>
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*Note. Significant at p < .05 is bolded.*

4.7.3 Different levels of science qualifications comparisons. For both universities, comparisons between different levels of science qualifications were possible. High school students are required to take science through Year 10 and have the option to take it in Years
11-13. Individuals who continued with science in Year 11 and beyond have some reason or purpose to study science than the individuals who stopped taking science at Year 10.

Year 10 science qualification pre-service teachers had higher summary means for three of the five scales on the Preferred survey when compared to the other science year levels (Scale 1–PR, Scale 3–CV, Scale 4–SC). Year 12 science qualification pre-service teachers had lower summary means for three of the five scales when compared to the other science year levels (Scale 3–CV, Scale 4–SC, Scale 5–SN.)

ANOVA tests on both universities’ data were completed. An indication of significance was $p < .05$. The ANOVA results indicated that Scale 1–PR was significant for University B on the Preferred survey, $F(4,136) = 2.67$, $p = .04$. The effect size was weak ($\eta = .07$). Follow-up tests (LSD) suggested Year 10 science qualification pre-service teachers ($M = 21.50$, $SD = 2.07$) viewed the classroom learning environment more positively than Year 11 ($M = 17.67$, $SD = 3.93$, $p = .00$), and Year 11 science qualification pre-service teachers ($M = 17.67$, $SD = 3.93$) viewed it less positively than Year 13 ($M = 19.38$, $SD = 3.04$, $p = .02$). All other comparisons were not statistical significantly (all $p$’s > .05). University A did not return any significant result for either survey (all $p$’s > .05). Displayed in Appendix I, Table I18 are complete results for the ANOVA tests for both universities. The number of pre-service teachers used for this ANOVA was low for some science year levels so further investigation is advised.

4.7.4 Age group comparisons. Another potential factor considered an influence in how pre-service teachers perceived classroom environments was age. Independent-samples $t$-tests were used with data grouped into pre-service teachers under 20 years of age and 20 years and over. The rationale for this comparison was 18 and 19 year olds were likely to have started the degree programme directly after finishing secondary school whereas the 20 years
and over were occupied in some manner before beginning the teaching degree programme. Additional experiences before beginning the degree programme had the potential to influence how pre-service teachers viewed the learning environment.

For University A, four of the five scale summary means were 15 or higher on both surveys. Scale 4–SC summary means were in the weak alignment to constructivist principles for the 20 years and over age grouping on the Preferred survey ($M = 14.59$, $SD = 3.32$) and for both age groups on the Actual survey ($>= 20 M = 9.97$, $SD = 3.01$ and $< 20 M = 8.90$, $SD = 3.32$). Scale 3–CV had the highest summary means for both groups on the Preferred survey ($>= 20 M = 19.64$, $SD = 4.70$ and $< 20 M = 18.89$, $SD = 4.64$) and Scale 5–SN on the Actual survey ($>= 20 M = 21.13$, $SD = 3.36$ and $< 20 M = 20.18$, $SD = 4.75$).

For University B, all scale summary means on the Preferred survey were at or above 15 or moderate alignment to constructivist principles for both age groupings. On the Actual survey, four of the five scale summary means were at or above 15. Scale 4–SC for the under 20s was in the weak alignment or below a 15 ($M = 12.42$, $SD = 4.29$) and in moderate alignment for the 20 years and over ($M = 15.72$, $SD = 4.75$). Scale 5–SN on both survey forms with both age groupings, scale summary means were above 20, or in the moderately strong alignment to constructivist principles.

To investigate age as a variable, independent-samples $t$-tests on the scale summary means of the two age groupings were conducted with significance set at $p < .05$. As displayed in Table 9, significant differences between under 20 years and over 20 years for University B were noted on the Preferred and Actual surveys for Scale 1–Pr, Scale 2–UC and Scale 4–SC. Significance was also noted on the Preferred survey on Scale 3–CV. The direction increased for 20 years and over scale summary means on four of the five scales and under 20 years decreased on two of the five scales. The effect size calculated for the significant results
ranged from modest to moderate effects ($d = 0.32–0.73$). University A did not return any significant result for either survey (all $p$’s > .05).

Table 9

*Independent-Samples t-Tests CLES Results by Age for University B*

<table>
<thead>
<tr>
<th>Scale</th>
<th>Preferred</th>
<th>Actual</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>df</th>
<th>t</th>
<th>F</th>
<th>p</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale 1–PR</td>
<td>&gt; = 20</td>
<td>75</td>
<td>20.00</td>
<td>3.57</td>
<td>161</td>
<td>2.44</td>
<td>.33</td>
<td>.02</td>
<td>0.38</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 20</td>
<td>88</td>
<td>18.74</td>
<td>3.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale 2–UC</td>
<td>&gt; = 20</td>
<td>74</td>
<td>18.42</td>
<td>4.10</td>
<td>161</td>
<td>2.07</td>
<td>.11</td>
<td>.04</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 20</td>
<td>89</td>
<td>17.21</td>
<td>3.35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale 3–CV</td>
<td>&gt; = 20</td>
<td>76</td>
<td>19.64</td>
<td>4.85</td>
<td>163</td>
<td>2.27</td>
<td>.22</td>
<td>.02</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 20</td>
<td>89</td>
<td>18.07</td>
<td>4.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale 4–SC</td>
<td>&gt; = 20</td>
<td>71</td>
<td>18.17</td>
<td>4.27</td>
<td>155</td>
<td>2.81</td>
<td>.07</td>
<td>.01</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 20</td>
<td>86</td>
<td>16.40</td>
<td>3.62</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale 5–SN</td>
<td>&gt; = 20</td>
<td>71</td>
<td>20.52</td>
<td>3.67</td>
<td>155</td>
<td>.05</td>
<td>.30</td>
<td>.96</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 20</td>
<td>86</td>
<td>20.49</td>
<td>3.83</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Significant at $p < .05$ is bolded.
For University B, the results suggested that age made a difference in the learning environment preference as well as how the classroom learning environment was actually perceived. There were no significant results for University A (all $p$’s > .05). These results hinted at some other factor in addition to age that might have influenced University B’s results. Further investigation with age as a variable is advised.

4.8 Summary

The purpose of this chapter was to validate the scale items used on the surveys and report the results of the CLES analyses. Cronbach’s alpha scores and Spearman’s rho scale correlations indicated the surveys were valid. The values from these analyses fell within acceptable research limits.

After reviewing the descriptive statistics for the Preferred surveys, indications were that the pre-service teachers from both universities preferred to learn in a classroom environment that had moderately strong alignments to critical constructivist principles. Both universities had lower alignment on Scale 4–SC but even this scale aligned positively to constructivism, with summary means of at least 15 on the Preferred survey.

On the Actual survey, four of the five CLES scales aligned positively to constructivist principles for University A’s pre-service teachers. The exception was for Scale 4–SC that was in the weak alignment range. The Actual classroom environment summary means were lower than the Preferred learning environment summary means on four of the five CLES scales for this university. Using paired-samples $t$-test, significant differences were indicated on two of the five scales. These results suggested that pre-service teachers only perceived some of the classroom learning environment elements measured. The non-significant results failed to reject the null hypothesis that pre-service teachers’ perceptions of a critical constructivist learning environment will not be affected by the teacher educator’s primary
science course for Scale 1–PR, Scale 2–UC and Scale 5–SN. Significant results on Scales 3–CV and Scale 4–SC, rejected the null hypothesis. The significant results had a moderate to large effect size.

University B’s pre-service teachers had higher scale summary means on four of the five scales on the Actual survey compared to the Preferred survey. Once again, it was Scale 4–SC, which had summary means below 15. Paired-samples t-tests had significant results on four of the five scales. Scale 1–PR failed to reject the null hypothesis and the other four scales rejected the null hypothesis. Effect sizes for the significant results ranged from moderate to large.

These results suggest that teacher educators’ primary science course learning environments were perceived by pre-service teachers in some areas, but not in all. The findings indicate where adjustments should be made if teacher educators desire to create a learning environment based on constructivism. Whether a constructivist learning environment was part of the design of the universities’ primary science course, is discussed in Chapter 5.

Comparisons between teacher educators and class groups were completed to review for consistency of course delivery. The calculation of paired-samples t-tests by class for University A pre-service teachers indicated that Scale 4–SC had significant results for all three classes. Two other scales had significant results for one class but it was a different class for both scales. The results suggested that the primary science course was not affecting some classes as significantly as others even though the same teacher educator taught the course.

For University B pre-service teachers’ paired-samples t-tests compared Actual and Preferred survey scores for the two teacher educators’ classes. Three scales showed significant findings for both teacher educators and Teacher Educator B2 had an additional
scale that indicated significance. The results revealed that the teacher educators’ influenced the classroom learning environment in a way pre-service teachers noticed. The findings indicated where improvements could be made between teacher educators’ classes to bring them more into alignment with each other.

The use of demographic data variables was to compare results on the CLES surveys to indicate if other factors influenced classroom learning environment perceptions. No significant results for either university for comparisons using gender as a variable were returned. For ethnic group comparisons between Pākehā and Māori, only one significant result on Scale 3–CV of the Actual survey for University A was indicated. Pākehā summary means increased compared to Māori pre-service teachers scale summary means. As participant numbers were low for males in the gender comparison as well as Māori pre-service teachers in ethnicity comparisons, more research would be required to confirm or refute these results.

For other ethnic groups, significant results were returned using independent-samples t-tests comparing Pākehā and Malaysian pre-service teachers. This finding was for the Preferred and Actual survey data at University B. On four of the five Preferred scales and three of the five Actual scales significant results were indicated. As University A did not have a self-identified Malaysian population, no tests were able to confirm or refute the findings from University B. Malaysian pre-service teachers perceived the classroom learning environment more positively for constructivist principles than Pākehā pre-service teachers on all of the CLES scales summary means. The effect sizes for the three significant scales for University B were calculated and these ranged from a moderate to a strong effect.

ANOVA tests used on pre-service teachers’ last year of science qualifications returned no significant results for University A and only one result on the Preferred survey on Scale 1–
PR for University B. Differences were noted for Year 10 and Year 11 as well as for Year 11 and Year 13 when post-hoc LSD tests were used. As participant numbers were low for some year levels of science qualifications, more research is required in this area.

Independent-samples $t$-tests were completed on age with a division of those under 20 years of age and those 20 years and older. For University B, significant results were returned on four of the five scales on the Preferred survey and three of the five scales for the Actual survey. There were no significant results on either survey for University A. There was an assumption that some significant results for University A would be returned, if age were a factor. As University A did not return any significant results, other variables might have returned the significant results for University B.

In review, the two CLES’ descriptive statistics revealed the classroom learning environment pre-service teachers and teacher educators preferred and what pre-service teachers perceived. The statistical results indicated that what teacher educators did in the classroom learning environment made a difference that pre-service teachers noticed, but in only some constructivist areas. Equally, some demographic variables returned significance for the universities, but not all. Teacher educators should consider that these variables may influence pre-service teachers’ perceptions and understanding of the classroom learning environment. The non-significant results also contributed to understanding the classroom learning environment as this indicated that the learning environment may not be understood the way the teacher educator desired. The research results indicated how complex the learning environment was and that ways to monitor it should be an important part of pre-service teacher education reviews.
Chapter 5-Syllabi, Semi-Structured Interviews and Effective Pedagogy Approaches

Chapter 5 reports the results of the data analyses from the primary science courses syllabi and the semi-structured interviews. Included in the sections is how these findings link to the CLES’ results and begin the triangulation process of the data. Section 5.1 outlines the two university primary science courses’ characteristics as stipulated on the syllabi. Also reported in this section are the findings regarding any links between the syllabi and the CLES’ constructivist underpinnings, as the syllabi stated that constructivism was the theory taught during all or part of the two primary science courses. Section 5.2 summarises and discusses the data of the semi-structured interviews and how the data links to the CLES scales. Highlighted within this section are the coded themes of: pre-service teachers’ attitudes towards science, their emerging science pedagogy, constructivism, science area strengths, beliefs about good science teachers and suggestions offered to improve future university primary science courses. Section 5.3 is a review of how the data results support or not support The New Zealand Curriculum’s effective pedagogy approaches. Finally in Section 5.4 is a summary of this chapter.

5.1 Syllabi Characteristics

To further investigate research question two regarding the type of classroom learning environment the teacher educators created and/or modelled for pre-service primary teachers, the syllabi for the primary science courses were collected along with the courses’ assignment requirements. This data was a second point of reference to link the syllabi information to the five scales of the CLES to ascertain whether the courses’ structures related to a constructivist learning environment. This study used syllabi and course information as these are recognised by the education departments as approved documents that encouraged consistency of teaching from course to course. As the primary science course classes were not formally observed
and/or videotaped, it was not known if teacher educators followed the syllabus. Even though formal observations did not occur, I administered the CLES once in person at each university. Following the administration, I stayed for the duration of the class and noted the basic classroom characteristics of each university’s primary science class.

Assigning a CLES scale to a syllabus item was only possible if a connection was clearly established by the syllabus’ wording. As this connection was not always achievable, it was quite probable that some coursework items could have linked to CLES scales but, due to the limited syllabus description, were excluded. Even with these limitations, each syllabus gave insight into the composition and characteristics of the primary science course.

An overview of the course structure for both universities as well as the number of stated syllabi items that connected to the five scales of the CLES is in Table 10. Each syllabus item counted for a scale only once, but could count for multiple scales as appropriate. Examples of some of the wording used to identify course components for the CLES scales and the number of times these linked to the scales are displayed in Table 10 (i.e. 2x–develop science ideas). Points of interest in Table 10 are that the two participating universities appeared similar in regards to the number of combined total required and recommended readings listed, number of aims, and CLES Scales 3–CV, 4–SC, 5–SN. The noted differences were in hours of course contact time, attendance requirements, assignments, time allocated to teach science in primary schools by pre-service teachers, listed objectives and CLES Scale 2–UC. No prerequisites were required to take either course other than to be an enrolled primary pre-service teacher. Both universities offered further primary science courses that used this course as a prerequisite. Pre-service teachers were required to enrol in the primary science course as part of their degree and obtain marks of C or higher on assignment to pass the course.
Table 10

*Syllabi Overview and Number of Course Items that Related to CLES*

<table>
<thead>
<tr>
<th>Overview</th>
<th>University A</th>
<th>University B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours in course</td>
<td>26 hours</td>
<td>32 hours</td>
</tr>
<tr>
<td>Attendance requirements</td>
<td>All, with exceptions</td>
<td>80% of classes</td>
</tr>
<tr>
<td>Assignments</td>
<td>2-lesson plans; 1-science background notes</td>
<td>1-essay; 1-lesson plan</td>
</tr>
<tr>
<td>Teach in schools</td>
<td>2x</td>
<td>1x</td>
</tr>
<tr>
<td>Readings–required</td>
<td>2-The New Zealand Curriculum; Purchased course readings</td>
<td>7-The New Zealand Curriculum; Online readings; Reserve book chapters</td>
</tr>
<tr>
<td>Readings–recommended</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Listed aims</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Listed objectives</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Pedagogy</td>
<td>3-Constructivist; Socio-cultural; Inquiry-based</td>
<td>1-Constructivist</td>
</tr>
<tr>
<td>CLES Scale 1–PR</td>
<td>4x-Variety of science ideas that children already have; Extend their science understandings</td>
<td>3x-Explore issues that link science learning to daily living</td>
</tr>
<tr>
<td>CLES Scale 2–UC</td>
<td>5x-Investigating in science, children’s understandings about world, how scientists work; Relationship between science, children’s learning and teaching of science</td>
<td>3x-Developing science ideas over time; Links with Te Ao Māori</td>
</tr>
<tr>
<td>CLES Scale 3–CV</td>
<td>1x-Policy on student’s concerns</td>
<td>1x-Student support</td>
</tr>
<tr>
<td>CLES Scale 4–SC</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CLES Scale 5–SN</td>
<td>3x-Reflect on lesson plans, explain relationships</td>
<td>3x-Engagement and eliciting children’s questions; Reflection</td>
</tr>
</tbody>
</table>

*Note. 2010 syllabus and assignment information were used from both universities.*
University A’s course allocated more time to practise teaching science in a primary school than University B, with two science teaching times allocated versus one. This extra time would permit pre-service teachers from University A to have more practise at science teaching and researchers have linked increases of successful teaching time to increased personal science teaching efficacy (Cantrell, et al., 2003). Syllabi did not state whether pre-service teachers selected the science topics they taught or were they told what they would teach when at the primary school. The number of aims and objectives listed in the syllabi were also greater at University A, which had a combined total of 16 versus 12 for University B. One of the noted differences was University A taught three pedagogies and University B taught one.

By using the aims and objectives as guides for the courses’ conceptual structures, pedagogical and curriculum concepts were the foci for the courses. This structure was the expected focus for a curriculum subject course. Similarities between the courses were that they both worked to strengthen basic primary science understandings by the use of science activities as teaching examples for the pre-service teachers. A presentation of the constructivist view of teaching and learning was listed in both courses. Differences were University A listed, in four different aims or objectives, a focus on children’s science and their understandings of science concepts. University B stated a focus of how science could link to students’ daily lives. University A listed in its objectives that pre-service teachers would be able to increase their CK and abilities in science. University B’s course did not focus on increasing or extending the pre-service teachers’ current science understandings. How University A evaluated whether pre-service teachers increased their CK was not in the syllabus.

