

Science and Mathematics Education Centre

**Evaluation of the Learning Environments
of the UTeach Teacher Development Program
for Secondary Science and Mathematics Teachers**

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Doctor of Philosophy
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DECLARATION

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

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

Human Ethics The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number #SMEC-36-12.

ABSTRACT

UTeach is a secondary science and mathematics teacher development program that is offered in numerous universities across the United States. This study evaluated UTeach by investigating whether UTeach students were experiencing positive classroom learning environments in three settings: (1) their UTeach pedagogical content courses; (2) their STEM major core courses; and (3) the FIELD classes that they teach during assigned practice teaching within public-school K–12 classrooms. This study also validated a modified version of the Constructivist Learning Environment Survey (CLES) for use with preservice teachers in three different settings.

The sample of prospective UTeach science and mathematics teachers who were monitored for four semesters of their university program totalled 702 students, of whom 575 students were involved in a FIELD course component.

The modified CLES was found to be valid when principal axis factor analysis with varimax rotation and Kaiser normalization was conducted separately for UTeach, STEM and FIELD classes to test its structure. As well, Cronbach's alpha reliability coefficient was high for all scales. This instrument has the potential for use in future studies with both preservice and STEM classes, as well as with programs involving three learning environment settings.

Using MANOVA and effect sizes, differences between the three settings (UTeach, STEM, and K–12 FIELD classes) were investigated in terms of preservice teachers' perceptions of the learning environment and how these perceptions changed over time. Students perceived the UTeach learning environment as being significantly more positive than the STEM and FIELD components; and the FIELD setting (where applicable) was perceived as significantly more positive than STEM courses. Effect sizes were small to medium for differences between the UTeach and FIELD settings, medium to large for differences between FIELD and STEM settings, and large for differences between UTeach and STEM classes.

Because UTeach preservice teachers are in a unique role as both students and teachers, their perceptions of the learning environments of their courses have the potential to enhance our understanding of the UTeach program and core STEM courses. This study suggests that the UTeach program provided a relatively positive learning environment in pedagogy and FIELD courses, but that the learning environment of numerous university STEM course could be improved.

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CHAPTER 1

OVERVIEW OF STUDY

1.1 INTRODUCTION

UTeach is a fast-growing, highly-replicated, secondary science and mathematics teacher development program in universities across the United States (UTeach Institute, 2015a). Science and mathematics majors are recruited to sample teaching as an alternative career; coursework is compatible with their current degree plan and is taught in a way that does not deter their progress. To be certified to teach in Texas, preservice science and/or mathematics teachers are also required to major in mathematics or in one of the sciences, taking core courses for their bachelor's degree (biology, physics, chemistry, geosciences, etc.). Unlike other programs, UTeach students begin teaching in public school classrooms during the first professional development class. They are taught pedagogically-modelled science and mathematics education courses within the UTeach model, but their core courses are taught within the departments from which they will earn their degrees (UTeach Institute, 2014).

The learning environment is comprised of the perceptions of the students, and sometimes those of the teacher. "It is the quality of life lived in classrooms that determines many of the things that we hope for from education — concern for community, concern for others, commitment to the task in hand" (Fraser, 2001, p. 2). Although classroom learning environment is a subtle concept, remarkable progress has been made in assessing and studying it through diverse and international research over the past four decades (Fraser, 2012). The present study drew upon and contributed to the field of learning environments, particularly through the availability of robust, convenient, and extensively-validated questionnaires and past success in exploring learning environment criteria in evaluating a wide range of educational programs (Fraser, 2014).

Do the learning environment perceptions of preservice teachers change as they progress through their program? Do they judge their classes' environments differently as they learn how to teach others? Does observing the classrooms of mentor teachers in the public school sector affect students' perceptions of their UTeach or university class learning environments? These questions helped to form the basis of this research study.

This chapter provides an introduction and overview for the thesis. Section 1.2 provides background on the UTeach program. The study of learning environments and their relevance to preservice teacher education programs are introduced in Section 1.3. Section 1.4 provides the research objectives for this study. Section 1.5 introduces the significance of this study. Finally, Section 1.6 provides a chapter summary and thesis overview.

1.2 BACKGROUND INFORMATION ABOUT THE UTEACH PROGRAM

“UTeach was created to attract a wide range of bright science and mathematics majors into secondary teaching careers, to prepare them through an advanced field-intensive curriculum, and to promote professional retention through induction support and ongoing professional development” (UTeach Institute, 2013b, para. 2). UTeach started in 1997 at The University of Texas (UTeach Institute, 2012), with the university's common nickname of UT being worked into the title of the program: UTeach. “Congress and the National Academy of Sciences have singled out UTeach in recent years as a promising model to help fill a national shortage of qualified schoolteachers in science and mathematics. The program has doubled the annual number of Austin's bachelor's-degree recipients certified to teach those subjects in secondary schools” (Brainard, 2007, para. 4). By 2014, UTeach had been replicated at 40 universities in 19 states across the country as reflected in Appendix A (UTeach Institute, 2015a).

The UTeach program caters to students who are science and mathematics majors interested in sampling teaching as an alternative career. This preservice teacher program is closely integrated with the students' current degree plans. These recruited preservice teachers are required to continue with their major in mathematics or in one of the science fields, as well as to complete the pedagogical courses required by the

State of Texas to earn a teaching credential (UTeach Institute, 2015b). In Texas, an education major is not allowed and, instead, students select a major of interest (Texas Education Agency [TEA], 2016). Because most Texas institutions of higher education have a revised liberal arts degree as the common track for teacher certification, that is the path that many traditional preservice teachers choose to take; very few students choose majors in the Science, Technology, Engineering, and Mathematics (STEM) fields. This path does not have many higher-level courses in the science and mathematics majors. However, primary and secondary classrooms need teachers with a higher level of knowledge and understanding than is provided by a general degree (Beth, Hughes, Romero, Walker, & Dodson, 2011).

UTeach students are immersed in teaching in public school classrooms from the onset of the program, in their first teacher education course, which is often in their first semester of college. Thus they are able to determine if teaching is a fit for them early on in their college career. This can be contrasted with traditional teacher preparation programs in which students complete all of their pedagogical coursework before ever teaching in a pre-college classroom. Students in a traditional teacher preparation program might observe a primary or secondary classroom for some hours and/or practice teaching lessons within their courses before student teaching (Brainard, 2007).

The UTeach program took these required pedagogical courses and revamped them, focusing on the STEM aspects in each course. Instead of taking courses with preservice English and history majors, now the STEM majors are together in their pedagogical classes. This allows a deeper understanding of the requirements to teach those types of courses, as well as allowing the courses to be considered as STEM electives in their degree plans. This permits students to have fewer requirements for graduation than for certification with traditional STEM majors. UTeach has eight courses in the program before student teaching (see Appendix B). These courses include two introduction-to-education courses [Step 1 and Step 2], education courses [Knowing and Learning, Classroom Interactions, and Project-Based Instruction], and two to three Specialized STEM content area courses [Research Methods, Perspectives on Science and Mathematics, and Functions and Modelling for mathematics majors only]. Apprentice Teaching and Apprentice Teaching Seminar are the UTeach versions of traditional student teaching programs. During Apprentice Teaching, students observe for 40 hours and then they slowly take on the responsibility of teaching multiple classes for 4 hours

a day while working closely with, and still observing, their mentor teachers' classes (UTeach Institute, 2015c).

In May 2014, there were over 2100 graduates of the UTeach program. These alumni represent teachers who graduated from the beginning of the program at UT Austin through to all of the replications (UTeach Institute, 2014). With this many preservice teachers graduating from the program, the learning environments associated with the program, and how these change as students learn to become educators, need further study. This provided the focus for my research.

1.3 PRESERVICE TEACHERS AND THEIR LEARNING ENVIRONMENTS

“Students spend approximately 20,000 hours in a classroom by the time they graduate from a university” (Fraser, 2001, p. 1) and therefore students' reactions to these classroom environments are important pieces of the education puzzle. Too often educators rely solely on achievement scores but, by doing so, they are not able to put the puzzle together and see a complete picture of what is happening in the classroom (Fraser, 2001).

Attempting to improve and develop a teacher preparation program requires reflection on and inquiry into its own practice as a way to measure its success. Further, teacher preparation programs are unique in that students arrive with a great deal of perceived knowledge regarding how to teach and the best ways to teach based on their personal world views of educational experiences as students. The students' worldviews lead to strong preconceptions about how to be an effective teacher or an effective learner, even though they might be early in their teacher education development (Harrington & Enochs, 2009; adapted from Grossman, 1990; Lortie, 1975; National Council of Teachers of Mathematics [NCTM], 2000). Thus, “any research on a teacher preparation program must acknowledge the difficult position that preservice teachers are in when they attempt to balance the theory from their coursework with what they are seeing in the field”, and how these sometimes disparate schema can enhance each other (Harrington & Enochs, 2009, p. 63). Some questions to consider when reflecting on and inquiring into the UTeach program could include: How does this affect their

learning environment within the UTeach program courses? How does it affect the learning environment of their STEM major courses? Do these perceptions change as students progress through the program and learn more educational theory?

In addressing these questions and the schema models that preservice teachers balance between being a student and becoming a teacher, the learning environments of preservice teachers need to be addressed in the various classroom roles in which they find themselves. They are students in their core classes. They are students in their preservice education classes, yet they are also ‘experimental’ teachers in these classes as they learn to become educators of the next generation. In addition, they are observing their primary-school and secondary-school mentors in action. It is important that meaningful learning is occurring throughout their preservice teacher program.

Meaningful learning involves relating new information to knowledge that students have already constructed, according to the constructivist model in which students are co-constructors of their own knowledge (Fraser, 1998a). The Constructivist Learning Environment Survey (CLES) (Taylor, Dawson, & Fraser, 1995; Taylor, Fraser, & Fisher, 1997) was developed to assist researchers and teachers to assess the degree to which a classroom is consistent with this constructivist model. The CLES consists of 36 items arranged in five scales [Personal Relevance, Uncertainty of Science, Shared Control, Critical Voice, and Student Negotiation] and uses a five-point frequency response format with choices ranging from Almost Never to Almost Always. Examples of items include “I help the teacher to decide what activities I do” (Shared Control) and “Other students ask me to explain my ideas” (Student Negotiation) (Fraser, 1998a).