Both universities had the Nature of Science (NoS), from The New Zealand Curriculum as a separate class or lecture focus. University B had two aims or objectives in regards to
The pedagogy approaches stated as being taught to pre-service teachers differed; University A listed three approaches and University B stated one on its syllabus. This difference might explain some of the variations noticed between the universities with the CLES results. University B stated it used constructivism while University A taught this practice as well as two other pedagogies. How well three approaches were understood by and modelled for pre-service teachers was not apparent from the syllabus. Also not stated on University A’s syllabus was how many classes were devoted to each of the three approaches. An assumption was that University B focused on constructivism for the entire course. A discussion of some of the interviewed pre-service teachers’ understandings of the different pedagogies is in Section 5.2.3.

Both universities had CLES items that related to syllabi items. University A had a slightly higher number of items that linked to Scale 1–PR and Scale 2–UC. Neither university had any linkages to Scale 4–SC. This CLES scale also showed the least alignment to constructivist principles for both universities. As it was difficult to match any syllabi items to this scale, it was not surprising that pre-service teachers did not perceive this characteristic in their actual learning environment either.

During the CLES administrations, I did an informal observation of the classes’ basic characteristics. Teacher educators concurred that the classes I observed were the norm for their primary science courses. Teacher educators worked with 25-30 pre-service teachers at a time and combined a lecture-type format with hands-on science activities that pre-service teachers investigated and discussed. Teacher educators modelled appropriate teaching
pedagogy and discussed with pre-service teachers what they observed during the modelling. The modelling consisted of role-playing with a group of pre-service teachers or a whole group activity where the teacher educators stated they were taking on the role of a primary teacher. When listening to small group discussions during science activities, I heard pre-service teachers’ misconceptions and lack of understanding of basic science phenomena. Also overheard were the correct explanations of science phenomena but only by a few pre-service teachers. This occurred at both universities.

Though the informal class observations yielded limited data, the pre-service teachers’ science background understandings, as well as the basic characteristics of the two university courses, appeared similar. The method of teaching the pre-service teachers, even though the syllabi showed varied content structures to each other, was comparable. The similarities made the comparison between the two courses valuable to understand how pre-service teachers understood constructivism especially when one course taught only constructivism and the other used multiple pedagogies.

5.2 Semi-Structured Interviews

To expand the findings on research questions one and three, semi-structured interviews were conducted with 14 pre-service teachers, two males and 12 females. The interview questions were informed by the constructivist principles from the CLES, how pre-service teachers saw their science PCK developing and what factors influenced its development. As the interview questions were semi-structured, the interviewer could follow-up any interviewee response with another question not in the interview protocol. The findings built up the fine-grained analysis or qualitative portion to support the coarse-grained or quantitative analysis (Tobin & Fraser, 1998) undertaken with the survey components and syllabi review. A copy of the questions is located in Appendix B. Questions were asked in the order presented on the copy in the appendix.
All individuals who volunteered were interviewed. As with the survey data, the participants were predominately female, Pākehā, and 18-20 years of age. The interview participants’ demographic data is displayed in Table 11. A point to note on Table 11, is the number of interviewees who completed science through Year 13, which is higher than in past New Zealand studies (Education Review Office, 2010; Lewthwaite, 1999).

Table 11

*Interview Participants’ Demographic Data*

<table>
<thead>
<tr>
<th>Demographic identifier</th>
<th>Participant numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>University A</td>
<td>3</td>
</tr>
<tr>
<td>University B</td>
<td>11</td>
</tr>
<tr>
<td>Male</td>
<td>2</td>
</tr>
<tr>
<td>Female</td>
<td>12</td>
</tr>
<tr>
<td>18-20 years</td>
<td>9</td>
</tr>
<tr>
<td>21-23 years</td>
<td>3</td>
</tr>
<tr>
<td>24-27 years</td>
<td>1</td>
</tr>
<tr>
<td>No response to age</td>
<td>1</td>
</tr>
<tr>
<td>NZ/Pākehā</td>
<td>10</td>
</tr>
<tr>
<td>Malaysian</td>
<td>3</td>
</tr>
<tr>
<td>No response to ethnicity</td>
<td>1</td>
</tr>
<tr>
<td>Science level attained - Year 11</td>
<td>3</td>
</tr>
<tr>
<td>Year 12</td>
<td>3</td>
</tr>
<tr>
<td>Year 13</td>
<td>7</td>
</tr>
<tr>
<td>No response to science level</td>
<td>1</td>
</tr>
</tbody>
</table>
All interviews occurred within 1 month of the completion of the university primary science courses. After transcription, the interviews were reviewed multiple times and coded. An interpretive theoretical framework was used for coding (Morehouse, 2012). Following this framework, an exploration of the shared meaning and understanding that pre-service teachers acquired from teacher educators of how to teach primary science transpired. The first coding process found general themes related to the CLES and research questions. These findings were then recoded to organise them into themes that were more specific. The voices of pre-service teachers’ understandings of primary science and their primary science course emerged.

The following interview sections use direct quotes from the transcriptions with names and identifying information removed. Brackets are used to include prior information that assists the reader in understanding the passage. This practice is only done when required to clarify the quote’s meaning.

5.2.1 Links to CLES. The number of responses made by pre-service teachers that related to the five scales of the CLES is located in Table 12. Coding interview comments to the CLES scales assisted in answering research question one on how pre-service teachers perceived the classroom learning environment and question three on what aspects of the course shaped the pedagogical practices pre-service teachers may use in science. Coding to the CLES scales also triangulated the data to support or refute the CLES and syllabi analyses findings. Participants were not specifically asked about the CLES during the interviews or to respond to it, so the linked responses were not prompted by the interviewer. CLES links were coded from across an individual’s entire interview. Notable points in the table are the low number of relatable comments to the CLES for University A, as well as the higher number of comments on Scale 1–PR and Scale 5–SN for University B. Quotes that supported the CLES scales follow the table.
Table 12

*Number of Interview Responses that Related to the CLES*

<table>
<thead>
<tr>
<th>Scale</th>
<th>University A (n = 3)</th>
<th>University B (n = 11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–PR</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>2–UC</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>3–CV</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4–SC</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>5–SN</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

Even though University B had a higher number of interview participants than University A, the number of times the CLES’ critical constructivist principles related to comments made by the pre-service teachers from University B, especially for Scale 1–PR and Scale 5–SN were noteworthy. These findings suggested that the classroom environment and the teacher educator’s practice might influence pre-service teachers for these constructivist-linked statements and their future science pedagogy. The comments for Scale 1–PR came from five different individuals and Scale 5–SN had three people respond, so these were not the same University B pre-service teachers making multiple comments relatable to a single scale. Comments coded to Scale 1–PR included, “science can also be ordinary things around us. It’s not that hard and complicated, in fact it can be fun!” and how when the pre-service teacher would be teaching they would use an, “activity that is still in carrying from their [primary students’] own life, so they can make connections from that.”

For University B, there were three comments that coded to Scale 4–SC, which had the lowest scale summary means of the five scales surveyed. There were no comments coded for University A. Comments coded to Scale 4–SC were when a pre-service teacher defined
constructivism and how primary students learned science, “using that knowledge to make up their own experiments or do an experiment to test whether what they think is right and then come back and evaluate it.” Another commented that the course, “really got us involved” and that, “If we were stuck on something, we could ask [the teacher educator] anything.” These comments were weak examples of Scale 4–SC, but there was the beginning of sharing control of learning between teacher and student.

For both universities, comments coded to Scale 5–SN were, “[The teacher educator] was always involving us students” and, “making our opinions like open like we were always like expected to ask questions.” At both universities the pre-service teachers felt comfortable to question and talk to the teacher educators and their peers, a practice that should help pre-service teachers gain insight into science PCK and even science CK. One pre-service teacher commented, “You had to know why you were answering it [questions] and back it up and think deeper into why you thought that way.”

5.2.2 Attitudes. Other themes coded were for pre-service teachers’ attitudes towards science and the teacher educator’s classroom practice. The two themes addressed research question three on the aspects of the primary science course that appear to shape teaching approaches and if other factors influence the shaping of these practices. The coding of comments for this section came from the Understanding the Course interview question section and developed into: a) attitudes to science and science teaching and b) attitude changes during the primary science course.

5.2.2.1 Attitudes to science and science teaching. There was a wide range of attitudes towards the subject of science at the beginning of the primary science course. These ranged from, “I love science”, “I was pretty neutral…didn’t have any strong feelings towards it”, “I lost interest in high school”, “it’s boring and a bit difficult” to, “As soon as I could drop it I
did [at secondary school].” Another pre-service teacher stopped taking secondary school science courses after Level 2 of 3 because:

I had other options that I wanted to take and I knew at that point what my career path was [teaching] so I didn’t really need them [science courses]. I was taking them to keep my options open and so when I figured that I was going into teaching, I sort of decided to stop and do my other options.

Many pre-service teachers in this study held negative attitudes toward science as the data collected on the CLES demographic form asked for past impressions of science classes. As the demographic portion of the survey gave no word prompts, pre-service teachers completed the survey answer space with as many or as few words as they desired. When coding items, a pattern emerged of common words used to describe past science experiences. Figure 3 displays the analysis from both universities. Figure 3 uses black bars for positive and white bars for negative descriptions of past science experiences. If a word was neutral, the next word written was the placing descriptor used (i.e. book, boring). When a word could not be placed, it was left off the graph, but less than eight pre-service teachers used only one word to describe their past science experiences and that could not be coded. Teacher educators should consider the negative attitudes pre-service teachers hold because as Palmer’s (2002) research noted, negative attitudes could influence how much science is taught in their future classroom. Past science experiences were also seen as the most important variable in affecting the attitudes held towards science (Parker & Spink, 1997).
This research finding coincided with the research literature that indicated pre-service teachers’ past experiences with science were inadequate in assisting them to learn the subject as well as enjoy it (Abell, Bryan, & Anderson, 1998; Jarvis, et al., 2005). This finding suggested that teacher educators must consider and work with a wide range of attitudes to science, positive and negative, that individuals retain when studying this topic. These attitudes towards science should be taken into account by teacher educators when teaching the course as negative attitudes, if not changed to a more positive stance, can influence how much pre-service teachers may teach science in the future (Palmer, 2002).

5.2.2.2 Attitude changes. Several of the interviewed pre-service teachers commented on the beginning transition they were experiencing, moving from a learner to a teacher of learners. One pre-service teacher said, “I found out about how to teach science and not just learn about science like a student does…[the teacher educator] showed us how to be a teacher.” Another stated, “my attitude towards science teachers…it improved.” A third pre-service teacher said, “I got a lot more respect for people who do teach science…more respect
towards science being taught than I did before I started doing the course.” At both universities, this appeared to be the pattern; there were improvements in attitudes felt toward science teaching and in some individuals toward science learning. Interviewees stated the improvements were directly due to the course and the teacher educator’s practice. This change was a positive attitude shift for pre-service teachers and their future classrooms where they might feel more inclined to teach primary science than before they did the course (Appleton & Kindt, 1999; Loughran, 1994). As pre-service teachers attributed the change in attitudes to their teacher educators’ practices, the positive impact might influence their future pedagogical practices.

Only one pre-service teacher indicated that her attitude towards science had decreased at the end of the course, “cause it [the course] got boring.” This pre-service teacher indicated that she loved all science before the course began. When questioned further on the change, she indicated that later in the course it seemed, “theory based” to her and she lost interest.

Pre-service teachers’ positive attitude changes in science were attributed, in part, to their teacher educators. Many of the interviewed pre-service teachers spoke of the enthusiasm and passion their teacher educators brought to science and the classroom learning environment. “Passion” and “enthusiasm” were the two words that came up the most for both universities when describing the teacher educators and their practices. Also commented on was how their teacher educator taught, “management techniques that [the teacher educator] modelled. And then [the teacher educator] got us to do it!” Another stated, “only time in my education that I actually learned any science. It has been really eye-opening…taught relevant things that I would be able to also teach.” All interviewees, except one, stated that they ended their course with a positive attitude towards the course and science. This one individual, who was the exception to the other interviewees, felt that after the required assignments were completed, was not sure why the course continued. This pre-service teacher queried, “Why
am I even here, well I’ve pretty much done what’s needed…I’m not the only one who thought this!” As she was a younger pre-service teacher who appeared to have the mindset of seeing education as a series of assignments to complete, it may be a concern that other pre-service teachers straight from secondary school agreed with this statement. It may be a challenge for teacher educators to achieve pre-service teachers’ understanding of the importance of pedagogic theory in pre-service coursework at this early stage of the education programme. This pre-service teacher’s comment hinted that the theory-practice gap, as indicated in research studies (Duit & Treagust, 2003; Russell & Chapman, 2001), was present for some individuals.

As the primary science courses at both universities were completed early in the teacher education programme, some pre-service teachers wanted practical advice on how to teach, not a discussion on theory (Smith, 2000). One pre-service teacher thought there was practicality to the primary science course, as it was described as, “practical stuff and [the teacher educator] taught us through practice rather than just sitting us down and doing theory…there was always a point behind it.” For teacher educators to develop an understanding in pre-service teachers of the importance of all the course’s classes may be a challenge. The majority of the pre-service teachers in this study were straight from secondary school and might not have made the mental shift from being a student in school to a student of a profession. There was some truth to the pre-service teacher’s statement of others thinking once assignments were done, why come to class, as the Actual CLES’ administration was rescheduled. The administration of it was changed from the last class session to the penultimate as teacher educators were concerned individuals might skip the last class if they felt they had meet all of the class’ requirements. To know that fewer individuals attended the last class suggested that teacher educators understood they had one less class session to instruct pre-service teachers in primary science.
The pre-service teachers’ attitudes towards science and the course indicated positive changes for most of the individuals interviewed. The interview analysis suggested that the university primary science courses had a positive impact on some of the negative memories displayed in Figure 3 of science teaching and learning for the pre-service teachers. Whether the primary science courses’ positive impact was a permanent change, could not be indicated by this data. What the results of this study indicated were that for the majority of the pre-service teachers interviewed, the university courses provided a positive science experience. The interviews also highlighted the role of other factors that might influence pre-service teachers such as attitudes to science coursework and understanding the importance of theory. As one pre-service teacher said, “[the primary science course] I find it very interesting. [Before course, science] it’s boring and difficult. I really like science when I was in primary school…I lost my interest in high school.” Another stated, “I think the course really helped build um, confidence cause you did have to go through it and understand what you were doing.” Even though the positive aspects varied with individuals, pre-service teachers’ attitudes and the impact teacher educators had on them, appeared to be important components that addressed research question three regarding what aspects of the course influence pre-service teachers.

5.2.3 Science pedagogy knowledge. Several of the questions from the interview section Effective Pedagogy/Constructivism asked about pre-service teachers’ understanding of constructivism and whether they could implement this pedagogy in a classroom. The response results informed research question three and hinted at how pre-service teachers might teach science one day. When an individual did not know or could not remember constructivism, a follow-up question asked how he or she learnt to teach science in the course. Also elicited were self-reported science area strengths and why the pre-service teachers saw these as their science strengths. Even though the number of interview participants remained
the same (University A \( n = 3 \); University B \( n = 11 \)), pre-service teachers commented on some topics multiple times at different points of the interview that were then counted as separate occurrences. In Table 13, category themes to note are the pedagogy challenge comments and science strength areas.

Table 13

<table>
<thead>
<tr>
<th>Category themes</th>
<th>Examples of quoted responses</th>
<th>Total responses (Univ. A / Univ. B) ( (n = 3 / n = 11) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedagogy</td>
<td>Try to model my teaching after; Hands-on; Management techniques</td>
<td>11 / 26</td>
</tr>
<tr>
<td>Pedagogy challenges</td>
<td>Not comfortable with it yet; So different from how I learned; Only time we’ll see science in 3 years</td>
<td>2 / 14</td>
</tr>
<tr>
<td>Define constructivism</td>
<td>Building on previous knowledge; Constructing new meaning with prior and new knowledge</td>
<td>2 / 9</td>
</tr>
<tr>
<td>Science strengths from The New Zealand Curriculum</td>
<td>Material World</td>
<td>1 / 3</td>
</tr>
<tr>
<td></td>
<td>Physical World</td>
<td>1 / 3</td>
</tr>
<tr>
<td></td>
<td>Living World</td>
<td>0 / 6</td>
</tr>
<tr>
<td></td>
<td>Plant Earth &amp; Beyond</td>
<td>1 / 0</td>
</tr>
</tbody>
</table>

Pre-service teachers’ comments on pedagogy and the challenges of actually teaching science dominated this portion of the interview for both universities. The excitement of teaching science was noticeable. “Learning how you can, how what you’re doing, actually can teach children!” one pre-service teacher said in a rather amazed tone. Another summed up her experience, “At primary school, it’s a lot of like, fun activities and like, hands-on
learning experiences as opposed to high school when it’s kind of learning facts.” The challenges of learning to teach science and develop PCK were also reflected in their comments. For example: “it was the only time we’re ever going to see science in our whole 3 years unless we take the option paper⁵”, “there have been other things I’ve been taught in the meantime”, “I haven’t done it like, practically myself, I can still, you know, visualise how I’m going to do it”, “I don’t know if I’m quite really confident in teaching primary science yet.” Another pre-service teacher said, “It is important, um, as kids grow up to make sense of their world that they live in and to know how things work because it’s only with their understanding that they can develop.” “Science is learning how to teach the science knowledge that you have because kids might not understand it the same way that you understand it. And you have to put it into children’s language and things like that,” said an individual. Overall, most pre-service teachers felt somewhat prepared to teach science, but almost all (12/14) stated they would like more science pedagogy at a later time in their education programme especially before they graduated. Increased confidence in teaching science for pre-service teacher was an important result for the courses. Researchers indicated as teachers’ science confidence increased so did the amount of science teaching time in the classroom and it also increased the use of appropriate pedagogical practices (Anderson, et al., 2009; Appleton & Kindt, 1999; Harlen & Holroyd, 1997).