The CLES-Comparative Student version (CLES2-CS) is a slightly-modified version of the original CLES with two response columns and with the number of items reduced to 20. Statements are placed between two response columns headed THIS and OTHER. “The distinct feature of this version of the CLES is that it asks the student [preservice teacher] to provide perceptions not only of ‘THIS’ classroom environment (the student’s current class), but also of ‘OTHER’ classroom learning environments (other classes at the same school)” (Nix, Fraser, & Ledbetter, 2005, p. 116). This comparison method could be adapted to be the name of the current course rather than THIS and more-specific comparison courses for the OTHER, such as for UTeach and

STEM courses. Because of the widespread validity and use of the CLES across countries and languages (Aldridge, Fraser, Taylor, & Chen, 2000; Johnson & McClure, 2004; Kim, Fisher & Fraser, 1999; Koh & Fraser, 2014; Peiro & Fraser, 2009), and the relative brevity of the instrument, a modified version of the CLES-CS was developed for assessing preservice teachers' views in this study (see Appendix C). More-detailed discussion of learning environments studies, the development of learning environment instruments, and the CLES, in particular, can be found later in this thesis in Sections 2.3 and 3.4.

1.4 RESEARCH OBJECTIVES

With UTeach programs expanding across the country, the learning environments of the participants within the program are of prime importance for evaluating the effectiveness of the program. This study grew from anecdotal evidence that, as preservice students progress through educational pedagogical courses, they become harsher critics of the learning environments that they experience throughout their university program. They would often discuss in the student workroom how a particular professor needs more training in how to teach and that some university classrooms provided undesirable learning environments. They would then compare him/her and the classroom to the primary-school and secondary-school mentor teachers, whom they previously had or currently were experiencing that semester, and to their classroom environments.

The main purpose of this study was to evaluate the effectiveness of UTeach in terms of preservice teachers' perceptions of their learning environments in three different settings: (1) their pedagogical content courses; (2) their STEM science and/or mathematics major (core) courses; and (3) the classes that they observe during assigned practice teaching within public school primary and secondary science and mathematics classes. This study's specific aims were:

1. To validate a modified version of the Constructivist Learning Environment Survey (CLES) with preservice teachers.

2. To evaluate UTeach by comparing the learning environments perceptions of preservice teachers' in the following three settings:
 - a. UTeach pedagogical content courses
 - b. STEM [science and/or mathematics] major (core) university courses
 - c. Science and/or mathematics classes that they teach/observe during assigned practice teaching within the K–12 public school system (FIELD).

1.5 SIGNIFICANCE OF THE STUDY

This study is significant for several reasons. First of all, it is significant to the fields of both learning environments and teacher education because very few previous studies have been undertaken into the learning environments of preservice teacher education. Training teachers to teach future generations includes not only pedagogy, the lesson cycle and technology, but also the importance of classroom climates to their learning and the learning in their future classrooms. We, therefore, need to assess which classroom climates preservice teachers find more positive and what changes can be made based on these perceptions.

This study is methodologically significant because it evaluated multiple learning environments, namely, UTeach courses, STEM courses, and their K–12 FIELD courses, over four semesters, in order to monitor changes over time in preservice teachers' perceptions of the varied learning environments as they learn more educational theory. This is the first known study to use the CLES to evaluate three different settings at the same time. Therefore, validation of this version of the CLES is methodology significant within the field of learning environments research because it added to the well-established research basis of the CLES described in Chapter 2.

Because the UTeach teacher preparation program is rapidly being modelled across the USA, it must be evaluated to ascertain how the students in all of these programs are having their perceptions affected; this study was the first step in that research. Because

of positive expectations of the UTeach students once hired, we need to know whether they are learning what makes an effective learning environment in each of the various settings that they experience as they progress through the UTeach program.

The results of this study could provide positive support to practitioners wanting to develop a more constructivist learning environment. The CLES provides feedback to teachers to help them to reshape their teaching practices (Aldridge et al., 2000). This study could be used to emphasize that a constructivist learning model can provide a positive learning environment and therefore better learning. ‘Better teachers mean better education’ and this is true for both novice and experienced teachers (Feiman-Nemser, 2000; Harrington & Enochs, 2009).

This study could illuminate the value of STEM teaching models at the university level compared with other teaching methods. This study is methodologically significant because, if students perceive these diverse learning environments differently, then perhaps this is the beginning of the implementation of teacher training for those who teach STEM courses at the post-secondary level. Further discussion of the significance of this study will be in Chapter 5.

1.6 SUMMARY AND THESIS OVERVIEW

UTeach preservice teachers are in high demand and replication of the UTeach program continues to grow rapidly. Therefore, in this study, I investigated whether these students are learning in a positive and satisfactory environment in their three learning environment settings: (1) their pedagogical content courses; (2) their science and mathematics major (core) courses; and (3) the classes that they teach during assigned practice teaching within the public school K–12 science and mathematics classes. For the remainder of this thesis, these settings are referred to as (1) UTeach courses, (2) STEM courses, and (3) FIELD courses.

This study also aimed to validate a modified version of the CLES for use with STEM preservice teachers and in three learning settings. Once validated, this widely-applicable questionnaire could be used with a variety of teacher preparation programs.

This thesis is comprised of five chapters. Chapter 1 introduced the UTeach program and why studying students' perceptions of the learning environments in these courses is significant. Chapter 2 reviews literature related to preservice teacher training and the field of learning environments. Next, Chapter 3 summarizes the research methods used in this study to evaluate the learning environments of the UTeach program. The data-collection procedures and data analysis for answering the research objectives also are explained in Chapter 3.

This is followed by a detailed reporting of the results of data analyses in Chapter 4, including the validity and usefulness of the preservice version of the Constructivist Learning Environment Survey (CLES). Research Objective 2 was answered by analysing data to compare students' perceptions of their UTeach course teaching, their STEM courses teaching, and their teaching in their K–12 field classroom. This question was also answered by tracking changes in CLES scale scores over time across the duration of the study period, as well as students' open-ended comments about the three learning environments that they experienced while in the program.

The thesis closes with Chapter 5 which offers a summary of the thesis together with conclusions and recommendations based on the evaluation of the UTeach preservice teacher program. In addition, Chapter 5 discusses limitations of this study, including sample selection and time constraints. The significance and implications of this study and suggestions for further research are also considered.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Chapter 1 began with an introduction to the UTeach teacher certification program and the roles and experiences of preservice teachers. This led to an introduction to the field of learning environments and how students' perceptions can be used to evaluate classroom environments. Lastly, the purpose and significance of this study were discussed, and the study's two research objectives were defined.

This chapter reviews the literature on the topics introduced in the previous chapter to support this research. Section 2.2 discusses teacher education programs and their relevance to this study. This section is divided into the following subsections: Section 2.2.1 discusses traditional teacher education programs in the United States and why a change was needed; Section 2.2.2 reviews the importance of secondary teachers being knowledgeable; Section 2.2.3 discusses constructivist learning environments for preservice teachers; Section 2.2.4 reviews the background and development of the UTeach program; and Section 2.2.5 examines the importance of preservice teachers and the unique role that they have in evaluating learning environments. Section 2.3 reviews literature from the field of learning environments using the following subsections: Section 2.3.1 provides a brief history of learning environment research; Section 2.3.2 presents some of the more-popular learning environment assessment instruments, particularly those that led to the instrument used in my study (e.g. CUCEI, QTI, SLEI, WIHIC, and the CLES); and Section 2.3.3 reviews past learning environments research, especially the use of learning environments assessments in the evaluation of educational programs. Finally, Section 2.4 provides a summary of the literature review in this chapter.

2.2 TEACHER EDUCATION PROGRAMS

As school districts across America strive to maximize student performance, especially after the passing in 2002 of the *No Child Left Behind* (NCLB) law (the update of the Elementary and Secondary Education Act that raised school accountabilities), the need for and importance of highly-qualified teachers has increased exponentially (Klein, 2015; Nagy & Wang, 2006). According to Kyle (1994 p. 775): “Seldom is the reform of K-12 schools and teacher education linked....Ought teacher education programs become connected to the inquiry associated with learning, thereby modeling current understandings of best practice?” Therefore it is important to examine teacher preparation programs. Section 2.2.1 reviews traditional teacher education programs, Section 2.2.2 addresses the importance of having knowledgeable secondary teachers, and Section 2.2.3 considers constructivist learning environments for preservice teachers and the need for the UTeach program.

2.2.1 Traditional Teacher Education Programs and the Retention of Teachers

The training that prospective teachers undergo is vital to any success that they might experience as effective teachers. Traditional teacher preparation programs set the greatest requirements for teachers (Qu & Becker, 2003). For instance, in order for teachers to become certified, they usually must first acquire a Bachelor’s degree in education. Further, traditional preservice programs tend to require that undergraduates focus on “pedagogy-heavy courses that ‘bore science students to death’ according to Kate Walsh, the President of the National Council on Teacher Quality” (Cavanagh, 2007, p. 23). These traditional programs often have students observing or tutoring in a K–12 classroom for a certain number of hours during their early pedagogy courses (UT Dallas, Teacher Certification, FAQ) rather than teaching lessons during this time. In addition, prospective teachers must complete a specified amount of time in teaching with an assigned mentor teacher (Qu & Becker, 2003).

Preservice preparation and support for teachers after they are in the field can make a big difference in their teaching success. Students taking education courses in most traditional university programs do not experience classroom teaching until they are third-year or fourth-year college students, often too late to change majors if they decide

they do not like teaching (Brainard, 2007). This leads to teachers who do not like teaching, yet are in classrooms because that was their major. Induction programs with sustained assistance over time have been proposed as one solution to beginning teacher retention (Carr & Evans, 2006). This mentoring and support provide an outlet for teachers, extra help in understanding problems that arise, and assistance with solutions to teaching or student issues. A huge proportion of new teachers do not stay in the profession for more than a few years; for example, more than 40 percent of new teachers hired in Texas in 1995 had left by 1999 (Marder & Confrey, 2000).

A recent study of secondary science and mathematics teachers in Texas (Fuller, 2009) concluded that secondary science and mathematics are subject areas with the most critical shortages and that, although development of secondary mathematics and science teachers has increased since 2001, the shortage has shown a drastic increase over the last five years (80% for high school science) and is projected to continue to increase. Perhaps programs for preparing teachers are not meeting the needs of preservice teachers. If this is the case, then these programs must change if the dearth of mathematics and science teachers is to be changed.

One approach for preparing mathematics and science teachers is the UTeach program. The US “Congress and the National Academy of Sciences have singled out UTeach in recent years as a promising model to help to fill a national shortage of qualified [secondary] schoolteachers in science and mathematics” (Brainard, 2007, ¶ 4). In 2008, approximately 80% of UTeach graduates were still teaching after five years, a significantly higher rate than the national average (National Science Teacher Association, 2008). With UTeach being highly recommended, it is important to evaluate the program in more depth.

2.2.2 Importance of Secondary Teachers Being Knowledgeable

“Nationwide, about 30 percent of high-school math students and 60 percent of physical-science students have teachers who either did not major in the subject in college or are not certified to teach it. Experts say that explains the mediocre performance by American students on international tests of science and math” (Brainard, 2007, p. A9). The importance of recruiting science and mathematics majors has become even more critical as the state and national standards continue to involve

higher academic levels and more requirements for the K–12 courses (Foster & Jasper, 2010; Nagy & Wang, 2006). One of the recommendations of the National Council on Teacher Quality was to “ensure that secondary general science teachers have the content knowledge to teach every subject they are certified to teach” (NCTQ, 2014, p. 88). To be certified does not necessarily mean that the teachers are well prepared in either pedagogical skills or content knowledge. This was often common with traditional general-studies teacher training programs.

As Foster and Jasper state: “Teachers who possess both pedagogical skills and knowledge of science [and mathematics] are vital to students’ attaining science [and mathematics] literacy” (2010, p. 5). However, many “science and math professors at research universities consider teaching school a waste of their students’ talents, and actively discourage them from teaching careers” (Brainard, 2007, ¶ 10); therefore, it is vital to involve mathematics and science professors in recruiting mathematics and science majors rather than only general-studies majors.

2.2.3 Constructivist Learning Environments for Preservice Teachers

In the *Blueprints for Reform Project 2061*, a suggested approach for improving science teacher education is that “students should be allowed to become active learners, have first-hand experience with making connections between their own ideas and the knowledge they develop in courses, and participate in classes where faculty model a teaching style that is conducive to active learning” (AAAS, 1998, Teacher Education, ¶ 11). The importance of active learning dates back to Jean Piaget (1958). Piaget theorized that assimilation and accommodation require an active learner, not a passive one, because problem-solving skills cannot be taught, they must be discovered. Within the classroom learning should be student-centered and accomplished through active discovery learning. The role of the teacher is to facilitate learning, rather than direct instruction. Active learning and constructing knowledge are very similar (McLeod, 2015). Lev Vygotsky’s (1934, 1978) social constructivist theory emphasizes social contexts of learning and that knowledge is mutually built and constructed. By interacting with others students they have the opportunity to share their views and thus generate a shared understanding related to the concept. Vygotsky's theories of education and instruction support instructional concepts such as "scaffolding" and

"apprenticeship", in which a teacher or more advanced peer helps to structure or arrange a task so that a novice can work on it successfully. Also, Vygotsky's theories lead to collaborative learning, suggesting that group members should have different levels of ability so more advanced peers can help less advanced members operate within their learning zone (McLeod, 2015).

"According to the constructivist view, meaningful learning is a cognitive process in which individuals make sense of the world in relation to the knowledge which they already have constructed, and this sense-making process involves active negotiation and consensus building" (Fraser, 1998a, p. 13). The sense-making process shifts emphasis to learning with understanding and away from procedural teaching; this can lead to higher levels of skill than can be attained by rote practice alone (Mathematics Learning Study Committee, 2001).

One of the best methods for teaching and addressing constructivist learning is through inquiry learning. Active inquiry learning is "the idea that students benefit from having to investigate and acquire some knowledge on their own, rather than simply being 'spoon-fed' information from teachers" (Cavanagh, 2007, p. 23). One way to achieve this inquiry learning is with the 5E Learning Model. In the 5E Model, teachers 'engage' students, encourage students to 'explore' subject topics on their own/in groups, have students 'explain' their reasoning, and ask students to 'extend' their knowledge to other applications/problems. Later, teachers 'evaluate' whether students have incorporated the new information into their existing knowledge (Bybee et al., 2006). The activities lend themselves to hands-on activities, with varied lesson tasks having the ability to reach many students with different learning styles, such as those who learn better through visual, kinesthetic, or audio means (Bybee et al., 2006; Cavanagh, 2007). "Constructivists recognize that learning does not occur in a vacuum, but is embedded in a particular social setting or learning environment" (Koh & Fraser, 2014, p. 158).

A collaborative research project involved nine teacher-preparation institutions in focusing on the alignment of the beliefs and practices of beginning secondary science and mathematics teachers. This research used the Constructivist Learning Environment Survey along with teacher interviews, analysis of videotaped lessons, and a teacher and student questionnaire to gather data leading to statements about

teacher knowledge and beliefs, teaching performance, and the comparison of knowledge and beliefs to teaching performance. One of the recommendations resulting from this project was a call for similar collaborative studies to “. . . strive to address the needs of students, teachers, teacher educators, and other stakeholders working to establish a common vision for excellent instruction and systemic, long-lasting reform” (Simmons et al., 1999, p. 931).

Overall, Lowery, Roberts, and Roberts (2004) found that the best way to train prospective teachers was to provide them with more training within the classroom. This training allows preservice teachers to create their own knowledge about teaching and to make sense of the pedagogical theory that they have encountered in more traditional teacher education classes. Other research shows that a way to create more effective teachers is to provide strong mentor support from seasoned K–12 teachers (Moffett & Davis, 2014). These findings are employed in the UTeach preservice program.

2.2.4 UTeach Program

For years, educators and policymakers throughout America have been concerned about the high attrition rates of beginning science and mathematics teachers (Johnson & McClure, 2004). In 1997, the Deans of the UT Colleges of Natural Sciences and Education “gathered together a group of award-winning secondary teachers and asked them to design the best teacher preparation program they could, drawing upon their years of teaching experience” (Marder & Confrey, 2000, p. 6). This program, which became known as UTeach, was designed to address teacher shortage and quality issues by transforming the way in which “universities recruit, prepare, and inspire new math and science teachers” (NMSI, 2010, p. 19). According to the UTeach Institute: “UTeach was specifically created to attract a wide range of bright science, mathematics, and computer science majors into secondary teaching careers, to prepare them through an advanced field-intensive curriculum, and to promote professional retention through induction support and ongoing professional development” (UTeach Institute, About UTeach, 2012). President Obama’s educational initiatives, such as Race to the Top, Change the Equation, and 100Kin10, all place STEM teacher preparation at the center of national education reform efforts and feature UTeach. The

President Obama Administration also lists UTeach as a national model for increasing the number of teachers available to fill hard-to-staff positions in STEM (Robelen, 2010).

“UTeach went through several phases. From 1998 to 2004 it grew to steady state at UT Austin. In 2007 UTeach started to be replicated across the United States, with three expansion sites in Texas. These sites began yielding graduates in 2010. As of 2016, UTeach has spread to 7 Texas institutions. These are UT Austin, UT Dallas, UT Arlington, UT Tyler, UT Rio Grande Valley (formerly UT Pan American and UT Brownsville), University of North Texas, and the University of Houston” (Marder & Hamrock, 2016, p. 9). UTeach has now been replicated at 44 universities in 21 states across the country as of spring 2015 (UTeach Institute, 2016).

“The core elements of the UTeach formula for success include:

- Active recruitment and financial incentives, such as offering the first two courses free or providing tuition stipends.
- A compact degree program that allows students to graduate in four years with a degree and a teaching certification.
- A strong focus on acquiring deep content knowledge in math and science, in addition to research- based teaching strategies focusing on teaching and learning math and science.
- Early and intensive field teaching experience, beginning in the students’ first semester.
- Personal attention and guidance from highly experienced master teachers, faculty and successful public school teachers.” (National Math and Science Initiative, UTeach Program, 2012, p. 2)

The typical UTeach student begins in his/her first fall at university and takes one course a semester for the next four years, as shown in Table 2.1. The first two courses (Step 1 and Step 2) are one-credit-hour courses, allowing undergraduates to try teaching without fully committing to the teaching option as in the traditional teaching model. Based on their experiences with these two trial courses, students either continue

with the UTeach program coursework or self-select out of the teaching option. Appendix B contains the full UTeach program’s entrance and course schedule for students entering at different time frames.

Table 2.1 UTeach Course Sequence if Entering in Freshman Fall Semester

Year	Semester	Course
1	Freshman	1
		2
2	Sophomore	3
		4
3	Junior	5
		6
4	Senior	7
		8

Adapted from UTeach Austin, Professional Development Sequence (2012)

This program is distinctive in that it: involves recruiting mathematics and science majors; requires early practice-teaching experiences; uses experienced, proficient and knowledgeable science and mathematics secondary teachers to design, improve and conduct the courses; and focuses on inquiry using the 5E constructivist lesson model (Cavanagh, 2007; NMSI, 2012). As discussed in Section 2.2.2, it is important for mathematics and science majors to become mathematics and science teachers, instead of general-studies majors, to ensure that secondary mathematics and science teachers are knowledgeable. Because students in the UTeach program also obtain degrees in either science or mathematics, they have learned a substantial amount of content, and are therefore more proficient in content knowledge than many other current teachers and traditional general-studies preservice teachers.

UTeach preservice teachers start teaching lessons in public school classrooms from their very first course, Step 1. By the time they reach Apprentice teaching, they have already written and taught approximately 15 lessons in 5E lesson format (described in Section 2.2.3) in public school classroom settings ranging from the elementary to the high school (UTeach Institute, 2013a). Apprentice teachers take over several classes for an eight-week period, while still observing their mentor teachers during the

remaining classes in the day. They plan instruction with their mentor teachers, write their own 5E lessons, and become the teacher for these class sections (UTeach Dallas, 2014).