5.2.3.1 Constructivism. The pre-service teachers were asked to define constructivism. The majority verbalised it in a basic fashion (9/14), two defined it competently and three struggled to define it. One person said, “I wouldn’t have a clue” and another stated, “I actually can’t even remember” what it was. One individual, who explained constructivism competently, said:

⁵ In New Zealand, university courses are usually referred to as papers.
Learn what their [primary students’] prior knowledge is but getting them to explain it themselves…come to an understanding about what they already know…do an experiment to test whether what they think is right and then come back and evaluate it.

Another definition was, “Basically it’s building on knowledge that was previously there…so they [primary students] can understand the concept first and then you can build on.” One pre-service teacher defined it as, “constructivism is taking prior knowledge and new knowledge and constructing new meaning.”

When universities were compared, the pre-service teachers from University A had two defining constructivism in a basic fashion and one individual who struggled to define it at all. The individual, who struggled to define constructivism, stated her pedagogy for science would be hands-on activities and explained this as, “We’re providing them with the means to go discover the answer themselves.” On further questioning of the two pre-service teachers from University B who struggled to define constructivism, one stated a revisit to the assignment essay on constructivism was required and then the individual thought constructivist teaching would be possible. The other individual said more education was required about constructivism before defining it or use of it as a pedagogy was possible.

When asked whether any pre-service teachers had experienced learning in a constructivist style as primary or secondary school students, only one of the 14 responded yes, but it was with only one teacher that the participant could remember.

5.2.3.2. Pre-service teachers’ science pedagogies. When asked if the pre-service teachers could use constructivism in a classroom to teach science, the responses showed some struggle with implementing it. “It [constructivism] will probably come with a lot more practice…with more experience,” one pre-service teacher said. “Would need more training to do it,” said another. “I do feel that I could probably do with a lot more learning and I
probably won’t be as confident in teaching science and I’ll have to brush up a lot of the time until I do get confident on it,” stated a third pre-service teacher. “No good at it cause I’ve had no experience with it!” stated another. An international student commented, “It’s something new, new for me it should make ah, connection for the student to understand what we are teaching. To give students opportunity to learn, you can’t make them learn but you can give them opportunity to learn.” A different pre-service teacher indicated that she tried to teach in a constructivist style while on practicum, but her associate teacher had assigned a topic that was new for the primary students. The pre-service teacher said, “I kinda helped them get a little bit of prior knowledge. I hope I was doing constructivism.” Even though many did not know if they could teach in a constructivist style, the pre-service teachers were confident to go teach science, “I feel comfortable to go and teach science in the classroom though,” stated one individual.

As University A used three different pedagogies when introducing how to teach primary science, defining just one pedagogy from the others at this point in their education could be a challenge for these pre-service teachers. A researcher from the United Kingdom advocated introducing pre-service teachers to a wide range of science teaching pedagogies as she saw teaching as having tensions (Traianou, 2012). These tensions evolved from the multitude of decisions teachers made regarding the learning needs of children and usually were not resolved by using a single pedagogy. The question remains, however, whether the time allocated to the primary science course was sufficient in length to develop basic understandings of the three pedagogies so that pre-service teachers could successfully implement any one of them. Interviews indicated that for both universities, most pre-service teachers understood constructivism at a basic level at this time in their teacher education programme. Whether or not they could implement constructivism at a later point in their teaching careers was not possible to determine from this interview data.
What emerged from the interview coding was that the science teaching pre-service teachers seemed to base their pedagogy on was ‘hands-on’ activities. Six of 14 pre-service teachers used this phrase when referring to science teaching. The concern with pre-service teachers’ stated science pedagogy as hands-on, means their students can end up understanding science as a set of process skill activities and not as activities to develop conceptual learning (Appleton, 2003). Follow-up interview questions were not asked of pre-service teachers on how the hands-on activities might be used; as single activities or as a way to develop conceptual understanding. Pre-service teachers had limited practicum time at this point in their education and did not have much experience with science teaching.

5.2.3.3. Science area strengths. Pre-service teachers were asked about their science strengths, as some researchers indicated that primary science teachers usually felt more comfortable with the Living World or biological areas of science (Lewthwaite, 2000; Salter, 2000). Living World (biology) had the most interviewees responding that this area was a science strength for them. What appeared promising was the number of participants that claimed other areas in science as strengths, especially Physical and Chemical World (physics/chemistry), as the New Zealand research studies from Lewthwaite (2000) and Salter (2000) indicated that these areas were usually weaknesses for primary teachers. A pre-service teacher indicated why chemistry was her preferred choice over biology, “I didn’t think it had much meaning in my everyday life. And I found it a lot of um, kind of English based almost, as everyone was always writing essays and you had to remember a lot of really long words that didn’t, really didn’t have much meaning.”

Pre-service teachers’ science strength choices were usually for three reasons. One reason was almost always an enjoyment factor; “I think I enjoy it more [chemistry] that makes me more willing to learn about it”, “I love to experience and explore the environment…in high school we went out into the environment…I really tied it to that [love
of biology], “I enjoy these areas and like to teach them.” The second and third reasons were the science area that the pre-service teacher had experience in, “I prefer to do something that I have done [physics]” or had background knowledge in, “it was my area of interest in high school [physics]…I sort of have more background knowledge than the other [science] areas.”

As this information was self-reported, there was no data on how well the pre-service teachers understood the CK of the strength science area. As a pre-service teacher said regarding teaching in her strength area, “I think I knew in more depth than what they’re doing [primary students when on practicum] so I had to like go back to the basics and so like before I taught it like I read through stuff and learnt what I had to.” The question also remained if enjoyment or having a good experience in science would then lead pre-service teachers to teach it in such a manner that children could develop conceptual science understandings.

As primary teachers teach all areas of science, pre-service teachers need to increase their science CK in the topic areas that are not a strength. Pre-service teachers considering teaching employment at the higher year levels such as Year 6-8 (10-12 year olds) also require more in-depth science CK so they can competently teach Levels 3 and 4 of the science curriculum. Year 6-8 students need a solid background in all learning areas of science (chemistry, physics, earth and space), not just biology, so they are prepared for secondary studies. Pre-service teachers indicated what year level of primary school they wished to pursue employment at on Actual CLES demographic forms. The bar graph created from this data was surprising. The interpretation of the graph should be with the knowledge that it was early in the education programme and many things could happen to change pre-service teachers’ minds before they were able to take up employment at a specific year level. In Figure 4, however, the number of individuals from both universities that indicated the middle school years (Years 6-8, 10-12 year olds) was much higher than anticipated due to the past negative experiences pre-service teachers stated they had with science.
5.2.4 Beliefs and suggestions. Throughout ITE, pre-service teachers develop their sense of what being a teacher entails, which often differs from their perceived reality of teaching primary science (Parker & Spink, 1997). During their time teaching in schools, they start to find their teaching strengths, the subject areas that require more development and observe experienced teachers teaching. Also influencing pre-service teachers’ teaching ideas are their past learning experiences (Onslow & Laine, 2000). In Table 14, the themes identified and coded in the interview data from the Beliefs and Personal sections of the interview questions are shown: a) practicum experiences with science, b) qualities of a good primary science teacher, c) ranked teaching areas and d) ideas on how to improve future university primary science courses. The themes addressed the second part of research question three whether there are other factors influencing pre-service teachers’ pedagogical approaches in primary science.
Table 14

Coded Responses for Beliefs and Primary Science Course Suggestions

<table>
<thead>
<tr>
<th>Category themes</th>
<th>Examples of quoted responses from University A / University B (n = 3; n = 11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed science teaching while on practicum</td>
<td>Making planets in art; Sound activities; Shadows; Water cycle</td>
</tr>
<tr>
<td>Qualities of a good science teacher</td>
<td>Create good lesson plans; Know how to research background knowledge; Passion; Know resources, patience; Interest in topic</td>
</tr>
<tr>
<td>How did they choose their top four teaching subjects</td>
<td>Fun ones, strengths; Enjoyed; Bit of experience with; Easier to teach; More fun for kids</td>
</tr>
<tr>
<td>Course improvement suggestions</td>
<td>Longer course; More time with science; More practical experience; Have some in year 3</td>
</tr>
</tbody>
</table>

5.2.4.1 Practicum. As pre-service teachers had the opportunity to view associate teachers teaching when on practicum in primary schools, seeing science taught by experienced professionals should increase the pre-service teachers’ PCK in science. When asked how many individuals observed or noticed science in their practicum classrooms, five indicated they had not observed science being taught nor seen any evidence that it had been taught before their visits. Six pre-service teachers observed science teaching or noticed evidence it had been taught before their practicum (i.e. work and wall displays). Two individuals were unsure. As pre-service teachers from both universities were near the end of their block practicum visits, which were longer placement times in schools, it was assumed more science would be observed or noticed. Individuals who observed science lessons when
on practicum were questioned how the associate teachers taught science. Pre-service teachers described the observed science pedagogy as: integrated with other subjects (i.e. art), direct teaching points with a verbal exchange, experiment stations setup around the classroom and the students, “discovered it all themselves” or it was a hands-on activity.

One pre-service teacher noted that her lesson was the only lesson on a science topic during her practicum time and that she taught it to only a small group of students. Another pre-service teacher noted, “It’s not an everyday thing [science]. I think it is like a special unit that they [students] have separately…but maths and literacy definitely happen every single day…[The students] do maybe one maybe two units a year.” This response concurred with other research studies in New Zealand that showed the amount of teaching time allocated for primary science has decreased (Baker & Jones, 2005; Lewthwaite, 2005). Not seeing science as an important part of the classroom routine nor observing experienced teachers teach it, might lead to lower PCK in science and/or might even discourage pre-service teachers to teach it (Ginns & Watters, 1999). The pre-service teachers who did not observe science teaching had science de-emphasised as an important curriculum subject. As a pre-service teacher said when responding to the question about whether she had seen science taught while on practicum, “not really, because like literacy and numeracy sort of comes first, first priority.”

Kenny’s (2010) study noted that Australia emphasised maths and literacy, to the apparent detriment of science, with the move to a national curriculum with learning areas similar to New Zealand’s curriculum. Australia’s national testing in numeracy and literacy kept science time minimised in the primary curriculum as accountability was placed on the national testing subjects (Kenny, 2010). Kenny’s (2010) research concluded that the curriculum reform of national testing in numeracy and literacy appeared to contribute to low science teaching levels in Australian primary schools. New Zealand might be following a
similar path with the instituted national standards in numeracy and literacy in primary schools. The importance placed on the standards might see primary science teaching time decline even more than what Chamberlain and Caygill’s (2012) and Caygill’s (2008) past research had noted.

5.2.4.2 Science teacher qualities. Pre-service teachers commented on the qualities they thought a good primary science teacher should possess. Seven different participants indicated that having CK in science was important and six indicated knowing how to teach science, PCK, was important. After those qualities, enthusiasm, passion and making the topic interesting to students were the characteristics most often stated. “Passionate about science, need to understand what you’re talking about,” said a pre-service teacher while another stated, “Passion, patience and a lot of time.” Pre-service teachers indicated that the primary science courses assisted them to become quality teachers as it showed them useful science resources, “[the course] used lots of modern resources.” Pre-service teachers also stated they, “know how to research background [science] knowledge” and how important that was when creating a lesson plan. The qualities listed all seemed to revolve around the selves of the pre-service teachers and not the learning needs of their students. Many of the qualities listed would affect their future students positively, but pre-service teachers were very self-focused. The focus on self or developing a teaching identity is usually encountered in beginning teachers (Ginns & Watters, 1999), but researchers indicated that it was then difficult for teachers to teach using methods that seemed to be against the grain or different from their teaching peers, especially in the area of science (Pedretti, Bencze, Hewitt, Romkey, & Jivraj, 2008).

Pre-service teachers responded to questions about their experiences with science teachers during their primary or secondary schooling. The comments ranged from, “I had some really terrible science teachers” to, “He just wasn’t interesting and enthusiastic about the subject he was teaching. That just really put me off the subject,” “I didn’t think it had much
meaning in my everyday life,” said another pre-service teacher. There were very few who made comments similar to this pre-service teacher, “we all understood it [science] like, and she’d make it fun.” Even though the pre-service teachers spoke about their teacher educator’s passion and enthusiasm during the primary science course, they had many more negative experiences to base their PCK on, as indicated by the data gathered in this study. A researcher’s conclusion from a United States study indicated that teachers might resort to teaching science the way they were taught even though they wanted to teach it using more effective pedagogy methods (Smith, 2000). As many of the pre-service teachers’ experiences were not positive in science before the primary science course, it is doubtful whether they would be able to create positive experiences for their students. Smith’s (2000) study indicated it was a struggle for teachers who had negative experiences to create positive ones for their students. In addition, researchers indicated that it was difficult to change teachers’ views on teaching and what they did in their everyday classroom practice (Duit & Treagust, 2003).

5.2.4.3 Ranked teaching areas. Building on the question of pre-service teachers’ past science experiences, interview participants were asked to rank four curriculum subjects that they would enjoy teaching the most. The reasoning behind the ranking was if pre-service teachers did not like science, it was assumed they would not enjoy or desire to teach it, as findings from research studies of beginning teachers with this issue noted (Smith & Jang, 2011; Tilgner, 1990). Science would not be one of the top four choices. Ten of the 13 pre-service teachers placed science as one of their top four choices. This ranking might be due to the nature of the interview or it might be due to the enjoyment the pre-service teachers had with the primary science course. Other ranked curriculum areas were: English/Literacy–8x, Maths–6x, Art–5x, Dance/Drama–5x, Social Sciences–5x, Music–4x, PE/Health–2x. Not all
pre-service teachers ranked four subjects during the interview. It should be noted that the pre-service teachers would not have experienced courses in all of the curriculum subject areas yet.

When questioned why pre-service teachers chose these topics, the majority said it was due to their own understanding and experience with the subject area or that they enjoyed the subject, so it would be fun to teach it. “I have a bit of experience in [those choices] so those are the ones I’ll be able to yeah, rub off onto the students a little more.” Another pre-service teacher said, “It’s easy to get kids motivated about the arts. To be a bit more fun, it doesn’t seem like they’re so work based, because it’s not like doing maths or literacy, you don’t have to write or think so much.” Other pre-service teachers stated, “I’m capable [in the subjects chosen] and in, Teachers’ College, you sort of realise which part of it you fit into the most and I think they’re the ones that I, really do fit into” and, “I have good background knowledge in them so they’ll be easier for me to teach.” Another pre-service teacher saw a connection between her chosen subjects, “[the subjects] link together. Like as I said, sometimes in science you have to use numbers, like mathematics in science. Yeah especially in English sometimes there are like elements in science you have to learn that are kind of similar.”

As teacher enjoyment of a topic often decides how much time is spent in the classroom on studying it (Smith & Jang, 2011; Tilgner, 1990), having science ranked highly by the pre-service teachers is promising. It might mean that science teaching would occur when they have their own classrooms. As it was early in the pre-service teachers’ education, other influences could still play a part in what topics they would enjoy teaching.

5.2.4.4 Suggestions for course. When asked for suggestions on how to change or improve the primary science course, six participants wanted more of this type of coursework or a longer course in primary science, three wanted more background knowledge and time working with science concepts and two wanted more time to practise science teaching in a
classroom. No individual stated that he or she had had enough of primary science and did not require more education in this area. “[The course] is so short!” one said. Another pre-service teacher thought she needed more CK, “because if you don’t know a lot about the subject, you’re more afraid to teach it.” Most felt they had enough knowledge from the course to go out and teach science but that once they did this, enough questions and queries would arise that they would like a follow-up session, perhaps in year 3 of their degree programme. “I wish we had science for next semester too. More experiments and hands-on activity,” said a pre-service teacher. As one pre-service teacher said, “Definitely more time to sort of suss all that out would have been good.” Another thought, “I reckon more time with students and just working with them and doing science. Maybe a day doing science at different year levels or something.” As the interviewed participants believed they had acquired the basic skills and pedagogy needed to teach primary science at a basic level, this finding would appear to bode well for their future science teaching. As many might not use the knowledge or skills until a later practicum, however, questions remained as to what influence future associate teachers would have. Would pre-service teachers have the time and inclination to do the science background work to be competent science teachers? Some research studies showed that unless science support was given by associates or the school, beginning teachers might abandon science teaching as it seemed too hard to do (Appleton & Kindt, 1999; Ginns & Watters, 1999).

The semi-structured interviews indicated that pre-service teachers experienced science teaching and learning in a style that was new to them. The experience was a positive one, which conflicts with the majority of past science experiences that the demographic data of the pre-service teachers revealed. The data from the interviews described how pre-service teachers perceived their classroom learning environment and their teacher educators’ pedagogy, which further addressed research questions one and three. The influences of the
course on pre-service teachers’ beginning science pedagogy indicated an emerging confidence to teach primary science, but also a desire by pre-service teachers for further development in the topic.

### 5.3 Effective Pedagogy Approaches

It is one of the study’s aims to find links from the results of the three data analyses to *The New Zealand Curriculum’s* seven effective pedagogy approaches. As pre-service teachers need an introduction to and experience in these approaches to incorporate them into their PCK, pre-service teacher education should monitor whether this assimilation happens. After a review of the results of the CLES, syllabi and semi-structured interviews, the following items correspond to the curriculum’s effective pedagogy approaches. Actual CLES data is used when relating to the approaches, as this data was the perceptions of the courses, not what was preferred. Only when the characteristics/wording on the data points are similar, are these matched to the curriculum’s pedagogy approaches. Following the paraphrased description of the curriculum’s explanation of each approach, the primary science course items that matched the approach are discussed.

“Create a supportive learning environment” (Ministry of Education, 2007, p. 34). This pedagogy approach states learning is social and cultural. Students learn best when they feel accepted by peers and teachers in a positive classroom environment. This positive relationship extends to the wider school community and families (Ministry of Education, 2007).