Master Teachers occupy a unique role at universities and are a core component of the UTeach program (Ostlund, 2007). K–12 teachers are hired by the UTeach program as ‘master teachers’, often with the non-tenure track title of ‘clinical associate professor’, becoming university instructors who “teach many of the pedagogy classes, act as mentors to the students, and place them in local schools for their practice-teaching stints. The master-teacher role is vital to UTeach’s success, say participants in Austin and observers elsewhere” (Brainard, 2007, ¶ 17-18). According to Ostlund (2007, p. 20): “Master Teachers have experienced years of successful teaching and are widely recognized for their educational leadership. They are credible because they have actually taught in the public school environment. It is essential to have this credibility when working with district personnel and UTeach students.” Master teachers also are crucial after graduation from the UTeach program; they continue to mentor graduates who have begun teaching. During this ‘induction’ phase of the program, master teachers focus on helping new graduates succeed during the crucial first years of teaching (Marder & Confrey, 2000; Ostlund, 2007).

The UTeach program replaced the traditional general-education courses that all preservice teachers must take with courses that integrate the key ideas of equity, educational technology, and multicultural education, and which are built on a foundation of research into learning (Brainard, 2007; Marder & Confrey, 2000; Ostlund, 2007). “The courses build prospective teachers’ understanding of how to guide classroom instruction and interactions, starting with individual lessons, and building to longer-length projects, culminating in student teaching” (Marder & Confrey, 2000, ¶ 11). By learning more classroom-based pedagogy, preservice teachers are taught not just how students learn, but how students learn mathematics and science, thus integrating pedagogy and science/mathematics courses (NSTA, 2008). How this focus on the manner in which students learn mathematics and science affects their perceptions of their own learning environments in their core/STEM courses at the university was one of the questions answered by this research.

Despite substantial investment from national foundations and rapid program replication across the country, there has been little research into the effectiveness of the UTeach program or the effectiveness of UTeach graduates (Backles, Goldhaber, Cade, Sullivan, & Dodson, 2016). Research on UTeach has primarily been conducted by UTeach-affiliated staff and their graduate students. Studies have focused on inservice and preservice teachers' knowledge and their use and perceptions of effectiveness of specific instructional approaches learned as part of the UTeach course curriculum (Confrey, Makar, & Kazak, 2004; Dickinson & Summers, 2010; Marshall & Young, 2006), as well as preservice teachers' development and use of mathematical and statistical discourse (Ares, Stroup, & Schademan, 2009; Makar & Confrey, 2005). Additional studies of UTeach involved a teacher observation protocol and used a statistical method for analyzing qualitative teacher and student data (Walkington & Marder, 2014; Stroup, Hills, & Carmona, 2011). Backles et al. (2016) showed that, relative to non-UTeach teachers in the state of Texas, teachers trained at the UTeach founding site in Austin and at replication sites were more effective as measured by their ability to raise student test scores in mathematics and science.

2.3 LEARNING ENVIRONMENTS

Because “establishing a positive learning environment is necessary for the implementation of an effective instructional program” (Cannon, 1995 as cited in Koh & Fraser, 2014, p. 159), evaluating the learning environment of the UTeach program or any instructional program is a desirable part of any program evaluation approach. This section reviews the field of learning environments, especially how assessing the learning environments can be used when evaluating educational settings and programs. Section 2.3.1 discusses the unique learning environment of preservice teachers. Section 2.3.2 reviews the history, development, and progression of many learning environment assessment instruments. Lastly, Section 2.3.3 highlights past research with learning environment instruments, especially applications that relate to this study.

2.3.1 Learning Environment and Teacher Education

A teacher preparation program that is attempting to improve and evolve should involve reflecting on and inquiring into its own practice as a way to evaluate its success (Harrington & Enochs, 2009). Teacher preparation programs are unique in that the students arrive with a great deal of perceived knowledge regarding how to teach and the best ways to teach based on their personal educational experiences as a student. This leads to strong preconceived notions about how to be an effective teacher or an effective learner, even though students might be early in their teacher educational development (Harrington & Enochs, 2009; adapted from Grossman, 1990; Lortie, 1975; National Council of Teachers of Mathematics [NCTM], 2000). “Any research on a teacher preparation program must acknowledge the difficult position that preservice teachers are in when they attempt to balance theory from their coursework with what they are seeing in the field”, how to combine the two, and how they can enhance each other (Harrington & Enochs, 2009, p. 63).

As Kramaski and Michalsky (2009) have shown in their research, teachers’ perceptions of teaching and learning provide a framework for their judgments about education practices. These perceptions determine how teachers make instructional decisions. A teacher’s perception can have a considerable impact on what he/she does in the classroom, affecting the way in which they conceptualize their instruction and how they learn from experience. Most novice teachers tend to have a perception of teaching/learning as being teacher-centered rather than student-centered. Preservice teachers must be shown, through direct lessons, observations, and their own learning and the learning of those around them, the importance of student-centered activities. Therefore, it is important to determine which learning conditions foster the best practices for preservice teachers’ knowledge base for their own teaching.

The classroom learning environment is the psychosocial atmosphere in which learning takes place. It is often referred to as the classroom climate or the educational environment (Johnson & McClure, 2004). Fraser (1994) regards these learning environments as the social-psychological contexts or determinants of learning. The classroom learning environment is a strong factor in determining and predicting students’ attitudes toward science (Lawrenz, 1976; Simpson & Oliver, 1990). Talton and Simpson (1987) argued that classroom learning environment is the strongest

predictor of attitude toward science at all grade levels. Taylor, Fraser and White (1994, p. 4) “found that the rationality of traditional teacher-centered classrooms is dominated by two cultural myths: (1) an *objectivist view* of the nature of scientific and mathematical knowledge; and (2) a complementary *technical controlling interest* that views the curriculum as a product to be delivered. If classroom learning environments are to feature negotiation and meaning-making, then teachers need to be empowered to deconstruct these repressive myths.” Therefore, teaching preservice teachers a constructivist method of teaching and learning, and illustrating that in the classrooms, is a good way to learn, placing new content in a personally relevant context.

“Field experiences that are in line with theories advocated in the university coursework are likely to feel more like laboratory experiences than some disjointed and unrelated to the ‘real world’ ” (McIntyre et al., 1996 as cited in Harrington & Enochs, 2009, p. 63). Field experiences such as these can help to develop preservice teachers’ instructional abilities and thus should be part of their program of study. The learning environments of the field experiences and the pedagogical courses set the stage for the environments of their future classroom.

2.3.2 Learning Environment Instruments Development and Applications

Learning environments research grew out of work that first began 80 years ago with Lewin (1936) and followed by Murray two years later (1938). Lewin’s work in social science established a ‘person–environment interaction paradigm’ in which $B = f(P, E)$, where B is the Human Behavior as a function of P , the Person, and E , the Environment. This could be reformulated to represent the classroom setting, in which learning (B) would be a function of the student (P) and the classroom atmosphere (E). Building on this work, Murray (1938) analyzed how an environment is observed and described by an external observer, such as a researcher or administrator; and how the environment is perceived from within the setting itself by students or teachers. This concept was expanded upon by Stern, Stein, and Bloom (1956) to include the individual’s perception of his or her environment. For example, in a classroom setting, an individual student can see the environment from his/her own personal perspective (private press), which could be different from how the individual sees the environment

from a group perspective (consensual press). This early historical research became the foundation for the more modern field of learning environments research.

Building on the foundation built by Lewin, Murray, Stern, Stein and Bloom, Walberg and Moos advanced the field of learning environments in the late 1960s in the USA. Walberg developed the Learning Environment Inventory (LEI) questionnaire as a part of the evaluation of Harvard Project Physics (Walberg & Anderson, 1968). The final version of the LEI contains 105 statements divided between seven 15-item scales descriptive of typical school classes. Shortly thereafter, Moos (1974) independently created psychosocial environment scales that were used in many settings, such as hospitals and prisons. Through his studies and research, Moos developed the Classroom Environment Scale (CES) (Moos, 1979; Moos & Trickett, 1974). The final version of the CES contains 90 True or False questions divided into nine 10-item scales.

The LEI was simplified for use in elementary classrooms with children aged 8–12 years to form the My Class Inventory (MCI) (Fisher & Fraser, 1981). In the MCI, the number of scales in the LEI is reduced to five scales for ease of use with children; also simpler wording and Yes–No responses were used. Goh and Fraser (1998) validated a modified version of the MCI with a three-choice response scale (Seldom, Sometimes and Most of the Time). Additionally, a Task Orientation scale was added in their study of 1512 primary students in mathematics classes in Singapore.

In Washington State, Sink and Spencer (2005) used the MCI with 2,835 upper-elementary students in an evaluation of school counselors' programs and practices. The MCI was used in Texas, where the use of science kits was evaluated with 588 grade 3–5 students. Scott Houston, Fraser, and Ledbetter (2008) reported higher Cohesiveness among students who used the science kits. Although originally developed for younger students, the MCI was also found to be very useful with below-level-reading students in a study involving 1,565 junior-high school students in Brunei Darussalam (Majeed, Fraser, & Aldridge, 2002).

These early American studies stimulated more research around the world, such as in Australia (Fraser, 1986) and The Netherlands (Wubbels & Levy, 1991, 1993), which led to the development of several learning environments questionnaires. In Australia,

development of the Individualized Classroom Environment Questionnaire (ICEQ) began as a response to individualized, open, and inquiry-based education that focuses on student-centered classrooms (Fraser, 1990; Fraser & Butts, 1982; Rentoul & Fraser, 1979). The ICEQ specifically assesses dimensions that differentiate an individualized classroom from a conventional classroom, in contrast to the LEI, CES, and MCI which focus on teacher-centered classrooms. The ICEQ contains 50 items in five scales of 10 items each. Each item is scored on a 5-point frequency response scale ranging from Almost Never to Very Often. Some of the items are negatively worded and scored in reverse.

In The Netherlands, the Questionnaire on Teacher Interaction was developed to assess the interpersonal relationships between teachers and students. It is built on different theoretical foundations from other learning environment instruments (Wubbels & Levy, 1993). This instrument is discussed further in Section 2.6.2.

Although the field of learning environments could provide valuable ideas and techniques for preservice teachers, this topic has had limited exposure in teacher education. Fraser (1993) reviewed some case studies of preservice and inservice teachers who incorporated classroom and school environment assessment in attempts to improve classrooms, for feedback on teacher performance, and to make teachers aware of subtle aspects of the classroom. Student perceptions were also found to be helpful when included along with information obtained from university supervisors, mentor teachers, and preservice student teacher evaluations (Duschl & Waxman, 1991). Pickett and Fraser (2009) evaluated a two-year mentoring program in science for beginning teachers of students in grades 3–5 in Florida, in terms of changes in learning environments in teachers' school classrooms. Seto (2014) evaluated a new teacher professional development strategy involving a networked learning community in Singapore in terms of the attitudes and learning environment perceptions of these teachers' 375 grade 5 students.