This approach appears similar to what Scale 3–CV, Scale 4–SC and Scale 5–SN of the CLES measured. For University A, the Actual survey descriptive statistics of the three scale mean summary scores indicated one scale was moderately aligned, one was weakly aligned and the other had a moderately strong alignment to constructivism. University B’s Actual
survey had summary mean scores for two scales in the moderately strong alignment and one just below 15, but in weaker alignment. The syllabi for both universities also stated one item each that related to Scale 3–CV and three different items that supported Scale 5–SN. Scale 4–SC had no items. During semi-structured interviews, three pre-service teachers commented that they could ask the teacher educator anything and felt empowered to do so.

With summary means for two of the three scales in positive alignment for both universities, pre-service teachers experienced a learning environment that had pedagogy characteristics of the ability to question the teacher educator’s plans and methods and the ability to explain and develop their ideas with other pre-service teachers. Other important characteristics advocated by this approach were weak for both universities such as the amount of control pre-service teachers had over the total learning environment to negotiate learning. As more syllabi items supported Scale 5–SN and few to no items for the other two scales, those important pedagogy characteristics measured by Scale 3–CV and 4–SC were minimal or absent from the printed course outline. Whereas Scale 3–CV summary means measured a stronger alignment to constructivism; an assumption was that the courses did teach using the characteristics of this scale even though there were few items listed on the syllabi. Scale 4–SC summary means measured a weaker alignment; an assumption was that the printed and enacted syllabi did not include principles of this scale.

“Encouraging reflective thought and action” (Ministry of Education, 2007, p. 34). Being a reflective learner is to assimilate new knowledge to old, use it and then to evaluate it critically. Teachers assist learners to achieve this by designing tasks and materials that encourage them to critically evaluate and consider the purpose of the learning (Ministry of Education, 2007).
Scale 5–SN supports this approach, which also had high scale summary means for both universities on the CLES. This scale measured if pre-service teachers had opportunities to develop and reflect on the validity of their own and others’ ideas. Syllabi items from both universities that highlighted reflection as being a component of a class or activity also support this pedagogy approach. Support for it is also noted in the hands-on science activities used in class sessions that then had the pre-service teachers reflect and discuss what occurred. As some activities elicited more reflection than others, this pedagogy would be an area where pre-service teachers might need work. As there were no course items specifically detailed on how to reflect critically on activities or on thinking, it might be difficult for pre-service teachers to engage in this process. Additionally, teachers are to encourage their students to engage in reflection. Would they be able to teach children how to critically evaluate activities and thinking, when as pre-service teachers, they had little experience of how to do this themselves?

“Facilitating shared learning” (Ministry of Education, 2007, p. 34). A community of learners is cultivated where reflective discourse within this and in the wider community is engaged. Through this discourse the language required for further learning is built (Ministry of Education, 2007).

Scale 5–SN, as well as the reflection items stated on the syllabi, support this approach. Scale 3–CV, in part, also support it especially where questioning the teacher educator was encouraged. This approach is supported when classes developed the language of teaching as well as the language used in science by engaging in hands-on science activities that included modelling by teacher educators and small group and/or whole group discussions. During CLES administration, it was noted that conversations were encouraged during activity time and participation in peer small group discussions was greater during these periods than during whole group discussions. One caveat to these discussions was some of the overheard pre-
service teachers’ science misconceptions that might then be perpetuated, due to low science CK by other pre-service teachers.

During interviews, a pre-service teacher remarked that she found out that it was, “ok for a teacher not to know everything” and that one could, “learn from your students” which were attitude shifts from how she learned science in school. Whether or not similar attitudes, as indicated by the quotes above, were pervasive in the classes, was not indicated by the research data, but support the facilitated shared learning approach.

“Making connections to prior learning and experience” (Ministry of Education, 2007, p. 34). Students learn best when new knowledge is incorporated with what they already know and connections can be made to other learning areas, as well as, outside of school (Ministry of Education, 2007).

Scale 1–PR supports this approach with a moderate and moderately strong alignment for both universities on the Actual CLES. Syllabi analyses indicated that four items from University A and three items from University B relate to this approach. The syllabi items descriptions included: extend science understanding and explore issues that link science learning to daily living. The approach is also supported by semi-structured interview data when pre-service teachers commented on how science could be ordinary things in every day life and that when teaching, they would use an activity that students would be able to connect to their own lives.

These three effective pedagogy approaches have little evidence to support them:

“Enhancing the relevance of new learning” (Ministry of Education, 2007, p. 34). Students learn best when they understand what, why and how they will be using their new learning. Students are involved in making their own learning decisions (Ministry of Education, 2007).
This approach relates to Scale 4–SC, which had the lowest summary means for both universities, there were no related syllabi items and only minimal links from University B’s semi-structured interviews. The pedagogy approach is an area where pre-service teachers need more learning experiences, especially when some do not see the relevancy of theory in the coursework. When reviewing other interview quotes not linked to Scale 4–SC, a little more support for the approach is indicated. For example, when the pre-service teacher was amazed that what was taught was having an impact on the primary student, supports the approach. It is also not supported by a quote from another pre-service teacher, when the course assignments were completed and she did not see the relevancy in attending the course as it seemed all theory based.

“Provide sufficient opportunities to learn” (Ministry of Education, 2007, p. 34). Students learn best when they have time to connect with, practise and transfer their new knowledge (Ministry of Education, 2007).

This approach is difficult to place as supported or not by the research data, as some pre-service teachers said that the course should be longer and that it was the only time they would take a science course during their degree. Yet, most indicated they now felt confident to go and teach primary science. Both universities did offer other courses in primary science that pre-service teachers could choose to enrol in, so additional opportunities to learn were available. The syllabi indicated the content covered in the primary science course was intense and fast-paced as there was a lot to contend with in the timeframe allocated. With 24 or 32 hours of course time in 2010 and with the push to decrease primary science course hours or change the teaching format (Vannier, 2012), there remains a question whether this format provided pre-service teachers a model of sufficient time to learn and connect new knowledge.
“Inquiry into the teaching-learning relationship” (Ministry of Education, 2007, p. 34). Teachers review and adjust learning as they teach and use evidence-based strategies to plan learning. Teachers also analyse how learning is progressing and make future plans to further learning for their students (Ministry of Education, 2007).

This approach is directed towards teachers and evaluates how their pedagogy affects the outcomes for their students. As stated by the syllabi, pre-service teachers planned a science lesson and then taught it in a primary school; there is support for part of this approach. As the pre-service teachers had limited time in primary schools, understanding what their students already knew and how to best build on this knowledge was only nominal at best. No future planning was necessary, as lessons did not build on each other. The limited planning could have future consequences as pre-service teachers struggle to connect lessons to develop conceptual understandings in their students. As science education research indicated that science is often taught as a set of one-off activities (Appleton, 2003), pre-service teachers need more assistance to understand how to assess and integrate science lessons. As indicated in interviews, they were not observing science taught by experienced associate teachers, so development of PCK for this approach is minimal, if at all.

5.4 Summary

Syllabi data analyses indicated that pre-service teachers’ primary science course experiences were both similar and different at the two universities. Differences were the number of hours spent in class that were 18.75% greater at University A than University B. University A had one more primary school science teaching time than University B (two versus one). The main difference noted was University A presented three teaching strategies where University B concentrated on one. This difference might account for the variations noted on the Actual CLES where University A’s pre-service teachers did not perceive constructivist principles in the classroom learning environment very strongly. Both
universities had syllabi items that related to the CLES scales, except for Scale 4–SC. In addition, this scale had the lowest summary means on the Actual CLES for the two universities.

Transcribed and coded semi-structured interviews used the interpretive framework of analytic induction to analyse the data. The themes that emerged were: pre-service teachers’ attitudes toward science, science pedagogy, constructivism, beliefs and course suggestions. The comments made during semi-structured interviews indicated that both universities were preparing pre-service teachers to teach primary science. For 13 of the 14 interviewed pre-service teachers, their attitudes towards science improved or remained positive after the coursework. Pre-service teachers indicated that more science coursework would be beneficial to their beginning PCK, especially if it could be done after they had experienced more science teaching in schools. Enthusiasm, passion and hands-on activities emerged as the dominant ideas that pre-service teachers took away from the primary science course. A key understanding for pre-service teachers, that became apparent from the interviews, was that learning science was an active process and that if they, as teachers, enjoyed science so would their students. Several pre-service teachers did not observe science teaching when on practicum but literacy and numeracy teaching was evident daily. Being able to practise teaching science would be important to the pre-service teachers as they learned to feel comfortable with a curriculum area that was not always a passion for some. As one pre-service teacher said about teaching science, “Instead of like I said, passively like shoving this information into their heads, like instead they actively learn with it, they do experiments they understand the concepts, they are actually learning.” The sentiment of this comment was what both universities wanted their pre-service teachers to learn from the course, how to teach so that primary students actually learned and understood science concepts.
Overall, four of the seven effective pedagogy approaches related to CLES Actual data, syllabi information and/or interviews. Minimal links were possible with the other three approaches. Whether an introduction to the non-linked approaches occurred during other university education courses, was not a focus of this study’s data. As pre-service teachers have limited induction time into these approaches before dealing with the reality of teaching in a classroom, more research into assessing what is understood and what more needs to be done is required.
Chapter 6–Conclusion

The purpose of this final chapter is to highlight the major findings of the research into the perceptions pre-service teachers and teacher educators have of their university primary science classroom learning environment and to discuss the implications of the research results. The chapter begins with Section 6.1 and the major findings of the study and how the findings respond to the three research questions posed in Chapter 1 and Chapter 3. In Section 6.2, the recommendations that develop from the study’s findings to the effective pedagogy approaches as stated in The New Zealand Curriculum, are presented. Next, Section 6.3 discusses the implications of this study for pre-service teacher education. Then, Section 6.4 explores the significance of the findings. Following this, Section 6.5 discusses the study’s limitations and Section 6.6 reviews the recommendations for further research in the topic area. The chapter concludes with Section 6.7 and the final remarks regarding the thesis.

6.1 Major Findings of the Study

The aims of this study were to identify aspects of teacher educators’ primary science courses and classroom learning environments that had particular impact on pre-service teachers’ potential pedagogical practices in primary science. This study also considered if demographic factors such as gender, age, ethnicity and science qualifications may influence the understanding of teacher educators’ classroom learning environments by pre-service teachers. Constructivism was the science teaching pedagogy reviewed. It was selected as it is a major pedagogy construct in primary science (Carlsen, 2007; Koch, 2006) and its principles are evident in the effective pedagogy approaches presented in The New Zealand Curriculum.

Following the lead of research completed in the classroom learning environments area (Fraser & Walberg, 1991; Tobin & Fraser, 1998), this thesis employed a mixed methods approach. Using a mixed methods approach, two lenses viewed the research questions.
Constructivist and interpretive lenses were used, as the shared understanding and meaning created via discourse and activities in the classroom were investigated.

The CLES, syllabi analysis and semi-structured interviews were evaluated as the best tools to investigate the research questions in the time available for the study. Triangulation of data (Denzin, 1989) from the different perspectives then developed a picture of the perceptions of the classroom learning environment and how pre-service teachers and teacher educators understood it. Two universities participated in the study. The number of surveyed participants totalled 241 pre-service teachers and two teacher educators who completed the CLES in a pre/post class survey format. The survey data was reviewed for descriptive statistics and then analysed to reveal if significant results were present. Analyses of course syllabi from both participating universities had findings that related to the CLES scales. Coded semi-structured interview themes with 14 pre-service teachers from the two universities were linked to the CLES scales and syllabi analysis results.

The results were reviewed in light of the research questions posed in the beginning of this study:

1. How do pre-service primary teachers perceive the university classroom learning environment created by science teacher educators? Do these perceptions change over the duration of the course?

The Preferred CLES’ five scale summary means for both universities indicated pre-service teachers preferred to learn in a classroom environment that was moderately aligned or stronger to critical constructivist principles. This result suggested pre-service teachers preferred a classroom environment that utilised the critical constructivist principles specified on the survey. The Actual CLES results revealed a different picture of what pre-service teachers experienced. University A’s pre-service teachers’ summary means for four of the
five scales were lower than their Preferred survey summary means. This result suggested that University A’s pre-service teachers did not notice or did not have a constructivist classroom learning environment as strongly as they preferred. Constructivism was only one of three pedagogical practices taught in the course and may explain why they did not experience it as strongly. University B’s pre-service teachers’ summary means for four of the five scales were higher than their Preferred survey summary means. This result suggested teacher educators at University B created constructivist learning environments that were noticed by their pre-service teachers. Researchers studying learning environments reported that students achieved better if their preferred learning environment was compatible to the actual learning environment they experienced (Fraser & Fisher, 1983). The pre-service teachers from both universities preferred to learn in a constructivist environment and as stated above, they would achieve better if teacher educators created this type of learning environment (Martin-Dunlop & Fraser, 2012).

The scale that had the lowest summary means for both universities on both surveys was Scale 4–SC. The low summary means raise concerns as the constructivist tenet measured with Scale 4–SC, appears to be a difficult principle for pre-service teachers to experience in their primary science coursework. This finding is consistent with other pre-service teacher CLES studies, Scale 4–SC scored lower than the other scales (Dryden & Fraser, 1998; Harrington & Enochs, 2009; Lomas, 2009; Nix, et al., 2005; Saleska, 2000). The lower summary means may be explained in the same way for both universities; with time constraints and following a set syllabus there was little time for the teacher educator and pre-service teachers to negotiate control. Teacher educators may have felt there was a limited amount of control that they could give to the pre-service teachers in determining the learning set in class, as there was a set syllabus for the course. The set syllabus would leave little time for shared negotiation between the teacher educator and pre-service teachers on what learning
happened in the classroom. In addition to this, some pre-service teachers, many of whom were right out of high school as indicated by the demographic data, might still see themselves as passive learners who leave the teacher educator to set most of the course’s curriculum (Stofflett & Stoddart, 1994). Notably, pre-service teachers at University B perceived some shared control of their learning environment as their scale summary mean on the Actual survey of $M = 14.04$ was just below the moderate range of constructivist alignment.

As taking part in planning learning is a principle of constructivism (Tobin & Tippins, 1993), would pre-service teachers be able to plan learning together with their future students if they were not comfortable to plan learning as students themselves? It could be assumed that they had a set idea of the role of ‘student’ and ‘teacher’ that might come from their own experiences of being a learner (Pajares, 1992; Stuart & Thurlow, 2000) and did not expect to plan their learning. It is apparent that the beliefs pre-service teachers hold filter how they understand and interpret new teaching pedagogy. The filtering of new ideas by their beliefs was shown by Skamp and Mueller’s (Skamp & Mueller, 2001) research as a challenge to modify to the actual pedagogical practices taught during the university course.

For University A, an increase of summary means was noted for Scale 5–SN on the Actual survey where the summary mean for the scale increased from the Preferred survey mean ($M = 18.98$ to $20.60$). The increase may be due to the classroom learning environment where speaking to classmates and comparing ideas was a feature of the programme.

Paired-samples $t$-tests on the Preferred and Actual CLES scales summary means for individuals’ that completed both surveys, identified two of the five scales, Scale 3–CV and Scale 4–SC, as significant for University A. The effect sizes calculated were modest to large sizes. Direction of the scale summary means decreased for four of the five scales. An explanation as to why most scales decreased may be, in part, due to the course’s syllabus
objective that listed constructivism as only one of the pedagogies introduced for teaching science. Pre-service teachers at University A were experiencing more than one pedagogy and the multiple pedagogies may have influenced the perceived learning environment.

Four of the five scales for University B were found to be statistically significant. The direction of the four scale summary means increased. The effect sizes calculated on the four significant scales ranged from modest to strong effects. This result suggested that teacher educators, in a way pre-service teachers noticed, influenced the classroom learning environment. This influence may potentially impact pre-service teachers’ future teaching practices in science. It appeared the teacher educators at University B had, for the most part, created a constructivist learning environment that was noticed by their pre-service teachers. This result is consistent with the learning environment research literature that states teachers can influence the learning environment positively for their students’ learning outcomes (Fraser & Fisher, 1983; Lizzio, et al., 2002; Pickett & Fraser, 2002).

Syllabi analyses for the universities had four of the five CLES scales with course content items matched to them except Scale 4–SC. The lack of matched syllabi items reinforced why pre-service teachers did not perceive this scale in the classroom learning environments.

Semi-structured interviews supported what aspects the pre-service teachers’ perceived of the primary science course and how their perceptions changed over the duration of the course. Most interviewees moved to a more positive attitude towards primary science than when they started the course and attributed this change to the teacher educators’ enthusiasm and passion for the topic. A positive finding from the interviews was that 10 of the interviewed pre-service teachers indicated science was one of their top four favourite subjects to teach. It is not known whether this positive ranking will continue throughout their degree
preparation so that science will be taught when the pre-service teachers are in their own classrooms. As teacher dislike of science is a reason given why some students are not taught science (Smith & Jang, 2011; Tilgner, 1990), the positive ranking of science by pre-service teachers is encouraging.

2. What perceptions do science teacher educators have of the classroom learning environments they created and/or modelled for pre-service primary teachers?

Two of the three teacher educators completed the Preferred CLES. The teacher educator from University A did not complete the Preferred survey and no teacher educators were asked to complete the Actual CLES. To address this question with the limited teacher educator data obtained, other data sources were used to investigate the perceptions of the classroom learning environment. CLES comparisons between classes, syllabi characteristics and interviews of pre-service teachers assisted in responding to the question.