The advancement of the field of learning environments continued with Fraser's development of other specific-purpose classroom environment instruments in Australia and their cross-validation and application in many research studies around the world (Fraser, 2002). The field spread to Asian researchers who made significant contributions in Singapore (Chionh & Fraser, 2009; Fraser & Teh, 1994; Khoo &

Fraser, 2008; Koh & Fraser, 2014; Quek, Wong, & Fraser, 2005; Teh & Fraser, 1995; Wong & Fraser, 1996), Indonesia (Fraser, Aldridge, & Adolphe, 2010; Wahyudi & Treagust, 2004), Korea (Fraser & Lee, 2009; Kim, Fisher, & Fraser, 1999), Taiwan (Aldridge & Fraser, 2000; Aldridge, Fraser, & Huang, 1999). Further research studies have included such locations as South Africa (Aldridge, Fraser, & Sebela, 2004; Aldridge, Laugksch, Seopa & Fraser, 2006) and the United Arab Emirates (Afari et al., 2013; MacLeod & Fraser, 2010). Additionally the field progressed even more starting in the 1980s with the formation of the Learning Environments Special Interest Group within the American Educational Research Association (AERA), then continuing in 1998 with the birth of a journal specifically for the field and published by Kluwer/Springer (*Learning Environments Research: An International Journal*), and comprehensive reviews of learning environments research in the *International Handbook of Science Education* (Fraser, 1998b), *Second International Handbook of Science Education* (Fraser, 2012) and the *Handbook of Research on Science Education* (Fraser, 2014).

In the almost 40 years since the start of contemporary research on learning environments with the evaluation of Harvard Project Physics, many learning environment assessment instruments have evolved and have been used at multiple grade levels and in a multitude of countries around the globe. These questionnaires assess student perceptions of aspects of their classroom learning environments, such as: whether the class is teacher or student centered; whether students are actively involved or passively sitting and listening; whether students work alone or in cooperative groups; whether the teacher is supportive and approachable; whether students have a choice in lesson and assessment methods; and whether student differences are taken into account (Fraser, 2001).

The historically-important LEI, CES, MCI, and ICEQ instruments were discussed in Section 2.3.1. The subsections below review significant contemporary instruments that have been used and validated around the world, namely, the College and University Classroom Environment Inventory (CUCEI) in Section 2.3.2.1, Questionnaire on Teacher Interaction (QTI) in Section 2.3.2.2, Science Laboratory Environment Instrument (SLEI) in Section 2.3.2.3, What Is Happening In this Class? (WIHIC) in Section 2.3.2.4, and Constructivist Learning Environment Survey (CLES) in Section

2.3.2.5. Table 2.2 summarizes salient features of these important historical and contemporary learning environment instruments in chronological order.

Table 2.2 Summary Features of Historically-Important Contemporary Learning Environments Instruments

Survey Acronym	Survey Title	Level	Time Frame	Noteworthy Features
LEI	Learning Environment Inventory	Secondary	1968	Developed from research on Harvard Project Physics
CES	Classroom Environment Scale	Secondary	1979	Evolved from research in a variety of environments from psychiatric hospitals, prisons, university residences
MCI	My Classroom Inventory	Elementary	1982	Simplified/reduced version of LEI for use with 8–12-year-olds
CUCEI	College/University Classroom Environment Inventory	Higher Education	1986	First designed for higher education for small seminars with 5–30 students
ICEQ	Individualized Classroom Environment Questionnaire	Secondary	1990	First survey for student-centered classrooms; assesses open or individualized classroom settings
QTI	Questionnaire on Teacher Interaction	Secondary/ Primary	1993	Focuses on teacher–student interaction/ relationships
SLEI	Science Laboratory Environment Inventory	Upper Secondary/ Higher Education	1995	Focuses on science laboratory classroom environments
CLES	Constructivist Learning Environment Survey	Secondary	1991, revised 1997	Used to assess the degree in which a classroom is consistent with the constructivist model
WIHIC	What Is Happening In this Class?	Secondary	1996, revised 1998	Combines modified versions of most prominent scales from a wide range of questionnaires with equity and constructivism issues

Adapted from Fraser (1998a, pp. 9–13)

2.3.2.2 Questionnaire on Teacher Interaction (QTI)

The Questionnaire on Teacher Interaction (QTI) began in The Netherlands with research on the nature and quality of interpersonal relationships between teachers and students. The QTI has been found to be reliable and valid (Wubbels & Brekelmans, 1998, 2012; Wubbels & Levy, 1993) and has been used in numerous studies. The QTI

measures student perceptions based on a model of proximity (cooperation–opposition) and influence (dominance–submission). The questionnaire results are then plotted with each dimension as an axis. The coordinate plane is divided into eight equal sectors and given a label based on the relationship between the two dimensions. For example, OD and DO are the sectors between dominance and opposition. The eight scales of the QTI span the four quadrants.

The QTI was first used in The Netherlands at the senior high-school level. It was then successfully used in studies around the world where it was cross-validated and comparative work was undertaken at various grade levels in the USA (Wubbels & Levy, 1993), Australia (Fisher, Henderson, & Fraser, 1995), China (Wei, den Brok, Zhou, 2009) and Singapore (Goh & Fraser, 1996). Goh and Fraser used a more-economical 48-item version. Quek, Wong, and Fraser (2005) also used the 48-item version, validated the QTI among 497 secondary-school students, and reported differences between gifted and non-gifted students and between genders.

The QTI continued to be used in many countries as research on teacher–student interpersonal behavior spread. The QTI was cross-validated at various grade levels in Korea (Kim, Fisher, & Fraser, 2000; Lee, Fraser, & Fisher, 2003) and the United Arab Emirates (MacLeod & Fraser, 2010). In the small country of Brunei Darussalam, Khine and Fisher (2002) validated and used the English version of the QTI with 1,188 science students, whereas Scott and Fisher (2004) validated a version of the QTI in Standard Malay with 3,104 upper-primary students in 136 elementary-school classrooms. The latter study showed that achievement had a positive relationship with cooperative behaviors and a negative relationship with submissive behaviors (Scott & Fisher, 2004). The QTI was also validated in an Indonesian-language version with 422 university students in 12 classes at a private university in Indonesia by Fraser, Aldridge, and Soerjaningsih (2010). In addition to confirming the validity of the QTI, the researchers also investigated connections between the QTI and student outcomes such as achievement and attitudes.

Further studies involving the use of the QTI to assess teacher–student relationships have been reviewed recently (Wubbels & Brekelmans, 2012). Den Brok, Brekelmans and Wubbels (2006) studied teacher–student relationships and the impact of decisions using the QTI. It was found that multilevel analyses could provide more specific

feedback regarding the validity of the instrument. Brekelmans, Wubbels, and van Tartwijk (2005) used the QTI in a study of over 6000 teachers and students in more than 200 schools in The Netherlands. According to the results of these analyses, teachers' perceptions of proximity and influence were fairly stable throughout their careers, whereas students' and teachers' perceptions of teacher influence grew mainly during the first three years of their career. This showed that teachers learned classroom management strategies in the first years of their career. In another study, the stability of the development of social climate and teacher–students relationship during the first months of the school year was investigated. On average, the emotional distance in teacher–student relationship during the first lesson of the year persisted throughout the year. Only a few classrooms showed an increase in the perceived social climate at the end of the study relative to the first lesson (Mainhard, Brekelmans, den Brok, &Wubbels, 2011).

2.3.2.3 *Science Laboratory Environment Instrument (SLEI)*

The Science Laboratory Environment Inventory (SLEI) was developed to assess the unique learning environment in science laboratory classrooms at the senior high-school or higher-education levels (Fraser, Giddings, & McRobbie, 1995; Fraser & McRobbie, 1995; Fraser, McRobbie, & Giddings, 1993). The SLEI contains only 35 statements which measure five scales: Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environment. While the SLEI is designed specifically for use in laboratory classes, some scales used were adapted from several previous instruments used in non-laboratory settings. Fraser, Giddings, and McRobbie (1993) interviewed numerous teachers and students at both the high-school and university levels to identify the most salient scales.

Fraser and Tobin (1991) noted that previous classroom environment instruments only measure a student's perception of the class and not his or her place within that class. The SLEI was one of the first instruments that addressed the problem by having two versions, a Personal and a traditional Class form (Fraser, Giddings & McRobbie, 1993). For example, items in the Class form would involve “the work of the class is difficult” or whether “the teacher is friendly towards the class”. In the Personal form

for the same questions, the wording would involve whether “I find the work of the class difficult” or whether “the teacher is friendly towards me”.

The SLEI was field tested and originally validated simultaneously in six countries with a sample of 5447 students in 269 classes (the USA, Canada, England, Israel, Australia and Nigeria) and cross-validated with 1594 Australian students in 92 classes (Fraser & McRobbie, 1995) and 489 senior high school biology students in Australia (Fisher et al., 1995).

The SLEI was also used in several studies in Asia. In Singapore, a study cross-validated a chemistry-specific English version (CLEI) with 1592 Grade 10 chemistry students in 56 classes in 28 schools (Wong & Fraser, 1995; Wong, Young, & Fraser, 1997). Quek, Wong, and Fraser (2005) examined differences between academic streams (gifted vs. non-gifted) and genders in a study of 497 gifted and non-gifted students. In Korea, a Korean-language version of the SLEI was used to study differences between three streams (science-independent, science-oriented and humanities) with a sample of 439 high-school science students (Fraser & Lee, 2009). All of these studies supported the validity and reliability of the SLEI.

A modified version of the SLEI was used in a study among 761 high-school biology students in Miami, Florida, USA (Lightburn & Fraser, 2007). This study supported the positive influence of using anthropometric activities in terms of classroom learning environment and student attitudes. The study also supported the SLEI’s factorial validity, internal consistency reliability and ability to differentiate between classrooms.