Teacher educators at University B had similar results to each other on the CLES scale summary means and appeared theoretically aligned to teach using critical constructivist principles. Comparisons between University B’s teacher educators and pre-service teachers were completed. Teacher educators and pre-service teachers were in alignment in preferring a learning environment that contained critical constructivist principles. University B’s teacher educators viewed their practices a little more strongly constructivist than the environment pre-service teachers preferred. This result is consistent with the findings in the research literature for other CLES studies that used the Preferred Survey; that teachers often view their practices more positively than their students do (Fraser, 2012; Johnson & McClure, 2004; Lomas, 2004; Martin-Dunlop & Fraser, 2012).

To see if there was consistency of teaching between teacher educators and between class sections, paired-samples t-tests were completed on pre-service teachers’ CLES results.
For University A’s three class sections taught by the same teacher educator, one scale was significant for all three groups, Scale 4–SC. Scale 3–CV was significant for one of the three groups as was Scale 5–SN. These results suggested that the primary science course’s constructivist principles affected some classes differently than others. As class sessions were not formally observed, why significance results were returned for only one class on two of the scales was difficult to discern from the data. The significant results might be due to chance, errors, or the teacher educator taught slightly differently and this slight difference affected the pre-service teachers from these classes. Alternatively, the class of pre-service teachers that did not have the significant results may have understood things differently when compared to their counterparts in other classes. More research is required to clarify what occurred with the different class’ results, but this research goes beyond the limits of this thesis. In the research literature, no studies were located that reviewed individual classes of a teacher educator when using the CLES. In the studies reviewed, class sections were combined to get an overview of what the learning environment of the teacher educator was (Cannon, 1995; Johnson & McClure, 2004; Lizzio, et al., 2002; Lomas, 2004). Highlighted from the research on teacher educators’ practice was that even if teacher educators believed they taught consistently, different groups of pre-service teachers might not understand the material in the same way as the other classes. The monitoring of perceptions and understandings of coursework are important, even if only one teacher educator teaches the course.

For University B, that had two teacher educators teaching the course, three of the five Actual survey scales were significant for Teacher Educator B1 and four of the five scales were significant for Teacher Educator B2. This result suggested that the teacher educators taught consistently for constructivist principles on three of the five scales. On Scale 3–CV that was significant for Teacher Educator-B2, pre-service teachers perceived an environment that strongly encouraged them to actively question their learning. The one scale that did not
have significant results between the teacher educators may be due to error, chance, or the number of participants, as one teacher educator had more classes to teach than the other. What this comparison indicates is that monitoring what perceptions the pre-service teachers have as grouped by teacher educator, can assist in pedagogy consistency and bring multiple teaching practices into alignment. The results of using the CLES for monitoring teaching consistency between teacher educators’ were also in the research literature in the other study completed in New Zealand with the CLES (Lomas, 2004). Lomas’ (2004) study results initiated reflection and review of practice between teacher educators at this university.

The syllabi analysis assisted in providing insight into the type of stated classroom learning environments that were created by teacher educators, as the syllabi were guidelines of what occurred in the classrooms. The syllabi indicated that the structure of the two university courses were similar with variances in time allocated to teach science in primary schools and type of primary science pedagogy taught. University B stated it modelled a constructivist environment and University A introduced this pedagogy and two others, socio-cultural and inquiry-based. Neither syllabus specifically referred to the effective pedagogy approaches in the curriculum document. As the effective pedagogy approaches can be linked to constructivism, and the syllabi contained constructivist elements, the general principles of the approaches would be covered during the courses. The CLES’ results corroborated the syllabi analyses both when no syllabi items related to the CLES and when items related. Whereas University B’s one learning pedagogy, constructivism, was perceived strongly by the pre-service teachers, University A with three pedagogies, had a learning environment with weaker perceptions of constructivist principles. Understanding whether the perceptions of a constructivist environment were diluted due to the two other pedagogies taught at University A, is beyond the scope of this thesis. The CLES also only measured critical constructivist
principles; so whether the other two learning pedagogies were more noticeable to pre-service teachers, these were not measured and are beyond the limits of this study.

During interviews, pre-service teachers stated their teacher educators modelled science teaching practices. What principles of constructivism were modelled and how pre-service teachers understood the modelling, were not remarked upon. Pre-service teachers, however, indicated that more work on their part was required or they required more coursework before they would feel comfortable teaching in a constructivist format. As researchers concluded in their studies, experiencing and using constructivism is important for it to be incorporated into a teacher’s PCK (Stofflett & Stoddart, 1994). For the interviewed pre-service teachers, implementing this pedagogy style in a classroom of their own requires PD in science, or time and concentrated effort on their part, to feel comfortable in using this teaching strategy. A concern though is the length of time some pre-service teachers may have to wait to teach science or even observe a primary science lesson. Remembering what a constructivist classroom environment is like may be a distant memory for some by the time they are able to teach science.

3. What aspects of the teacher educators’ primary science course appear to shape the pedagogical approaches the pre-service teachers may use when teaching primary science? Do other factors influence the shaping of the pedagogical approaches?

One aspect of the primary science course that pre-service teachers commented on in interviews was the introduction to constructivism. After being introduced to it, pre-service teachers stated they required more assistance before using it. These pre-service teachers, however, stated they felt prepared by their coursework to go and teach science. This finding is supported by research in New Zealand on pre-service teachers that indicated confidence levels to teach science can be improved by ITE (Anderson, et al., 2009; Salter, 2000).
However, once pre-service teachers are in a teaching position, research indicated it is difficult for them to implement the pedagogy they learnt at university as they cope with full-time responsibilities of a classroom (Loughran, et al., 2001).

Hands-on activities were used during the coursework and the use of activities like these were stated as a key pedagogical approach that shaped how many of the interviewed pre-service teachers would begin to teach science in their own classrooms. This finding is a positive one for science teaching as it moves away from the classic science lecture/textbook/notes format (Stofflett & Stoddart, 1994; Varma, et al., 2009). However, whether pre-service teachers would actually use hands-on activities once they are classroom teachers is not known. Nor was it apparent what each pre-service teacher meant regarding hands-on, other than it was something the students do with their ‘hands’. As the reality of limited school resources, teacher preparation and setup time, as well as scheduling time for science teaching impacts beginning teachers (Education Review Office, 2012), more research is required to indicate whether high quality hands-on activities are actually used.

Another aspect of pre-service education that may affect future science pedagogy was the struggle pre-service teachers had with observing, teaching, or even seeing evidence, that primary science occurred prior to their visits when on practicum. Few of the interviewees observed science lessons or taught in this subject area when in schools. The interview question included any time in the university academic year the pre-service teachers were in a primary school. The study acknowledged that this year was the first in their degree programme and pre-service teachers had limited time in primary schools. As a national report indicated, however, the teaching of primary science has been given less of a priority in schools (Education Review Office, 2010). With a low priority, then less time to observe and less time to teach science for pre-service teachers would be a consequence. Observing associate teachers who should be experienced in teaching science, which is an important
aspect of developing pre-service teachers’ PCK (Appleton, 2006; Kenny, 2010), would also then be missing from the pre-service teachers’ practicum experiences.

Another concern noted in interviews that may affect pre-service teachers’ science pedagogy, is the emphasis on literacy and numeracy. Some associate teachers and schools present this emphasis, which then leads to a suggested de-emphasis on other curriculum areas. This de-emphasis could have grave implications for future science teaching by pre-service teachers who experienced these situations. Emphasis on literacy and numeracy is a reason given in the 2010 ERO report as to why primary science teaching time decreased in schools. Other researchers reported that when science was not considered important by teachers or assigned a low priority compared to other subjects like literacy and numeracy, little time was spent teaching it (Appleton & Kindt, 1999, 2002; Roden, 2000). Evidence from a longitudinal study of primary curriculum subject teaching time in the United Kingdom indicated that when English and Mathematics were the central policy foci for raising national test scores, it reduced teaching time allocated to science (Boyle & Bragg, 2005). Boyle and Bragg (2005) calculated that in 2003 between 15-18% of schools surveyed did not teach science even once per week due to the focus on national testing. New Zealand may be facing these issues with its implementation of National Standards in literacy and numeracy, and noted decreased teaching time in science (Chamberlain & Caygill, 2012). The continued emphasis on literacy and numeracy may decrease science teaching observations and science teaching time for pre-service teachers in the future even more than what is recorded in Chamberlain and Caygill’s (2012) study.

Other factors that potentially shaped the pre-service teachers’ pedagogical approaches were the differences noted on the syllabi in introducing the teaching of one or three types of pedagogies. The use of multiple pedagogies was noticeable with the CLES paired samples t-test results as University A did not notice a constructivist learning environment as strongly as
University B. More research is required into the potential pedagogical impacts on University A’s pre-service teachers due to this instruction format.

The use of demographic data categories when analysing CLES data reviewed if any other factors also influenced the shaping of pedagogical approaches. Gender, even though participant numbers were skewed heavily in favour of females at both universities, was reviewed with independent sample $t$-tests. No significant results were indicated for gender. Further studies need to be conducted to indicate whether gender is an influence, especially using a larger sample size of pre-service male teachers. The result showing no significance between genders is supported in the research literature that found both female and male secondary school students did not view science differently as they both valued science and both felt challenged at times by the subject (Schmidt, Strati, & Kackar, 2010). Another study reported that females and males have the same interest in science, but that the science has to be relevant to them (Qualter, 1993). Even though the Qualter study was with 13 year old students, the relevancy of learning how to teach science applies to both genders in the primary science course and may partially explain why there were no significant findings between genders.

Similarly, ethnicity was used to see if differences were perceived in the classroom learning environment. Māori and Pākehā pre-service teachers’ results were compared with independent-samples $t$-tests on both survey forms. One significant result on Scale 3–CV was indicated on the Actual survey for University A. Otherwise, no significant findings were found between Māori and Pākehā for either university. As data numbers were low for Māori participants, more research would be required to substantiate these results. One explanation as to why there were little significant differences between the groups is that many Māori experience the same educational system as Pākehā pre-service teachers. As demographic data did not ask if individuals attended a kura, or how strong their cultural links to their self-
designated ethnicity were, there was little to indicate whether these ethnicities influenced the perceptions of the classroom learning environments.

When comparing this study’s Māori and Pākehā results to Lomas’ (2004) study that also used the CLES, differences were noted. Lomas (2004) reported that Māori pre-service teachers marked their surveys more positively or more aligned to constructivist principles than Pākehā pre-service teachers did. He also had a significant result on one scale, but on a different scale from this study’s result. Lomas also noted he had a small population sample of Māori pre-service teachers hence, more research would be required to support or refute either study’s results.

When reviewing the literature to see whether a difference between Māori and Pākehā pre-service teachers should be expected, evidence was located that linked Māori traditional learning practices to constructivist tenets. The traditional practices’ characteristics were listed as: support for teacher and student learning together, learning of a topic develops over time and complexity, learning is relevant and connects to past knowledge, and development of a perspective, not just answers (Hemara, 2000). These practices may in part explain why there were limited significant results in this study between Māori and Pākehā pre-service teachers, even if the pre-service teachers attended a kura. When Māori pre-service teachers did not attend a kura, it was likely they experienced the same primary/secondary schooling system as Pākehā pre-service teachers.

To look for other potential factors that may influence understanding, Malaysian and Pākehā pre-service teachers survey data were compared for University B, as University A did not have a population of identified Malaysian pre-service teachers who completed the surveys. Descriptive statistics scale summary means indicated that the Malaysian pre-service teachers viewed a constructivist classroom learning environment more positively when
compared to Pākehā pre-service teachers. Statistically significant findings were indicated on
four of the five Preferred survey scales and three of the five Actual survey scales when
independent-samples t-tests were computed. Effect sizes for the significant findings ranged
from a moderate to strong effect. This perception difference may potentially be explained by
the pre-service teachers who experienced schooling in a different culture and system that
stressed different academic outcomes compared to New Zealand’s curriculum achievement
objectives (Anderson, et al., 2009). Science classes taught in Malaysian secondary schools
are described as being teacher-centred, didactic with problem solving activities to find facts,
even though there is an effort to integrate more critical thinking into Malaysian teachers’
practices (Osman, 2004). These results were congruent with the findings from a cross-
national study done on Australian and Taiwanese students that found that cultural factors
affected responses to the CLES scales (Aldridge, et al., 2000). These findings suggested that
the past learning environments the pre-service teachers experienced played a significant part
in their understanding of a classroom environment and potentially, in the future, how they
would create it in their own classrooms. The results are informative for teacher educators
who teach at institutions with populations of international students. The background of some
pre-service teachers’ past education experiences can influence how they understand the
current classroom environment.

The level of science qualifications was chosen as a variable to investigate classroom
learning environment perceptions, as primary pre-service teachers often do not have higher
levels of science content knowledge (Cochran & Jones, 1998). No pattern emerged when
reviewing the scale summary means for the Preferred survey other than all groups desired to
learn in an environment that was at least moderately aligned to constructivism or higher. One
significant result for University B on Scale 1–PR was returned but, no significant results for
University A. When the same statistical tests were used on Actual survey data following the
same year divisions, no significant difference was indicated between science qualifications at any year level. It is noteworthy that the scale that did have the statistically significant result on the Preferred survey was Scale 1–PR, which is the scale that measured if pre-service teachers saw science as relevant to their everyday lives. There is the possibility that when pre-service teachers did not see science as relevant in their lives, they would not continue taking the course during their secondary schooling. A partial assumption made is that the primary science course played some part in levelling the differences noted on the Preferred survey results as this course was the only science class the pre-service teachers were able to enrol in at the first year level. No other science course would be influencing their perceptions. This result suggested that the amount of science qualifications the pre-service teachers had did not affect their perceptions of the classroom learning environment. Not having a difference in perceptions due to level of qualification is supported by the research of Stoddart et al. (1993) where pre-service teachers understandings of science concepts were not improved by taking more science classes. The research study mentioned above supports this study’s limited significant results on statistics completed by science qualifications. Other studies that used the CLES did not review data by level of science qualification.

During interviews, self-reported science area teaching strengths for pre-service teachers once again leaned to the biological sciences just as past New Zealand studies indicated (Lewthwaite, 2000; Salter, 2000). Even though some pre-service teachers stated the chemical and physical sciences as strengths, what area of science they would eventually feel confident to teach was not discerned, as it was their first year of study. The science strength area mentioned, however, the pre-service teachers would feel more confident to begin teaching (Salter, 2000).

Age was used as a grouping variable to indicate whether this variable might influence pre-service teachers’ understandings. Descriptive statistics from both universities showed the
scale summary means of items for the under 20 year olds was usually lower than the 20 years and over. This result suggested the under 20s were less inclined to prefer and notice constructivist learning environments as the 20 years and over did. Independent-samples t-tests were run on the CLES scale summary means from both universities. University A did not return any significant results. Significant results were returned for University B on four of the five scales between the age groups on the Preferred survey and three of the five scales on the Actual survey. The calculated effect sizes ranged from modest to moderate. No significant results at University A is supported in the research literature by a study that reviewed school-leavers and mature-aged students understanding of NoS. In this study, there were few differences noted between the two age groups (Murcia & Schibeci, 1999). A study by Appleton (1991), however, found mature-aged pre-service teachers (over 21 years) had a more positive attitude to science, would put less emphasis on teacher led discussions and explanations and more on problem solving and how science related to everyday life, among other findings. As University A did not have any significant results, but University B did, there is a possibility that other factors influenced University B’s pre-service teachers’ perceptions when grouped by age. The significant results may be explained, in part, by the ethnic diversity of the participants of University B, many whom were in the 20 years and over age grouping. The non-Pākehā ethnicity combined with the older age of the pre-service teacher may influence the results of the 20 years and over age grouping for University B. Otherwise, it would be expected to see similar results to University A where no significant results were found for the same age groupings. There is also the potential that some other variables that were not collected with the demographic data influenced one or both universities’ results.

The results from this study suggested that some factors have more influence than others, as indicated by the rejected null hypothesis on some, but not all statistical tests.
Monitoring these factors is useful to ensure that teacher educators’ practices are interpreted as planned. The data results can inform teacher educators’ practices to indicate where informed change is required when creating an environment based on constructivist principles. The CLES results can also be the catalyst required to inform classroom practice to align it closer to a constructivist perspective. Used over time, as it was in the Johnson and McClure study (2004), the CLES can examine how the classroom learning environment changes through the development of the teacher educator’s teaching career. The syllabi analysis and semi-structured interviews revealed the specific aspects of the classroom learning environment created by teacher educators that affected pre-service teachers and potentially their future science pedagogy. Affecting pre-service teachers’ understandings is supported by the research literature that found ITE can make a difference in primary science (Anderson, et al., 2009). The CLES findings suggest that pre-service teachers do notice the classroom learning environment, and that their perceptions do change over the course.

6.2 Relating the Course’s Learning Environment to Effective Pedagogy Approaches

In Chapter 5, the seven effective pedagogy approaches in The New Zealand Curriculum had links drawn to the research data that supported the pre-service teachers’ development in understanding how to use the approaches. The research findings supported four approaches, while three approaches were lacking in support. As this year was the first of the pre-service teachers’ education, it was not apparent if further development of the effective pedagogies would transpire during further coursework.

The following sections list a short phrase of the effective pedagogy characteristic only as full definitions are in Section 5.3. Next, evidence from the study that supports the pedagogy follows. At the end of each pedagogy characteristic, the recommendations derived from reviewing the data findings of this study are stated.
“Create a supportive learning environment” (Ministry of Education, 2007, p. 34). Of the three CLES scales that aligned to this pedagogical characteristic, two were in positive alignment and one was in weak alignment for constructivist principles at both universities. The CLES scales measured constructivist characteristics such as the ability to question the teacher educator’s plans and methods and the ability to explain and develop ideas with other pre-service teachers. Support for this pedagogy approach is indicated in the areas of the coursework linked by the data, however, pre-service teachers will require additional experiences during their ITE to solidify this pedagogy approach.