2.3.2.4 *What Is Happening In this Class? (WIHIC) Survey*

The WIHIC combines significant scales from previously-existing questionnaires with additional scales, such as equity and constructivism (Dorman, 2008). The WIHIC evolved from a 90-item survey with nine scales to the final form with 54 questions distributed among seven scales (Fraser, McRobbie, & Fisher, 1996). The second version of the WIHIC was reduced to 80 items in eight scales for field testing in junior-high school classes with 1,081 students in 50 Australian science classes and 1,879 students in 50 Taiwanese science classes (Aldridge, Fraser, & Huang, 1999). After this

field testing, the final form of the WIHIC was established containing seven eight-item scales (Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation, and Equity). The cross-cultural factorial validity and internal consistency reliability of the WIHIC instrument has been established, together with the ability to differentiate significantly between classrooms in Australia-Taiwan, Australia-UK-Canada, and Australia-Indonesia (Aldridge & Fraser, 2000; Dorman, 2003; Fraser, Aldridge, & Adolphe, 2010)

The WIHIC is the most widely used learning environments questionnaire, and it has been used successfully in various settings and countries, such as the examples below. Dorman (2003) validated the WIHIC using a cross-national sample in Australia, the UK, and Canada of 3,980 high-school students. Results reinforced that the WIHIC is a valid measure of classroom psychosocial environment with international applicability. Dorman (2008) conducted another study, with a sample of 978 secondary-school students in Australia, which again supported the validity of the actual and preferred forms of the WIHIC.

Khoo and Fraser (2008) used a modified version of the WIHIC to evaluate adult computer application courses with 250 working adults attending five computer education centres in Singapore. The WIHIC was found to be valid and reliable with this new adult population. Overall students perceived their classroom environments positively, with similar patterns for students of different sexes and ages. Differences by gender appeared in these scales: “males perceived significantly more involvement, whereas females perceived more equity. Also, whereas males’ perceptions of trainer support were independent of age, older females had more positive perceptions than younger females” (Koh & Fraser, 2014, p. 160).

In New York, the WIHIC was cross-validated and used to evaluate the effectiveness of using inquiry-based laboratory activities with 1,434 middle-school science students in 71 classes. Analyses for a subsample of students showed that inquiry instruction promoted more student cohesiveness than non-inquiry instruction, and that inquiry-based instruction was differentially effective for male and female students (Wolf & Fraser, 2008).

The WIHIC was used as the basis of the Technology-Rich Outcomes-Focused Learning (TROFLEI) and the Constructivist-Oriented Learning Environment Survey (COLES) instruments. The TROFLEI was used by Aldridge and Fraser (2008) in Western Australia to evaluate a new senior-high school. The TROFLEI includes the seven scales from the WIHIC and three additional scales that focus on technology and outcomes in secondary school classrooms. The TROFLEI consists of 80 items in a side-by-side comparison format of actual versus preferred environment. It was validated when 1,918 students over four years were surveyed, with results supporting the efficacy of the school's new educational system that emphasized outcomes-focused teaching, rather than a set syllabus.

The COLES, which is designed to provide feedback during teacher action research (Aldridge, Fraser, Bell, & Dorman, 2012), includes six of the seven scales from the WIHIC (excluding Investigation), together with two scales that focus on technology and outcomes in secondary school classrooms and the Personal Relevance scale from the CLES (described in the next section). Additionally, two new scales were added that focus on assessment (Formative Assessment and Assessment Criteria) related to the assessment of student learning, which had not been addressed in any previously-existing learning environment instrument. Aldridge et al. (2012) sampled 2,043 grade 11 and 12 students from 147 classes in nine Western Australia schools. Both the actual and preferred versions of the COLES showed satisfactory factorial validity and internal consistency reliability, as well as being capable of differentiating between the perceptions of students in different classrooms. Of special note, the researchers applied the Rasch model to convert the data into interval data; the results from this analysis were virtually identical to those using raw scores.

2.3.2.5 *Constructivist Learning Environment Survey (CLES)*

Because the CLES was the instrument selected for this study, this review is more comprehensive than for previous instruments. "According to the constructivist view, meaningful learning is a cognitive process in which individuals make sense of the world in relation to the knowledge which they already have constructed, and this sense-making process involves active negotiation and consensus building" (Fraser, 1998a, p. 13). The Constructivist Learning Environment Survey (CLES) (Taylor, Dawson, &

Fraser, 1995; Taylor & Fraser, 1991) was developed in 1991 for researchers and teachers to monitor the degree in which a classroom is consistent with this constructivist model of teaching science. The original CLES had 36 items with five frequency response alternatives ranging from Almost Always to Almost Never. Typical items are “I help the teacher to decide what activities I do” (Shared Control) and “Other students ask me to explain my ideas” (Student Negotiation) (Fraser, 1998a). The CLES was revised in 1997 (Taylor, Fraser & Fisher, 1997) with several format and content changes to address problems identified in a series of studies. Format changes included reducing the number of negatively-worded questions, which many respondents found confusing, and changing the arrangement of the items for each scale from a repeating cycle pattern to a block pattern in which the questions are grouped by scale. Factorial validity and reliability were supported for a Western Australian sample of 494 13-year-old students in 41 science classes in 13 schools (Taylor, Fraser & Fisher, 1997).

The current version of the CLES consists of 30 items arranged in five blocks, with a frequency response scale [Almost Always, Often, Sometimes, Seldom, and Almost Never]. The five scales of the CLES are defined by Taylor, Dawson, and Fraser (1995) in the following way: 1) Personal Relevance– “... concerned with the connectedness of school science to students’ out-of-school experiences. We are interested in teachers making use of students’ everyday experiences as a meaningful context for the development of students’ scientific knowledge”; 2) Uncertainty of Science– “... has been designed to assess the extent to which opportunities are provided for students to experience scientific knowledge as arising from theory-dependent inquiry, involving human experience and values, evolving and non-foundational, and culturally and socially determined”; 3) Critical Voice– “... assesses the extent to which a social climate has been established in which students feel that it is legitimate and beneficial to question the teacher’s pedagogical plans and methods, and to express concerns about any impediments to their learning”; 4) Shared Control– “... concerned with students being invited to share control with the teacher of the learning environment, including the articulation of their own learning goals, the design and management of their learning activities, and determining and applying assessment criteria.”; and 5) Student Negotiation– “... assesses the extent to which opportunities exist for students to explain and justify to other students their newly developing ideas, to listen

attentively and reflect on the viability of other students’ ideas and, subsequently, to reflect self-critically on the viability of their own ideas.” Table 2.3 depicts, for each CLES scale, a short description and a sample item.

A study of science education reform efforts in Korea (Kim, Fisher, & Fraser, 1999) validated and used a Korean version of the CLES with 1,083 students in 24 tenth-grade science classes. The study revealed a relationship between classroom environment and students’ attitudes to science, and that students exposed to a new curriculum perceived a more constructivist learning environment than students who had not been exposed.

Table 2.3 Scale Name, Scale Description, and Sample Item for Each Scale of the Constructivist Learning Environment Survey (CLES)

Scale Name	Scale Description	Sample Item
Personal Relevance	Relevance of learning to students’ lives	I learn about the world outside of school.
Uncertainty of Science	Provisional status of scientific	I learn that science has changed over time.
Critical Voice	Legitimacy of expressing a critical opinion	It’s OK for me to ask the teacher “why do I have to learn this?”
Shared Control	Participation in planning, conducting, and assessing of learning	I help the teacher to plan what I’m going to learn.
Student Negotiation	Involvement with other students in assessing viability of new ideas	I ask other students to explain their thoughts.

Adapted from Nix, Fraser, & Ledbetter (2005)

Some early research with the CLES included: qualitative studies of the nature of science knowledge among science teachers and their respective students (Lucas & Roth, 1996; Roth & Bowen, 1995; Roth & Roychoudhury, 1993); a multilevel study that also incorporated classroom observations, student diaries, and teacher interviews (Tobin & Fraser, 1998); an evaluation of a large-scale initiative in an urban district designed to change high-school science instruction (Dryden & Fraser, 1998); a study of teacher effectiveness (McClure, Johnson, Jackson, & Hoff, 2000); and an Australian study of associations between mathematics classroom environments and student

academic efficacy (Dorman, 2001). Two additional early studies on preservice teachers with the CLES include investigations by Watters and Ginns (1994) of preservice science teachers' self-efficacy and science anxiety and by Waggett (2001) on the beliefs of secondary preservice teachers.

In South Africa, Aldridge, Fraser, and Sebela (2004) further validated the English version of the CLES with 1,864 grade 4–6 mathematics students in 43 classes. This study focused on improvement in teaching when the teachers became more reflective in their daily teaching over a 12-week intervention.

In Miami, USA, Peiro and Fraser (2009) studied a three-month intervention among early-childhood students in Florida. When they used a modified version of the CLES in Spanish and English with 739 grade K–3 science students, the study supported the validity of the CLES with young students in both English and Spanish. Also, positive associations were found between students' attitudes and the nature of the classroom environment during the intervention, which led to important changes in the classroom environment.

In Singapore, a modified version of the CLES was used to evaluate the effectiveness of the Mixed Mode Delivery (MMD) model (Koh & Fraser, 2014). Two groups of secondary-school business-studies students taught by preservice teachers were compared: 2,216 students in an MMD group and 991 students in a primarily teacher-centered control group. The MMD model showed a positive impact in terms of students' perceptions of their classroom environments for all CLES scales.

Fraser and Lee (2015) used a translated Korean version of the CLES in Korea along with a translated version of the Test of Science-Related Attitudes (TOSRA). Differences in attitudes and the constructivist orientation of the learning environments were found for a sample of 440 grade 10 and 11 students in three different streams (humanities, science-orientated, and science-independent). Each of the scales, except Critical Voice, was a significant independent predictor of two or three attitude scales. This Korean study supported the validity and reliability of the CLES.

The CLES has been modified a few times since the 1997 revised version. Some of these modified versions have been used with teachers and preservice teachers. When Johnson and McClure (2004) used a 30-item version of the CLES with 290 teachers

and preservice teachers from the upper-elementary, middle-school and high-school levels in Minnesota, USA, they reported strong factorial validity and reliability. Johnson and McClure (2004) also created a shortened 20-item version of the CLES known as the CLES2, which was field tested with a different sample of teachers within the same set of grade levels. This more-economical version of the CLES was also found to be valid and reliable.