A recommendation is to reinforce this pedagogy approach across pre-service education classes, not just in the primary science course. A supportive environment is important in learning, whatever the subject area, and modelling how to do this in different subject areas has pre-service teachers meet this approach in multiple ways. Meeting knowledge in multiple ways reflects a constructivist concept of learning (Driver, et al., 1994).

“Encouraging reflective thought and action” (Ministry of Education, 2007, p. 34). The moderately strong alignment scores on the Actual CLES of Scale 5–SN show support for this approach, in part, for both universities. Syllabi items from both universities support this pedagogy. There were no course items, however, specifically detailed on how to reflect critically on activities or on thinking, or how to help their future primary students learn how to reflect on learning.

After reviewing this information, a recommendation is that at least one session in how to critically reflect is required at some point in the pre-service teachers’ education making this practice explicit. Unless there is a course component sometime in their degree programme on being a reflective practitioner (Schön, 1987), it is difficult to envision how pre-service
teachers will enact this pedagogy practice. Ideally, a session on reflecting should be included with all curriculum areas so that each subject area highlights how to reflect.

“Facilitating shared learning” (Ministry of Education, 2007, p. 34). Support for this approach is indicated when classes developed the language of teaching as well as the language used in science. One issue noted with shared learning was with pre-service teachers discussing science concepts and activities together. The concern was pre-service teachers may perpetuate science misconceptions to each other. Perpetuating misconceptions was identified in the research literature as an issue when pre-service teachers discussed learning without an individual who could address their misconceptions (Ginns & Watters, 1995).

A recommendation for this approach is to emphasise that pre-service teachers need to check and improve their science CK. To assist pre-service teachers in locating reliable background information, teacher educators can indicate resources that help develop scientifically accepted science CK. As resource introduction is a component of both universities, the main emphasis is for pre-service teachers to acquire the scientifically accepted science CK.

“Making connections to prior learning and experience” (Ministry of Education, 2007, p. 34). Both universities had CLES scores, as well as syllabi items, that link to this effective pedagogy approach. Semi-structured interview data also support it. As pre-service teachers had limited time in the primary classroom teaching science during the university course, learning to build on primary students’ prior knowledge would be difficult to practise at this time in the ITE programme. Pre-service teachers require more guidance in how to do this on a practical level, especially on scaffolding lessons (Kenny, 2010). Evaluating primary students’ prior knowledge and developing lessons to build on the knowledge should be made explicit to pre-service teachers during their teacher education.
The recommendation for this approach is to have a repeat teaching times in science to scaffold lessons or to develop plans that carry on from the lesson taught. A suggestion also is that pre-service teachers observe how experienced teachers make science teaching connections to students’ prior learning. Observations will help pre-service teachers learn how to attend to students’ prior knowledge other than only elicit it.

There is little research evidence to support the following three effective pedagogy approaches:

“Enhancing the relevance of new learning” (Ministry of Education, 2007, p. 34). Minimal support is found in the CLES results, syllabi analysis or semi-structured interview results to link the primary science course to this pedagogy approach. The research data indicated pre-service teachers required more learning experiences so they could use this approach effectively with their future students.

The recommendation is that pre-service teachers require additional experiences with this approach. To ensure pre-service teachers understand how to enhance the relevance of new learning, the pedagogy should be made explicit during teacher education. Ideally, pre-service teachers will experience this pedagogy approach more than one time and over curriculum subject areas during ITE.

“Provide sufficient opportunities to learn” (Ministry of Education, 2007, p. 34). This approach is difficult to place as supported or not as some pre-service teachers desired more time with science yet, most indicated they now felt confident to go and teach primary science. The confidence felt to teach might be due to the inexperience of the pre-service teachers as this anomaly of confidence to teach in science yet having low science understanding was noted in the research literature (Harlen, 1997). As some universities might decrease primary science course hours or change the teaching format (Vannier, 2012), there remains the
question whether there is sufficient time to experience how to learn and connect new knowledge in primary science for the pre-service teachers.

The recommendation is to increase primary science observation and teaching time over year levels. This way, pre-service teachers build on how learning in science progresses from year to year. There are also, then, more opportunities for pre-service teachers to observe experienced classroom teachers teaching science. More time to observe science teaching is also a recommendation for making connections to prior learning. By including more time to observe science teaching, there is the possibility two of the pedagogies will be better supported.

“Inquiry into the teaching-learning relationship” (Ministry of Education, 2007, p. 34). This approach is directed towards teachers and the evaluation of how their pedagogy affects the outcomes for their students. As pre-service teachers had limited time in primary schools at this point in their ITE, understanding what their students already knew and how to best build on this knowledge was only nominal at best. No future science lesson planning was necessary, as lessons did not have to build on each other. This limited planning experience can have future consequences as pre-service teachers may struggle to connect lessons to develop conceptual understandings in their students. As science education research already indicates that science is often taught as a set of one-off activities (Appleton, 2003), pre-service teachers require more assistance to understand how to assess and integrate science lessons.

A recommendation is to integrate this approach in a variety of education courses and curriculum subject areas. Then there will be a distinct emphasis on how this approach is best utilised by teachers. If done over the duration of ITE, pre-service teachers will have more experiences in which to consider how their teaching affects students.
Ideally, the effective pedagogies would be taught throughout all subject areas during the pre-service teachers’ education. To evaluate what pre-service teachers experience, ITE providers can review what is on the syllabi throughout the teaching degree programme and evaluate if the effective pedagogy approaches are taught, linked and explicitly made known. In addition, if the Ministry of Education is interested in having these approaches utilised by teachers, more research into the application of the approaches, as well as pre-service and in-service teacher PD in the use of the approaches, is required. As the effective pedagogy approaches are not just for the curriculum area of science, education in how to effectively use them is warranted for across the entire curriculum.

As Lewthwaite’s (Lewthwaite, 2006) research results indicated with his study of the 1993 science curriculum document implementation, support from colleagues and the administration, time, confidence in science CK, and personal commitment of the teacher all influenced how well science was implemented in the classroom. The effective pedagogy approaches need the same type of support, in all curriculum learning areas, for teachers to incorporate them into their practices in the primary classroom.

6.3 Implications of the Study

This study revealed several concerns for pre-service teacher education. The CLES highlighted specific areas of constructivist pedagogy that were not perceived in the classroom learning environment. This was evident in Scale 4–SC that had the lowest scores by both universities on the Actual CLES and was in the weak to low moderate alignment range for constructivist principles. These results are supported by research that showed classroom teachers did not always use certain principles of constructivist pedagogy as often as they stated and they used some principles more than others (Baviskar, Hartle, & Whitney, 2009). When classroom teachers struggle using some of the constructivist principles, it is probable that pre-service and beginning teachers would struggle using this pedagogy also. A concern
with Scale 4–SC on the CLES was the lower score and no syllabi items could be related to it. This leads to the question of how pre-service teachers would experience or learn to share control with their students effectively when they are not practicing this technique at the university level. It is documented that beginning teachers want to be seen as having behaviour management control in their classrooms (Roehrig & Luft, 2006). Would they then be able to effectively share learning and control as stated in The New Zealand Curriculum, “In such a community, everyone, including the teacher, is a learner; learning conversations and learning partnerships are encouraged; and challenge, support, and feedback are always available” (Ministry of Education, 2007, p. 34). Would they be able to engage in effective science assessment as one effective assessment characteristic listed in The New Zealand Curriculum states students should be involved in the assessment process with teachers, parents, peers and via self-reflection. Without pre-service teachers able to experience this pedagogy during their university coursework, it is doubtful they will be able to implement it in their own classrooms. By not involving students in sharing control in the classroom, it is likely the pre-service teachers may use a teacher-centred style of teaching with sporadic student-centred moments (Kagan, 1992).

In addition to not experiencing shared control at the university level, observing science taught by an experienced teacher was non-existent to low as reported by interviewees when on practicum during their first year. It is not known whether pre-service teachers will continue to experience or observe limited science time in subsequent practicum years. For year 1, however, this meant there was a limited opportunity for pre-service teachers to observe, experience and understand shared control when primary science was a subject area focus for them. This finding also reflected the New Zealand literature that stated the time given to the teaching of primary science has decreased (Education Review Office, 2010) so
opportunities to observe science in the future might be limited as well for pre-service teachers.

In reviewing factors that influence perceptions of the classroom environment, several demographic factors had significant results. As there were sporadic significant results for some demographic factors, more research is required to confirm or refute these findings. Teacher educators, however, should be aware of the factors that influence perceptions and monitor if the environment they create, students understand as designed. As evaluating coursework can be difficult and time consuming for teacher educators, the CLES demonstrated an available tool that is reliable, valid and can be used effectively to monitor constructivist classroom learning environments.

During interviews, the use of hands-on activities was mentioned by seven of the 14 interviewees. A concern with hands-on activities is how pre-service teachers understood this concept. Will the future teachers use set science activities that students get their hands on but do not need to think about the outcomes? Research into hands-on activities indicates that students’ minds are often not engaged if the activities are not used correctly (Appleton, 2002). Another concern is that pre-service teachers may see this as their science pedagogy; give students an activity to do and this activity is doing science (Appleton, 2003). Developing pre-service teachers’ CK and PCK is crucial here to complement the hands-on activities so that more actual science learning is achieved during the activities.

To improve science CK and self-confidence, full-day short courses directed at pre-service or beginning teachers are manageable approaches that can be replicated on a larger scale. Researchers studied the use of short courses with English pre-service teachers who held physics misconceptions. The short courses consisted of several full-day sessions to concentrate on science concepts, not teaching practice (Jarvis, et al., 2005). While this type of
course did not succeed in changing the misconceptions for all pre-service teachers involved, it changed some pre-service teachers’ ideas. Other ways that researchers noted improvement to CK was through peer discussions supported by teacher educators or class tutors so misconceptions were confronted and not just shared between individuals. Once again, this type of intervention may not banish all of the pre-service teachers’ science misconceptions, as conceptual change occurred slowly (Jarvis, et al., 2005).

The high number of pre-service teachers stating they did not observe science being taught by associates when on practicum is also concerning. One way to develop PCK is to observe experienced teachers teaching or to be mentored in the topic (Hudson & Skamp, 2002). When these experiences are not happening in science, pre-service teachers’ science PCK will not develop as effectively (Lindgren & Bleicher, 2005). Being able to reflect and discuss with associates and teacher educators about what occurs when teaching is important to develop PCK. In addition to not developing PCK, a United Kingdom study identified that limited opportunity to teach science and limited opportunity to observe science being taught, influenced the extent to which pre-service teachers felt they were able to implement a constructivist approach in their own teaching (Patterson, 2011).

Contributing to the issue of not observing science in the classroom is the pressure of National Standards in literacy and numeracy and the preoccupation with these subject areas by some schools and classroom teachers. During interviews, pre-service teachers commented on this issue without the interviewer prompting them. This preoccupation by teachers and schools may leave a lasting impression on pre-service teachers and how they approach the curriculum and teaching in their future classrooms.

Also noted during interviews was that pre-service teachers indicated they felt prepared to teach science in primary schools. This is encouraging, but can be undermined when the
reality of the classroom and the expectations of being a new teacher begin to take hold. Will the confidence they now feel to teach science remain? Will pre-service teachers teach in a constructivist style, or will this concept be lost amongst the other concepts they learn during their teacher education? Zeichner and Tabachnick (1981) found that many educational concepts were washed out when students did their practicum. Even if the construct of constructivism is not diluted, Savasci and Berlin (2012) showed that even experienced teachers struggled with implementing constructivism in their classrooms. If experienced teachers struggle, what does this infer about how pre-service and beginning teachers will cope when teaching? A longer-term research study to explore how pre-service teachers incorporate science into their classroom teaching practice is required.

When interviewed, 11 of 14 pre-service teachers stated the basic principles of constructivism, but whether or not they could translate the definition into constructivist pedagogy and reflect on how to best use their beginning PCK to meet the learning needs of their students is unknown. Feeling confident to teach science and knowing pedagogy characteristics are good places to start, but is it enough to sustain a beginning teacher? This good feeling will be tempered by the reality of teaching science in the classroom and the eventual realisation of the high level of pedagogical skills required to teach science well.

Wideen et al.’s (1998) research suggested to improve PCK or to learn to teach using constructivism, year-long not short course components, were required to change pre-service teachers’ conceptions. Teacher educators then maintained a regular and consistent influence on pre-service teachers’ learning. Research studies also noted to affect change, pre-service teachers needed to examine their beliefs about teaching (Savasci & Berlin, 2012; Skamp & Mueller, 2001). During ITE, teacher educators also should consider pre-service teachers’ beliefs for effective change to those beliefs to occur.
This study’s results suggested teacher educators had generally given their pre-service teachers the necessary basics to begin science teaching in the primary classroom. There are, however, the underlying issues of pre-service teachers being able to practise, observe and continue to grow in science CK so they can become competent in science PCK as well. Science PD does not seem to be used or offered regularly to help address these issues in New Zealand (Cameron, et al., 2007b; Gluckman, 2011). Science PD is the largest significant influence on science instruction as indicated by a study of 287 primary teachers in the United States (Saleska, 2000). As the Ministry of Education’s priorities for primary schools do not target science specifically, as it does literacy and numeracy, this may continue to direct the focus away from the subject (Ministry of Education, 2013).

The implications of this research should be tempered in the understanding that this study reviewed one course from the entire primary education programme. Other courses or components of the programme may introduce the missing aspects and reinforce the others at a later time. The concern is that pre-service teachers did not learn and practise these aspects during the primary science course. This course may be the only time pre-service teachers have the opportunity to practise constructivism and the effective pedagogies within a science context.

6.4 Significance of Study

This study is the first in New Zealand to use the CLES to inform teacher educators about the way pre-service teachers perceive the classroom learning environment in their university primary science course. There is only one other published New Zealand study which used the CLES to inform teacher educators’ practice at the university level (Lomas, 2004). This study, however, is in mathematics not science. The CLES is shown to be reliable and valid in the New Zealand context with university pre-service primary teachers.
The useful information for teacher educators that comes from this study, reflects points made by Fraser (1991). He stated that a review of pre-service programmes: (a) informs teacher educators of subtle but important aspects of classroom environments (b) shows how assessing classroom environments can be useful for teaching improvements and (c) demonstrates how a review may be used as a tool as part of an overall monitoring programme. This thesis’ findings indicated which constructivist tenets the participating pre-service teachers perceived in the university classroom environment during the primary science course. If teacher educators want to model a classroom on constructivist principles, this study revealed some areas of constructivism that are understood well by pre-service teachers. The study also provided guidance on which principles need to be emphasised more. As indicated during interviews, only one pre-service teacher experienced learning with constructivist pedagogy when a student herself and then only for 1 year during her primary school years.

Constructivism is not a new teaching concept. As it is not a recent construct, the assumption that more pre-service teachers would have experienced learning in this style as students and be familiar with constructivism’s characteristics, is incorrect. As it appears they have not experienced constructivism as learners, pre-service education is important to introduce them to the concept. The Actual CLES results demonstrated that certain concepts need more emphasis or demonstration for pre-service teachers so they understand these constructs better. Research studies indicated there are inconsistencies between what teachers perceive they are doing in the classroom and what is observed as occurring by others (Mellado, 1998; Savasci & Berlin, 2012). Generally, for these pre-service teachers, their preferred learning environment fit the classroom environment created by teacher educators. The literature indicated that pre-service teachers should achieve better when there was greater alignment between those environments (Fraser & Fisher, 1983). Whether this achievement translates
into a better primary science teacher is not known, as that outcome cannot be measured by this study.

Demographic data analysis highlighted the different understandings and scoring of the same concept between gender, ethnicity, age groups and different levels of science qualifications. Not all demographic data results had significant findings. As first year primary teaching courses can expect to have a cross-section of individuals, teacher educators need to remember this point when planning lessons and when reviewing how concepts are understood. Pre-service teachers have already completed many hours as students and often how they view teaching depends on their previous experience as learners (Onslow & Laine, 2000). Modelling how to teach, having pre-service teachers participate in activities they can use when teaching and showcasing resources that will be of use in the future are ways to counteract different understandings of concepts. Not indicated on either university’s course is a session where pre-service teachers confront their own beliefs of primary science teaching. As research studies showed, pre-service teachers beliefs strongly influenced how they teach (Haney, et al., 2003; Savasci & Berlin, 2012). No reference to addressing beliefs was on the syllabi, spoken about in interviews or asked about on the CLES.

One of the strongest outcomes from this study comes from the semi-structured interviews where pre-service teachers indicated their enjoyment and confidence in science had risen. They were also clear, however, that more primary science would help them solidify how to teach science. Almost all of the pre-service teachers interviewed commented they had never experienced science teaching in the way they were experiencing it in the university classroom setting, so implementing teaching in this fashion would be completely new to them. The interviews highlighted how learning new pedagogies for pre-service teachers need to be followed up with further classes or PD courses early in their first year of teaching to assist them in building confidence and recalling how to teach science well.
Research evidence that supported having further classes to assist learning comes from a Turkish study. Tartar, et al.’s (2012) study indicated pre-service primary teachers’ mental models of how to teach were teacher-centred until they experienced practicum and further university courses where their mental models shifted to more student-centred pedagogies. This same study also suggested that first year pre-service teachers used more teacher-centred models compared to final year pre-service teachers.