In Texas, Nix, Fraser, and Ledbetter (2005) used a modified version of the CLES to study the effectiveness of a teacher education program. They created the CLES-Comparative Student version (CLES-CS), which is a slightly-modified version of the original 30-item CLES, with two response columns: one column to provide students' perceptions of 'THIS' classroom environment; and the other column focusing on 'OTHER' classroom learning environments (Nix, Fraser & Ledbetter, 2005). This version was used to answer the general question of whether changing teachers' learning environments might lead to a change in their respective students' learning environments. In this study involving 1079 students from 59 classes in Texas, the CLES was found to be valid and reliable. Figure 2.1 illustrates the two columns in the comparative form of the CLES, the CLES-CS.

I learn about the world outside of school									
In THIS class...					In OTHER classes...				
Almost	Often	Sometimes	Seldom	Almost	Almost	Often	Sometimes	Seldom	Almost
Always				Never	Always				Never

Adapted from Nix, Fraser, & Ledbetter (2005).

Figure 2.1. Sample Item Illustrating the Comparative Format of the Constructivist Learning Environment Survey (CLES-CS).

Nix and Fraser (2011) successfully used the shortened 20-item comparative version of the CLES, the CLES2-CS, in another study of 17 teachers and 845 middle-school students over three semesters. Nix and Fraser (2011) were able to demonstrate that changes in the teachers' university classroom environment translated into changes in their students' perception of the classroom environment, as well as to confirm the factorial validity and internal consistency of the CLES.

The data-collection instrument for my study was based on the CLES and it was used to evaluate the learning environments experienced by the UTeach preservice teachers. The CLES was chosen because of its widespread use with teachers, secondary students, and preservice teachers, as well as the fact that it had been modified to form the CLES2-CS. Explanation and elaboration of the modifications to the CLES2-CS are in Section 3.4.

2.3.3 Applications of Learning Environment Instruments

As the field of learning environments has matured over the last half a century and spread across the world, research has illustrated the importance of the student's perception of the classroom as a mediating factor in student learning (Stern et al., 1956). These applications have included relationships between student outcomes and learning environments, the evaluation of educational innovations, attempts by teachers to improve classroom environments, and teacher education and teacher assessment (Fisher & Khine, 2006; Fraser, 2014).

Because the most common line of past classroom environment research has involved associations between student outcomes and the nature of the learning environment, this type of research is reviewed briefly in Section 2.3.3.1 below. One of the aims of this research was to evaluate the UTeach teacher development program in terms of the preservice student teachers' perceptions of the learning environments in the multiple program settings. Therefore, Section 2.3.3.2 reviews in depth some of the past learning environment studies that involved the evaluation of educational programs.

2.3.3.1 Relationships between Classroom Environment and Student Outcomes

Much of the past classroom learning environments research has focused on students' cognitive and affective learning outcomes and their associations with perceptions of classroom environments. Fraser (1994) tabulated 40 past studies that show a relationship between perceived classroom environment and student outcomes has been replicated with various classroom environment instruments and an assortment of samples across a range of grade levels and countries. This research has replicated

associations between student outcomes and learning environment perceptions regardless of language, country, or grade level (Fraser, 2012).

An early study by Walberg and Anderson (1968) showed strong relationships between learning environment scales and outcome measures, beginning a long tradition in science education research. Walberg and Anderson (1968) used a preliminary version of the LEI, namely, the Classroom Climate Questionnaire, to survey 76 classes. The number of significant correlations between learning environment dimensions and outcome dimensions was four times that expected by chance. Multiple regression analysis revealed a significant multivariate influence of the Classroom Climate Questionnaire scales on achievement.

This relationship between student outcomes and learning environments continued as a focus in more recent studies. In the United States, a study in Florida using the WIHIC revealed an association between learning environment scales and students' outcomes among Grade 4 and 5 students (Allen & Fraser, 2007). In New York, Cohn and Fraser (2016) showed that the learning environment was positively and significantly associated with students' attitudes and achievement for 1,097 grade 7 and 8 students in 47 classes.

The CLES, SLEI, and WIHIC were used together to investigate associations between the classroom environment and student outcomes when students were participating in activities that integrated science process skills and the use of information technology (Lightburn & Fraser, 2007). Chionh and Fraser (2009) used the WIHIC to investigate associations for geography and mathematics classrooms involving 2,310 grade 10 students in Singapore. Ogbuehi and Fraser (2007) used WIHIC and CLES scales among 661 middle-school students to investigate relationships with mathematics outcomes. Fraser, Aldridge, and Soerjaningsih (2010) used the QTI to investigate associations between instructor–student interactions and outcomes among 422 Indonesian computer and management university students. Additionally, studies such as those previously discussed, by Peiro and Fraser (2009) with the CLES among 739 early-elementary Florida students and by Quek et al. (2005) with the QTI among 497 gifted and non-gifted Singapore students, illustrate this consistent relationship between student outcomes and the nature of the classroom learning environment.

2.3.3.2 *Evaluation of Educational Innovations and Programs*

A strong tradition in the field of learning environments is using instruments to evaluate educational innovations, which dates back to Walberg's (1968) evaluation of Harvard Project Physics. Students' perceptions of their learning environment can shed light on the reality of the classroom. Innovations in education can be simple changes made by teachers, such as new classroom activities, or an extended professional development program. These innovations can be evaluated using classroom environment instruments such as the CLES or WIHIC. For example, Spinner and Fraser (2005) used the CLES, the Individualized Classroom Environment Questionnaire (ICEQ) and a mathematics version of the Test of Science-Related Attitudes (TOMRA) to study the classroom environment when students followed a constructivist approach with an interactive elementary mathematics program. Students in the program perceived more favorable changes in attitudes to mathematics, mathematics concept development, and perceived classroom environments on several CLES scales (Personal Relevance and Shared Control) and ICEQ scales (Participation and Differentiation).

Lightburn and Fraser (2007) used the SLEI to show that new lesson activities involving anthropometric activities with 761 high-school biology students had a positive effect in term of SLEI and attitude scales. Wolf and Fraser (2008) used the WIHIC to show that inquiry-based instruction promoted higher Student Cohesiveness among 1,434 middle-school students in 71 classes. The study also revealed that the inquiry-based lessons were differentially effective based on gender.

The introduction of games into a college-level mathematics course was studied by Afari, Aldridge, Fraser, and Khine (2013) in the United Arab Emirates (UAE) to see if it was effective in improving students' attitudes towards mathematics and their perceptions of the learning environment. Students who had been involved in the games had significantly higher posttest Teacher Support and Involvement scores than prior to the games' introduction.

Learning environments criteria were used in recent evaluation studies in the US. Long and Fraser (2015) evaluated the effectiveness of two distinct middle-school science curriculums, a general-science model and a topic-specific model, with 367 grade 8

students from two states. Science was enjoyed more by students following the topic-specific sequence. The two models were equally effective for Caucasian students in terms of Task Orientation, but the general curriculum model was more effective for Hispanic students. Cohn and Fraser (2013, 2016) evaluated using Student Response Systems in classroom teaching by showing that users of the system had significantly higher learning environment, attitude, and achievement scores. When Oser and Fraser (2015) investigated the effectiveness of using virtual laboratories in genetics with 322 grade 8–10 students, they reported no significant difference between instructional groups in terms of the learning environment and student outcomes.

Learning environment criteria have been used in teacher education in evaluating innovations in professional development, mentoring, preservice teacher training, and certification. Nix, Fraser and Ledbetter's (2005) research, which was discussed previously in Section 2.3.2.5, used a modified version of the CLES to show that teachers who participated in an extended, three-semester professional development program had created classrooms where students perceived an appreciably higher level of Personal Relevance and Uncertainty of Science compared with the students' other classes. A follow-up study, involving 17 teachers and 845 students over the three-semester period, revealed that using that innovative model in a science teacher education program cultivated a more positive learning environment in middle-school science classrooms (Nix & Fraser, 2011).

Martin-Dunlop and Fraser (2008) used learning environment scales from the SLEI and WIHIC to evaluate the effectiveness of an innovative science course for preservice elementary teachers in California. For a sample of 525 female preservice teachers in 27 classes, there were very large differences between the new course and previous courses for all learning environment scales. Effect sizes ranged from 1.51 standard deviations for Student Cohesiveness to 6.74 standard deviations for Open-endedness.

A two-year mentoring program for beginning elementary teachers was evaluated using a version of the WIHIC that had been modified for use by elementary students (Pickett & Fraser, 2009). The 573 students of the seven teachers who participated in the mentoring program responded to the WIHIC as pretests and posttests. MANOVA and effect sizes showed that the program was effective in promoting improvements in students' perceptions of classroom environments, attitudes, and achievement.

The WIHIC and TOSRA were used in South Florida, USA in evaluating the effectiveness of the National Board Certification (NBC) for teachers (Helding & Fraser, 2013). The perceptions and attitudes of 442 8th and 10th-grade students in 21 classes taught by National Board Certified teachers were compared with those of 484 students in 17 classes taught by non-National Board Certified teachers. Classrooms taught by National Board Certified teachers had significantly higher scores for five WIHIC scales (Teacher Support, Involvement, Task Orientation, Investigation, and Cooperation) and student attitudes. The effect sizes ranged from small to modest (from 0.07 for Student Cohesiveness to 0.35 standard deviations for Attitudes).

Other studies that used learning environment questionnaires as a source of criteria in evaluating educational innovations focused on computer-assisted learning (Maor & Fraser, 1996; Teh & Fraser, 1994), computer courses for adults (Khoo & Fraser, 2008), science instruction with science kits (Scott Houston, Fraser, & Ledbetter, 2008), and instruction with mathematics and children's literature (Mink & Fraser, 2005).

As mentioned earlier, a modified version of the CLES was used to evaluate the effectiveness of the Mixed Mode Delivery (MMD) model taught by preservice teachers to business study students in Singapore (Koh & Fraser, 2014). When two groups of secondary-school business-studies students taught by preservice teachers were compared, the MMD model showed a positive impact in terms of students' perceptions of their classroom environments for all CLES scales relative to a teacher-centered control group.

The above studies illustrate the variety of educational innovations and programs, ranging from classroom activities, to teacher training and certification programs, to alternative courses, have been evaluated through the use of learning environment questionnaires. Past applications of learning environment questionnaires in evaluating teacher education, development, and certification programs are directly related to my evaluation of the UTeach teacher development program.