When reviewing how the courses support the constructivist linked effective pedagogy approaches in *The New Zealand Curriculum*, there is evidence from the data collected for some approaches and less evidence for others. Of the seven approaches listed, four have evidence that supports their development at both universities with varying links made with the other three listed approaches. There is evidence to support that pre-service teachers experienced learning in the effective teaching approaches during the primary science course. The effective pedagogy approach supported the most in both courses is creating a supportive learning environment. The teacher educators’ practices created this type of supportive environment and it was evident in comments made during the semi-structured interviews. Pre-service teachers, from both universities, felt confident to ask questions and interact with their teacher educators. Even though evidence at both universities supported the learning of some effective pedagogy approaches, the evidence was sometimes a briefly experienced point for pre-service teachers such as, talk to your group partner about what you saw. This study did not investigate whether the effective pedagogies were reinforced in other university teacher education courses. To gain experience in using these teaching approaches, pre-service teachers require time and practise, both of which are not usually available as a first year education student. The question remains if pre-service teachers’ experiences with the effective pedagogy approaches develop by the end of the degree programme. Only when teacher educators in a degree programme work together to ensure that clear links are made
across subject areas, will learning of the effective pedagogy approaches by pre-service teachers be fully supported.

In addition to pre-service teachers’ issues with constructivist-informed pedagogy, a question is whether constructivism is best for all types of schools. Tobin (2000) reflected that when he taught in an urban school in the United States with low-tracking students who were African-American, he began to think of teaching as, “… knowledge in action and learning as a social process that occurs through co-participation in communities” (p. 249). Richardson (2003) found that for some schools in the United States that were predominately African-American, constructivism was not useful and questioned if constructivism is useful for all ethnicities. With New Zealand’s diverse student population, these ideas give pause for thought. Hemara (2000) wrote about the traditional conventions of Māori pedagogies that can be linked to current constructivist principles. However, if pre-service teachers as well as classroom teachers cannot even implement constructivism effectively in the classroom now, how will one know if it is a useful pedagogy for students to learn in New Zealand.

6.5 Limitations to Study

This study relied on self-reported information from pre-service teachers who agreed to participate in the research. It did not capture the perceptions of all pre-service teachers or the perceptions of randomly chosen individuals. The results of the study are based on the assumption that both pre-service teachers and teacher educators participated in a careful and accurate manner, be it for the survey and/or interviews. The frequency of CLES scoring for each scale is displayed in Appendix B and C. The graphs in the appendices demonstrate the grouping of scores and suggest participants took care when completing the survey. The study used individuals from just 1 year, so the classroom learning environment experienced by other pre-service teachers during other years is not known. These items make the generalisations of these findings tempered in this light. However, unless the courses’
structures change dramatically, an assumption is consistency is maintained in the courses from year to year and past students would have experienced a similar environment to the environment studied.

As the sampled populations came from only two universities, caution is suggested in applying these results to other universities that may advocate different science pedagogies in their courses. The demographic data indicated that the makeup of the participants in this study were similar in most factors (i.e. gender, age, ethnicity) to other universities’ teacher education programmes (Cameron & Baker, 2004; Gray & Renwick, 1998; Lomas, 2004) so the findings in this study may prove useful to other institutions. With the low number of teacher educators who participated, limited comparisons could be made between this data. The return rate of paired surveys for pre-service teachers from both universities, however, was at least 59% of the pre-service teachers in the courses.

Four participants stated the wording of the CLES statements was unclear, as the Preferred survey seemed to be written in the past tense (i.e. I learned about the world…) even though the directions asked the pre-service teachers to mark what they wish would happen. Additionally, the wording of a few statements caused confusion for two pre-service teachers as they viewed several items as redundant. Whether there were enough statements on the CLES that caused problems, these issues could influence the results. The creators of the survey have repeatedly evaluated the CLES and it now contains 25 statements with no negatively worded items. I had permission from the survey’s creators to use the most recent version of the CLES. This version was trialed and validated by other researchers before I used it. The number of Preferred surveys that had comments written on them was very low and no comments were written on any of the Actual survey forms. As the internal consistency of the five scales was tested by Cronbach’s alpha and found to be at acceptable levels, the effect of any confusion should be limited. Type I and type II errors were mitigated
by using as large a sample size that could be obtained and by using probability values of \( p < .05 \).

There were time constraints in administering the CLES and problems administering it in two places at once, as both courses met during the same semester. To mitigate this effect, I prepared a written statement to be read before each CLES administration. In this way, no matter who was administering the survey, there were consistent directions on how to take it.

As a teacher educator administered the CLES when I could not, this individual’s position could have influenced the pre-service teachers’ responses on the CLES. The issue could not be avoided due to course scheduling. To help control for any potential influence, the CLES was scheduled early on in the course and then again after assignments were marked. Pre-service teachers were also informed that participation in the study would not influence their course marks.

The syllabi from the primary science courses were the only documents analysed from the education programmes. Whether or not other papers or components of the education programmes contributed to pre-service teachers’ understanding of the effective pedagogies and constructivism was not investigated. The focus of this study was on the primary science course and what aspects of constructivism and the effective pedagogies it contained. The study did not reflect the full primary teacher education programme, but suggested further research is required to evaluate whether courses within an ITE programme link with each other.

Interviews had to contend with the issues of distance and time. Most of the interviews were conducted on the phone or by using the basic version of Skype (not video) so no body language could be used to understand questions or to indicate items to question further. Not seeing each other may also have affected some of the interviews, as four of the interviewees
did not have English as their first language. I tried to rephrase questions and would query interviewees further if there appeared to be a problem with understanding what was asked. There was also the issue of pre-service teachers potentially giving answers that were meant to be acceptable to the researcher, not what the pre-service teacher thought. As there were pre-service teachers interviewed from across the different science classes and from the two universities, the variety of individuals was expected to help balance any non-valid response.

The limitations listed above did not appear to negate the findings of the study. As there are always limitations to any study, the procedures used in this thesis to mitigate the limitations were as robust and as valid as possible to address the issues stated.

6.6 Recommendations for Further Research

After concluding this research, several other lines for further inquiry presented themselves. A follow-up study of the pre-service teachers in this research is warranted and possible as they graduated in late 2012 and begin teaching in 2013. How do they teach science now? Can they still recall the passion and enthusiasm they noted in 2010? Do they think they need more pedagogical skills in science and did they take their own advice and elect to take more science courses? Where does science place on their list of favourites to teach now?

Another area to review is, whether the university course structure of primary science has changed, what are pre-service teachers’ pedagogical understandings from this newly structured coursework? When there are course changes, are the changes based on research findings or other administrative requirements? When the course is shortened, can pre-service teachers still encounter enough of the constructivist background and curriculum recommended pedagogy to teach primary science well? When it is lengthened, does this help
solidify primary science CK and PCK in the mind of pre-service teachers so they feel even more confident to teach science?

As the effective pedagogy approaches are not just for the subject area of science, reviewing whether the approaches are covered during other education courses will benefit ITE programmes. This review will ensure pre-service teachers have an introduction to, as well as experience in, all approaches over the degree period.

Another issue to consider for researchers is should constructivism be seen as the polar opposite of objectivist learning approaches. Cronjé (2006) modelled these approaches not as linear but as an orthogonal relationship, i.e. two axes at 90-degree angles, which could be integrated. Two hundred and five course designers, developers and instructors at United States universities and colleges were surveyed on their use of pedagogical practices and they overwhelmingly reported integrating constructivist and objectivist learning approaches in their courses (Elander, 2012). This integration theory holds some merit at the university level where pre-service teachers can experience some learning in the style they are most familiar with but then coursework can include constructivist elements. This paradigm may be more acceptable to other degree areas of university study and may prove useful for other students, not just pre-service teachers. It will also give professors/educators a paradigm that is not one or the other, and give credence to a mixed form. More research is required in how a mixed paradigm affects learning outcomes and understandings for pre-service teachers, as well as other university students.

Other research areas that intersect with this study and that should be researched are what influences do associate teachers in the classroom have on pre-service teachers’ emerging science pedagogy? What does the emphasis on literacy and numeracy do to the emerging PCK of science for pre-service teachers in the primary classroom when on practicum?
The use of this initial study can be the basis of further studies in pre-service teacher education. All the potential studies listed above will be useful to inform and strengthen teacher education programmes and increase the knowledge of how pre-service teachers learn to teach primary science.

6.7 Summary and Concluding Remarks

The main drivers that instigated this thesis are my desires to improve science teaching at the primary level through quality pre-service science education and the new curriculum document that contains the effective pedagogical approaches that are encouraged for use in the classroom. As the curriculum’s pedagogy approaches are drawn from the principles of constructivism, many pre-service primary teachers have not experienced learning in this style themselves (Appleton & Kindt, 2002) or know how to teach in this style (Patterson, 2011). These issues are a challenge for teacher educators, to introduce pre-service teachers to this pedagogy and encourage them to teach using this style even though many have not experienced learning in this style previously.

The data obtained through the three research tools revealed a picture of the issues, diversity and challenges that teacher educators face when teaching pre-service teachers in the primary science course. Teacher educators try to create a learning environment that pre-service teachers understand and that the pre-service teachers can then replicate in a classroom. Social factors, both past and present, can influence the understanding of that classroom environment. In addition, there are the factors the teacher educators have no control over that may also impact pre-service teachers’ pedagogy: associate teacher’s pedagogy, the primary school’s curricular emphasis, what the pre-service teacher is assigned to teach during practicum and other pedagogical practices emphasised in other subject area courses. This study illustrates the challenges confronting teacher educators and the need for continued
INFLUENCES ON PRIMARY SCIENCE PEDAGOGY

research into, and reviews of, how pre-service primary teachers understand teacher educators’ learning environments.

This study started with my passion and desire to have pre-service teachers teach science well. It ends with me realising that the passion and enthusiasm I feel for this topic can be imparted to pre-service teachers during their coursework. What happens to the enthusiasm felt by pre-service teachers by the time graduation arrives is unknown. This study also endeavoured to reveal the development of pre-service teachers’ science pedagogy in constructivism. It is heartening to find that many pre-service teachers in this study understood they required more development of their science CK and PCK. Whether they will have the opportunities to engage in this development, however, is not known. Science PD is not funded readily, due to other priorities dictated by government policy and school officials.

The Prime Minister’s Chief Science Advisor, Sir Peter Gluckman, in a discussion paper prepared by the New Zealand Council of Educational Research, recommends having science champions in primary schools; lead science teachers who support science learning in their own schools and potentially with a cluster of primary schools (Gluckman, 2011). Professional development is suggested in the report as a way to assist these champions to then go back and progress science teaching. No mention of how to fund this professional development is in the report.

When the research findings from this thesis are published, it is my hope that ITE providers and government bodies will review this study and realise that to improve students’ science literacy and understanding, good quality science education has to happen before students are at the secondary or tertiary level. In the government’s recent report by the National Sciences Challenge Panel (2013), the panel created a special Science and Society challenge as this topic was seen as outside the criteria set for the other 12 science challenges but deemed important to give the other challenges “optimal effect” (p. 2). Examples the panel
gave as to how to achieve the Science and Society challenge included research on STEM (Science, Technology, Engineering and Mathematics) subjects in primary and secondary schools. However, even though the other science challenges had a large increase in funding, no funding is currently provided for this special challenge.

In addition to understanding science for everyday life, there is also a government desire to increase tertiary numbers in science and engineering occupations (Tertiary Education Commission, 2012). To accomplish this, students need to be interested in science from the time they are in primary school. This issue is the challenge to government and other ITE providers; either to educate pre-service primary teachers well so that science is effectively taught at the primary level and student interest continues or have decreasing numbers of students taking elective science classes when they reach secondary and tertiary levels as by then, science holds no interest or relevancy for them. As one pre-service teacher said during interviews, “they [primary students] need to know how science works to understand it. Instead of I don’t know, just having facts laid out for them, they have to actively be involved.” Whatever is decided by government and universities to deal with the problems in science education, it will have a lasting influence on New Zealand society for years to come.
References


Chamberlain, M., & Caygill, R. (2012). Key findings from New Zealand's participation in the progress in international reading literacy study (PIRLS) and trends in international mathematics and science study (TIMSS) in 2010/11. Wellington, New Zealand: Ministry of Education.

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doi:10.1080/0950069970190107


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Retrieved from


doi:10.1080/095006999290101


Appendix A
CLES: Survey Forms, Permission Email, Written Instructions

What I wish would happen in my primary science course classroom
• Pre-Service Teacher/Student form •

DIRECTIONS

1. Purpose of the Questionnaire
This questionnaire asks you to describe important aspects of the primary science course classroom that you are in right now. There are no right or wrong answers. This is not a test and your answers will not affect your assessment. Your opinion is what is wanted. Your answers may enable us to improve future primary science classes.

2. How to Answer Each Question
On the next few pages you will find 25 sentences. For each sentence, circle only one number corresponding to your answer. For example:

<table>
<thead>
<tr>
<th>Sentence</th>
<th>Almost Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Seldom</th>
<th>Almost Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>In this class I wish that . . .</td>
<td>8</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

• If you think this teacher almost always asks you questions, circle the 5.
• If you think this teacher almost never asks you questions, circle the 1.
• Or you can choose the number 2, 3 or 4 if one of these seems like a more accurate answer.

3. How to Change Your Answer
If you want to change your answer, cross it out and circle a new number, For example:

4. Completing the Questionnaire
- Now turn the page and please give an answer for every question.

Personal Details

Please fill in the following details to assist with this research project. If you do not wish to fill out some of the details, please leave them blank. This sheet will be separated from your answers to help preserve your anonymity. Thank you for your participation.

Name: ___________________________ Highest Level/Qualification in Sci.: Yr 10 Yr 11 Yr 12 Yr 13
Name of Last Science Course Taken: ___________________________ Age: _______ Gender: Male Female
Ethnicity: ______________ Year/level you desire to teach when you are a primary teacher: ____________
How you would characterise how you were taught science when you attended secondary school?

______________________________

4. Completing the Questionnaire - Now turn the page and please give an answer for every question.
Learning about the world

<table>
<thead>
<tr>
<th>In my Primary Science class I wish that . . .</th>
<th>Almost Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Seldom</th>
<th>Almost Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 I learned about the world outside of the university.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
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<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
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<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4 I would get a better understanding of the world outside of the university.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5 I learned interesting things about the world outside of the university.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Learning about science

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<td>1</td>
</tr>
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</table>

Learning to speak out

<table>
<thead>
<tr>
<th>In this Primary Science class I wish that. . .</th>
<th>Almost Always</th>
<th>Often</th>
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<th>Seldom</th>
<th>Almost Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 It was OK for me to ask the teacher &quot;why do I have to learn this?&quot;</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
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</tr>
<tr>
<td>12 It was OK for me to question the way I'm being taught.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>13 It was OK for me to complain about activities that are confusing.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>14 It was OK for me to complain about anything that prevents me from learning.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>15 It was OK for me to express my opinion.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Learning to learn</td>
<td>Almost Always</td>
<td>Often</td>
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<td>Seldom</td>
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<td><strong>In my Primary Science class I wish that . . .</strong></td>
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</tr>
<tr>
<td>16 I could help the teacher to plan what I'm going to learn.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>17 I could help the teacher to decide how well I am learning.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>18 I could help the teacher to decide which activities are best for me.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>19 I could help the teacher to decide how much time I spend on activities.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>20 I could help the teacher to decide which activities I do.</td>
<td>5</td>
<td>4</td>
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</tbody>
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<th>Learning to communicate</th>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>21 I got the chance to talk to other students.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>22 I could talk with other students about how to solve problems.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>23 I had the chance to explain my ideas to other students.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>24 I could ask other students to explain their ideas.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>25 Other students could listen carefully to my ideas.</td>
<td>5</td>
<td>4</td>
<td>3</td>
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</tr>
</tbody>
</table>
What happened in my primary science course classroom

• Pre-Service Teacher form •

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- Now turn the page and please give an answer for every question (1-25).
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### Learning about science

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### Learning to speak out

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<td>13 it was OK for me to complain about activities that were confusing.</td>
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<td>14 it was OK for me to complain about anything that prevented me from learning.</td>
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<td>15 it was OK for me to express my opinion.</td>
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<td>Learning to learn</td>
<td>Almost Always</td>
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<td>Sometimes</td>
<td>Seldom</td>
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<td>16 I helped the teacher to plan what I learnt.</td>
<td>5</td>
<td>4</td>
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<tr>
<td>17 I helped the teacher decide how well I was learning.</td>
<td>5</td>
<td>4</td>
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<td>18 I helped the teacher to decide which activities were best for me.</td>
<td>5</td>
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<td>19 I helped the teacher to decide how much time I spent on activities.</td>
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<td>2</td>
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<tr>
<td>20 I helped the teacher to decide which activities I did.</td>
<td>5</td>
<td>4</td>
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<td>2</td>
<td>1</td>
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</tr>
<tr>
<td>Learning to communicate</td>
<td>Almost Always</td>
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<td>In this class . . .</td>
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<td>21 I got the chance to talk to other students.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 I could talk with other students about how to solve problems.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 I had the chance to explain my ideas to other students.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
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<td>In this class . . .</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>24 I could ask other students to explain their ideas.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 other students could listen carefully to my ideas.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What I wish would happen in my primary science course classroom?
• Teacher Educator form •

DIRECTIONS

1. Purpose of the Questionnaire
This questionnaire asks you to describe important aspects of the primary science course classroom that you are in right now. There are no right or wrong answers. Your opinion is what is wanted. Your answers may enable us to improve future science teaching.

2. How to Answer Each Question
On the next few pages you will find 25 sentences. For each sentence, circle only one number corresponding to your answer. For example:

<table>
<thead>
<tr>
<th>In this class . . .</th>
<th>Almost Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Seldom</th>
<th>Almost Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 I ask the students questions.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

- If you think that you almost always ask the students questions, circle the 5.
- If you think that you almost never ask the students questions, circle the 1.
- Or you can choose the number 2, 3 or 4 if one of these seems like a more accurate answer.

3. How to Change Your Answer
If you want to change your answer, cross it out and circle a new number. For example:

8 I ask the students questions. 5 4 3 2 1

Personal Details

Please fill in the following details to assist with this research project. If you do not wish to fill out some of the details, please leave them blank. This sheet will be separated from your answers to help preserve your anonymity. Thank you for your participation.

Highest Degree / Qualification: Last Science Course Taken: ____________
Age: _______ Gender: Male Female Ethnicity: ____________
Year/level last taught if you were a primary or secondary school teacher: ____________
How you would characterise how you were taught science when you attended secondary school?

4. Completing the Questionnaire
Now turn the page and please give an answer for every question.
### Learning about the world

<table>
<thead>
<tr>
<th>Wish</th>
<th>Almost Always</th>
<th>Often</th>
<th>Some-times</th>
<th>Seldom</th>
<th>Almost Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>In my Primary Science Education class I wish that . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Students learned about the world outside of the university.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2 Students' new learning started with problems about the world outside of the university.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3 Students learned how science can be part of their out-of-university life.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4 Students got a better understanding of the world outside of the university.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5 Students learned interesting things about the world outside of the university.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

### Learning about science

<table>
<thead>
<tr>
<th>Wish</th>
<th>Almost Always</th>
<th>Often</th>
<th>Some-times</th>
<th>Seldom</th>
<th>Almost Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>In my Primary Science Education class I wish . . .</td>
<td></td>
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<tr>
<td>6 Students learned that science has changed over time.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>7 Students learned that science is influenced by people's values and opinions.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>8 Students learned about the different sciences used by people in other cultures.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>9 Students learned that modern science is different from the science of long ago.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>10 Students learned that science is about <strong>inventing</strong> theories.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
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</table>

### Learning to speak out

<table>
<thead>
<tr>
<th>Wish</th>
<th>Almost Always</th>
<th>Often</th>
<th>Some-times</th>
<th>Seldom</th>
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</tr>
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<tbody>
<tr>
<td>In my Primary Science Education class I wish . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 It was OK for students to ask me &quot;why do I have to learn this?&quot;</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>12 It was OK for students to question the way I'm teaching.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>13 It was OK for students to complain about activities that are confusing.</td>
<td>5</td>
<td>4</td>
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<td>15 It was OK for students to express their opinions.</td>
<td>5</td>
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</table>
## Learning to learn

<table>
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<tr>
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<tbody>
<tr>
<td>16 Students helped me to plan what they're going to learn.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>17 Students helped me to decide how well they are learning.</td>
<td>5</td>
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</tr>
<tr>
<td>18 Students helped me to decide which activities are best for them.</td>
<td>5</td>
<td>4</td>
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</tr>
<tr>
<td>19 Students helped me to decide how much time they spend on activities.</td>
<td>5</td>
<td>4</td>
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<td>2</td>
<td>1</td>
</tr>
<tr>
<td>20 Students helped me to decide which activities they do.</td>
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</table>

## Learning to communicate

<table>
<thead>
<tr>
<th>In my Primary Science Education class I wish . . .</th>
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<tbody>
<tr>
<td>21 Students got the chance to talk to other students.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>22 Students talked with other students about how to solve problems.</td>
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<tr>
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</tr>
<tr>
<td>24 Students asked other students to explain their ideas.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>25 Students listened carefully to each other’s ideas.</td>
<td>5</td>
<td>4</td>
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<td>2</td>
<td>1</td>
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</table>
Permission was given by Dr. Peter Taylor, Curtin University, Australia, to use his CLES survey for this study. An e-mail attesting to this was received by Victoria Rosin on 2/11/09.
Preferred CLES Written Instructions

Introduction, I am Victoria Rosin, Ed.D student

I would like you to fill out a questionnaire about the primary science classroom environment you are attending now and what you wish would happen during the duration of this course. It looks at the extent to which lecturer’s intended messages are received and accepted by teacher education students (you).

The summary data from these questionnaires will be of use to the lecturer, to help him or her examine his/her classroom practice and for me to use as data for my doctoral thesis.

All information collected will be treated in complete confidence with class summary information only being shared with your lecturer after the completion of the course.

All information will be stored securely and used only for the stated purpose.

More detailed information can be found on the blue sheets or you can contact me at victoria.rosin@otago.ac.nz

Any Questions?

Thank you.

Actual CLES Written Instructions

Introduction

Hello again. It is nearly the end of the science portion of EDCR 132 for you. You may recall, you were invited to participate in a survey for Victoria Rosin, an Ed.D student at the University of Otago, College of Education during your first week of this course. This survey was to show what you wished this science course would be like.

As the second part of the research I invite you to fill out a questionnaire again about the primary science classroom environment you attended but now with the focus of what you actually experienced. This second survey looks at the extent to which the lecturer’s intended messages were understood by you.

All information collected will be treated in complete confidence, with class summary information only being shared with your lecturer after the completion of the course. This survey does not influence your grade for this section of the course. The front page of the survey is separated from the actual survey to preserve your anonymity.

All information will be stored securely and used only for the stated purpose on the information form.

More detailed information can be found on the blue sheets or you can contact me at victoria.rosin@otago.ac.nz

Thank you very much for your participation.
Appendix B
Semi-Structured Questions – Pre-Service Teachers

Understanding of Course – 1. Do you look forward to this course’s science lessons? How would you describe your attitude towards science before the course? After? Can you describe what led to any changes?

2. Did course readings/assignment assist you to develop an understanding of the issues in teaching science?

3. Has your lecturer practice influenced your future teaching in any way? Can you identify what aspects have?

Effective Pedagogy / Constructivism 1. What do you understand about Constructivist learning in science?

2. Do you feel you have learned to teach in a constructivist style and feel comfortable doing it? If not, why? If yes, why?

3. What do you think you need to be a good science teacher? Do you think you have obtained this while taking this course? If not, what could be improved? If yes, what aspects do you think helped you the most?

4. How do you think you will teach science (in what style or manner)? Do you think you have subject areas of strength to teach in science? If so, which areas?

-Planet earth & Beyond -Material World -Physical World -Living World

Beliefs – 1. How do you view science teaching?

2. What do you think you need to be a good science teacher? Do you think you obtained this while taking this course? If not, what could be improved? If yes, what aspects do you think helped you the most?

3. During your postings, have you seen science being taught? If so, what topic and how would say it was being taught?

Personal - 1. What high school level did you do science to? If you stopped, why?

2. What influences you to want to teach the level you’ve selected?

3. What four subjects do you think you will enjoy teaching the most. Why?

4. Can you remember an incident or comment that may have influenced your science teaching?

5. Could you make a suggestion on how pre-service teachers could effectively increase their skills in teaching science?

Conclusion - Is there anything else you’d like to tell me regarding your beliefs of primary science or this course?
Appendix C
CLES Scales Frequency Graphs for University A

Figure C5. Preferred and Actual survey score frequency comparisons for Scale 1–PR at University A.
Figure C6. Preferred and Actual survey score frequency comparisons for Scale 2–UC at University A.
Figure C7. Preferred and Actual survey score frequency comparisons for Scale 3–CV at University A.
Figure C8. Preferred and Actual survey score frequency comparisons for Scale 4–SN at University A.
Figure C9. Preferred and Actual survey score frequency comparisons for Scale 5–SN at University A.
Appendix D
CLES Scales Frequency Graphs for University B

Figure D10. Preferred and Actual survey score frequency comparisons for Scale 1–PR at University B.
Figure D11. Preferred and Actual survey score frequency comparisons for Scale 2–UC at University B.
Figure D12. Preferred and Actual survey score frequency comparisons for Scale 3–CV at University B.
Figure D13. Preferred and Actual survey score frequency comparisons for Scale 4–SC at University B.
Figure D14. Preferred and Actual survey score frequency comparisons for Scale 5–SN at University B.
Appendix E
Request Letters/Participant Information Sheets/Consent Forms

Date:

Dear (University),

I am writing to ask for your cooperation with my research study I am conducting on primary science teacher educators (lecturers) and pre-service primary teachers (students) and their perceptions of primary science learning environments. I am researching this for my doctoral studies at the University of Otago, Dunedin College of Education. The purpose of this study is to investigate how teacher educators’ primary science learning pedagogies are understood and potentially incorporated into pre-service teachers’ teaching behaviours. The study will also attempt to identify teacher educator’s beliefs, practices in teaching, and the degree of congruence between these and the classroom-learning environment. The results of the study may benefit teacher educators to decide if the environment perceived is the environment they were meaning to create. This research may also assist them when planning future courses or when updating current courses. Though primary science is the focus, findings of this study may be of interest to other subject areas of pre-service education to assist teacher educators in evaluating and monitoring other courses.

Your (insert course and section number) has been selected for the study as it is for first degree students and is part of your requirements for a bachelor’s degree in primary teaching. The study will use a Likert scale survey of 25 items that the pre-service teachers and the teacher educator will complete. The survey and personal details solicitation will take about 20 minutes to complete and ideally will be done during the first week of the course and again during the last. The data will be compiled, to assure both pre-service teachers’ and teacher educator’s confidentiality. I will also request a class syllabus to analyse for the composition of the course and the type of classroom learning environment the teacher educator works to create.

It is also desire to conduct semi-structured interviews with the teacher educator and some of the pre-service teachers. This will be done outside of the normal class time and should not interfere with coursework. Any identifying factors will be removed to maintain confidentiality of the individuals and university.

I realise your time and the class time of the course is precious. However, an investigation into the science education environment may assist teacher educators in planning and modifying their teaching practices and understanding the impact their course has on pre-service teachers’ perceptions and potential teaching behaviours. I would greatly appreciate your university’s cooperation with this study. I will be contacting you shortly to further discuss this project and to confirm your university’s participation in the study. If you have any questions, please contact me at 03-479-5843 e-mail victoria.rosin@otago.ac.nz or my advisor Dr. Mary Simpson 03-479-3795 e-mail mary.simpson@otago.ac.nz

Sincerely,

Victoria Rosin

This study has been approved by the University of Otago Human Ethics Committee. If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (ph 03 479 8256). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.
Dear Teacher Educator/Lecturer:

I am a doctoral student at the University of Otago, Dunedin College of Education. I am writing to ask for your cooperation with my doctoral research study. The purpose of this study is to investigate how teacher educators’ primary science learning pedagogies are understood by pre-service teachers. It will also attempt to identify teacher educator’s beliefs, practices in teaching, and the degree of congruence between these and the classroom-learning environment teacher educators create for pre-service teachers. The results of the study may benefit teacher educators to decide if the environment perceived is the environment you were meaning to create. This research may also assist you when planning future courses or when updating current courses. Though primary science is the focus, findings of this study may be of interest to other subject areas of pre-service education to assist teacher educators in evaluating and monitoring other courses.

Your course (name) has been selected for the study. The study will use a Likert scale 25-item survey that the pre-service teachers of the course and that you will complete. The survey and personal details solicited will take about 20 minutes to complete and ideally completed during the first week of the course and again during the last. The data will be compiled, to assure both pre-service teachers’ and your confidentiality. I will also request a class syllabus to analyse for the composition of the course and the type of classroom learning environment you work to create.

It is also desired to conduct semi-structured interviews with you and some of your pre-service teachers. This will be done outside of the normal class time and should not interfere with coursework. This will be set up at a later date. Any identifying factors of individuals or the university will be removed to maintain confidentiality.

I realise your time and the class time of the course is precious. However, an investigation into the perceived environments may assist you and others in planning and modifying your teaching practices and understanding the impact your course has on pre-service teachers’ perceptions and potential teaching behaviours. I would greatly appreciate your cooperation with this study. Even if you do not wish to participate, I would still like to survey your students. I will be contacting you shortly to further discuss this project and to confirm your course’s participation in the study. If you have any questions, please contact me at 03-479-5843 e-mail victoria.rosin@otago.ac.nz or Dr. Mary Simpson 03-479-3795 e-mail mary.simpson@otago.ac.nz

Sincerely,

Victoria Rosin

This study has been approved by the University of Otago Human Ethics Committee. If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (ph 03 479 8256). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.
Thank you for showing an interest in this project. Please read this information sheet carefully before deciding whether or not to participate. If you decide to participate - thank you. If you decide not to take part there will be no disadvantage to you of any kind and thank you for considering the request.

What is the Aim of the Project?

This project is being undertaken as part of a Doctorate of Education project, University of Otago, Dunedin College of Education. The information solicited from participants will be used:

1. To identify aspects of teacher educators’ (lecturers’) classroom practices which have particular impact on pre-service teachers’ (students’) pedagogical understandings in primary science.
2. To identify teacher educators’ (lecturers’) perceptions of their classroom-learning environment.
3. To identify pre-service teachers perceptions of the learning environment.
4. To investigate if there is a relationship between pre-service teachers’ potential teaching behaviour and other educationally related factors (i.e. science knowledge, age, gender, etc).

What Types of Participants are being sought?

-Pre-service teachers (university students) 18 years and older who are enrolled full or part-time, are completing a primary teaching degree, and who are taking the primary science paper (course) in 2010 for the first time.

-The teacher educators (lecturers) of the primary science course.

What will Participants be Asked to Do? Should you agree to take part in this project, you are indicating your willingness to be asked to:

1) fill out a 20 minute survey during the first and last week of the primary science course
2) provide some personal details.
3) to potentially participate in an individual interview with the researcher in the last week of class. The interview will be audio-recorded and should take no more than 30 minutes. Individuals selected for this will be contacted later in the study. Individuals may decline to be interviewed.

No individual answers or interview parts will be identifiable in the research thesis or available to teacher educators (lecturers) or other pre-service teachers. Totalled class survey scores will be available to teacher educators (lecturers) if they request them to benefit their classroom teaching. The surveys and interviews will not affect any grade or mark in your coursework. Please be aware that you may decide not to take part in the project without any disadvantage to yourself of any kind.
Can Participants Change their Mind and Withdraw from the Project?

You may withdraw from participation in the project at any time and without any disadvantage to yourself of any kind.

What Data or Information will be Collected and What Use will be Made of it?

The data collected will be based on teacher educators and pre-service teachers understanding of a constructivist learning environment as measured through the Constructivist Learning Environment Survey (CLES). Personal details will be solicited of participants who volunteer to do the CLES surveys. In addition, some participants will be asked to participate in an individual interview that will be audio recorded and transcribed. This interview will consist of semi-structured questions. A class syllabus will also be requested for analysis.

The data being collected is being used for the completion of a Doctorial thesis and to show how teacher educators and pre-service teachers perceive the learning environment of the primary science coursework. This study aims to benefit teacher education programmes by completing this work.

Any information that is collected in connection with this study and that can be identified with you will remain strictly confidential. If direct quotes from interviews are used in the dissertation, it will not identify participants or the university to assure anonymity of participants. Only the researcher will have access to raw data.

Teacher Educators (lecturers) will have access to class compiled survey data only. No identifying features of individuals will be apparent.

The results of the project may be published and will be available in the University of Otago Library, Dunedin, New Zealand. You are most welcome to request a copy of the results of the project should you wish.

The data collected will be securely stored in such a way that only those mentioned below will be able to gain access to it. At the end of the project any personal information will be destroyed immediately except that, as required by the University's research policy, any raw data on which the results of the project depend will be retained in secure storage for five years, after which it will be destroyed.

Reasonable precautions will be taken to protect and destroy data gathered by email. However, the security of electronically transmitted information cannot be guaranteed. Caution is advised in the electronic transmission of sensitive material.

What if Participants have any Questions?

If you have any questions about our project, either now or in the future, please feel free to contact -

Victoria Rosin - Dept. of Education-Portobello Aquarium - University Telephone Number: 03-479-5843 e-mail victoria.rosin@otago.ac.nz Or Dr. Mary Simpson - College of Education, Office of the Dean, Humanities - University Telephone Number: 03-479-3795 e-mail mary.simpson@otago.ac.nz

This study has been approved by the University of Otago Human Ethics Committee. If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (ph 03 479 8256). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.
Constructing Primary Science Pedagogy –

What Pre-Service Teachers Comprehend from Teacher Educators’ Coursework

CONSENT FORM FOR PARTICIPANTS

I have read the Information Sheet concerning this project and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I know that:

1. My participation in the project is entirely voluntary.
2. I am free to withdraw from the project at any time without any disadvantage.
3. Personal identifying information such as audiotapes will be destroyed at the conclusion of the project but any raw data on which the results of the project depend will be retained in secure storage for five years, after which they will be destroyed.
4. As the project does include semi-structured interview questions, the researcher will endeavour to reduce any discomfort or risk to participants during the interview. However, if I feel uncomfortable and do not wish to continue the interview, I may discontinue with no disadvantage of any kind. An individual’s interview transcript will be available to correct or change items as requested.
5. Teacher Educators (lecturers) will have access to class compiled survey scores that are also available to me, if I request a copy. No identifying information of individuals will be apparent.
6. There is no remuneration or compensation with participation in the research, and understand that data will not be used in any commercial way.
7. The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve my anonymity.

I have read the information sheet and consent form. I agree to take part in this project.

.......................................................... ...........................................................
(Signature of participant) (Date)

This study has been approved by the University of Otago Human Ethics Committee. If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (ph 03 479 8256). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.
### Appendix F

Table F15 Independent-Samples *t*-Tests CLES Results by Gender for University A and B

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*Note. F = Female, M = Male.*
### Appendix G

Table G16 Independent-Samples $t$-Tests CLES Results for Pākehā and Māori Pre-Service Teachers for University A and B

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Note. Significant at $p < .05$ is bolded. $P = $Pākehā, $M =$Māori
### Appendix H

Table H17 ANOVA CLES Results by Ethnic Groups without Pākehā for University B

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*Note. Significant at $p < .05$ is bolded.*
### Appendix I

Table I18 ANOVA Preferred CLES Results by Science Qualifications for University B

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