2.4 SUMMARY OF LITERATURE REVIEW

This chapter comprehensively reviewed literature related to teacher development programs, the development of the UTeach program, the unique position of preservice teachers, and the field of learning environments, including its history, questionnaires, and research applications.

Section 2.2 discussed various aspects of teacher education programs in the United States, including: traditional teacher education programs and why a change was desirable (2.2.1); the importance of secondary teachers being knowledgeable (2.2.2); and constructivist learning environments for preservice teachers and the need for a program like UTeach (2.2.3). Consideration was given to the development of UTeach and what distinguishes it from the traditional teacher preparation programs (2.2.4), including the role of classroom teachers as ‘master teachers’, the importance of recruiting of students with science and mathematics majors, and the importance of early field experiences. Attention was focused on preservice teachers’ unique role in evaluating learning environments in their university classes, their pedagogy classes, and as novice teachers during their field experiences (2.2.5).

Section 2.3 reviewed the field of learning environments and its relevance to this study. A brief history of research in the field of learning environments was described in Section 2.3.1, beginning with the early work of Murray and Lewin in the 1930s and progressing to the pioneering educational work by Walberg and Moos, who sparked the growth of learning environments research by multiple researchers around the world. A variety of educational learning environment assessment instruments have been used over the 40 years of modern learning environments research. A review of historically-important instruments (LEI, CES, MCI, and ICEQ) in Section 2.3.1 was followed in Section 2.3.2 by the significant contemporary instruments (CUCEI, QTI, SLEI, CLES, and WIHIC) that have been used extensively and validated in multiple countries. The adaptation and modification of these instruments to suit specific research purposes and contexts was also described, with new versions also being validated for new designs or study groups. This is especially important because the version of the CLES used in my study has been modified multiple times from its original design and cross-validated.

Past learning environments research was reviewed in Section 2.3.3. Studies of the relationship between student outcomes and classroom learning environments were reviewed in Section 2.3.3.1. The use of learning environment instruments to evaluate a variety of educational innovations and programs, from new classroom activities to extended professional development programs, was reviewed in Section 2.3.3.2. This application is particularly important because my study evaluated the UTeach program using learning environment criteria.

This literature review allows a thorough understanding of the background and context of my study. Chapter 3 presents the research methodology, including sample selection, the assessment instrument used, and the data-analysis methods chosen in this study. Chapter 4 reports the results of analyses of the data to answer my research objectives regarding questionnaire validation and an evaluation of the UTeach program.

CHAPTER 3

RESEARCH METHODS

3.1 INTRODUCTION

The main purpose of this study was to investigate the effectiveness of the UTeach program in terms of the learning environment perceptions of preservice teachers. The previous chapters provided insight into the theoretical basis for this study. Chapter 1 considered the background, context, and rationale of the study while Chapter 2 reviewed the literature regarding preservice teachers, the UTeach program, and the field of classroom learning environments research.

This chapter discusses the research methods used in this study by recapitulating the research objectives (Section 3.2), providing details of the sample of students involved together with some limitations of the sampling (Section 3.3), describing the survey instrument that was used in this study to assess students perceptions of their multiple learning environments (Section 3.4), and outlining the methods of data analysis used in answering the research objectives (Section 3.5). Finally, Section 3.6 summarizes these research methods.

3.2 RESEARCH OBJECTIVES

In this investigation, I evaluated the effectiveness of UTeach through preservice teachers' perceptions of their learning environments in three different settings: (1) their pedagogical content courses; (2) their STEM science and/or mathematics major (core) courses; and (3) the classes that they observed during assigned practice teaching within public school primary and secondary science and/or mathematics classes (FIELD). This study's specific aims were:

1. To validate a modified version of the Constructivist Learning Environment Survey (CLES) with preservice teachers.

2. To evaluate UTeach by comparing the learning environments perceptions of preservice teachers' in the following three settings:
 - a. UTeach pedagogical content courses
 - b. STEM [science and/or mathematics] major (core) university courses
 - c. Science and mathematics classes that they teach/observe during assigned practice teaching within the K–12 public school system (FIELD).

The following sections describe the research methods used to answer these research objectives including site selection, the survey instrument, and data analyses.

3.3 SAMPLE AND SELECTED SITES

The university site chosen was one of the first replication sites in the UTeach expansion program (The UTeach Institute, 2013a). It is located in a metropolitan area in North Central Texas and, during this study's time frame, had an average of 11, 980 undergraduate students, of whom 44% were female and 56% were male. When the undergraduates were divided by year classification, 17% were freshmen/first year, 15% were sophomores/second year, 32% were juniors/third year, and 36% were seniors/final year. Within this total undergraduate population, 5,325 students or 44% of the undergraduates were STEM majors; and 2,309 students or 43% of these students majored in Computer Science or Engineering. Of the remaining STEM majors, 1,589 students were in the traditional sciences (biology, chemistry, or physics), 1,269 students were undertaking other STEM degrees, such as earth science or brain science, and only 158 students or 3% of the students were considered mathematics majors. Although this university is smaller than the original UTeach campus, the numbers of students participating in the UTeach program are approximately the same as at other replication sites, as is the breakdown by gender, year classification, and ethnicity breakdown (UTeach Institute, 2013a, 2014).

FIELD experiences took place in K–12 public schools that are geographically near the university. The FIELD experience schools ranged from upper-elementary science classrooms to single-subject (mathematics or science) secondary-school classrooms. Mentor teachers are chosen from a pool of cooperating teachers who work with the UTeach program preservice teachers each semester based on the schedules of the UTeach students and the cooperating teachers. Although many of the mentor teachers willingly volunteer each semester, new mentors are continually solicited.

The UTeach program recruits STEM majors on campus who choose to try teaching as a possible career choice by enrolling in Step 1, the first class in the UTeach program. Those who choose to continue move on to Step 2 and then on to the remaining higher-level courses. Very few Computer Science or Engineering students are enrolled in the UTeach program because of the heavy elective requirements of these two programs. The research sample included prospective UTeach science and mathematics teachers who were monitored during their university program in terms of their perceptions of their multiple learning environments.

UTeach students completed the survey instrument at the end of each semester for four consecutive semesters as the students progressed through the UTeach preservice teacher training program. This meant that some students only completed the survey one, two, or three times, whereas others completed it every semester depending on where they were in the program for the four-semester timeframe. This enabled a cross-curricular view and insight into overall trends by course. Students were surveyed in all the eight UTeach required courses (nine for mathematics majors) ranging from those in the beginning of the program to courses at the end of the program (refer back to Table 2.1 for the UTeach course sequence). These courses include (1) the two trial teaching/recruitment courses (Step 1 and Step 2), (2) three education courses (Knowing and Learning, Classroom Interactions, and Project-Based Instruction), and (3) two to three Specialized STEM content area courses (Research Methods, Perspectives on Science and Mathematics, and Functions and Modelling for mathematics majors only). Apprentice Teaching/Apprentice Teaching Seminar is the UTeach version of traditional student teaching classes. During Apprentice Teaching, students observe their mentor teacher's classes for 40 hours, slowly taking on the responsibility of teaching multiple classes for four hours a day while working closely with and continuing to observe their classes (UTeach Institute, 2015c).

Students were surveyed in person by the researcher or a substitute because some class times overlapped. Informed consent was secured from the students before the surveys were administered to any participant. There was limited resistance by students to participate in the survey.

Although the study included samples of students from each level of the UTeach program, time limitations prevented the tracking of students from their initial UTeach course through to their last course; the program is designed to be taken throughout their entire undergraduate career (refer to Appendix B for the possible course sequence based on undergraduate entry point). The first two courses, Step 1 and Step 2, are considered trial teaching courses, and students are not considered to be fully a part of the teacher certification program until their third field course in the program, namely, Classroom Interactions. If the students discover in these trial courses that teaching is not the right fit for them, they no longer continue with the program. Because of this, there was a decrease in the number of students after the first course. This, in turn, decreased the number of students surveyed in each semester and, in turn, the number of students who were tracked throughout the program.

During the research timeframe, UTeach at this site averaged 329 students considered enrolled in the program. This included students who had taken any UTeach courses within the current or two prior semesters. After four semesters of surveying, a total of 702 surveys were collected; 142 the first semester, 170 the second semester, 191 the third semester, and 199 the fourth and final semester. Of these 702 collected surveys, 66% of the participants were female and 34% were male. The 702 surveys were divided into the following undergraduate classifications: 28% freshmen/first year, 15% sophomores/second year, 28% juniors/third year, 24% seniors/final year, and 5% post-baccalaureates (including students who graduated while in the program and stayed to finish their certification); see Figure 3.1. In the UTeach program, students seek certification in one of the sciences or in mathematics. For the sample collected, 61% were science preservice teachers and 39% were mathematics preservice teachers; Figure 3.2 illustrates these proportions.

■ Yr 1 ■ Yr 2 ■ Yr 3 ■ Yr 4 ■ Postbac

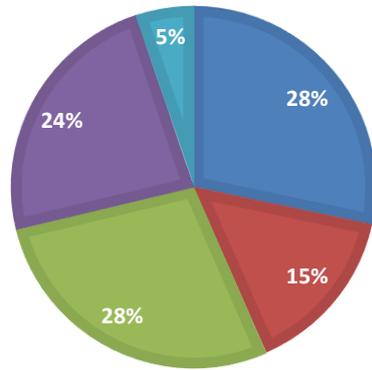


Figure 3.1 UTeach Preservice Students by Undergraduate Year Classification

■ Science ■ Math

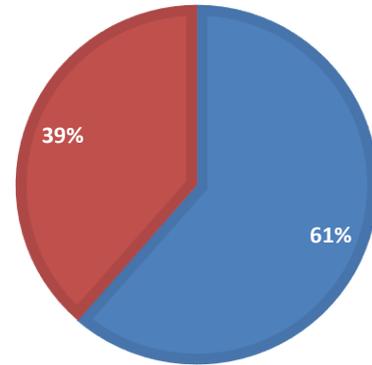


Figure 3.2 Proportion of Science and Mathematics UTeach Preservice Students

The research sample involved 702 students in both UTeach and STEM courses but, because not all UTeach courses have a field component, the number of students in FIELD classes totalled 575. These were broken down into the following totals by FIELD course: Step 1 = 234, Step 2 = 143, CI = 100, PBI = 59, and AT = 37. Therefore, all major data analyses for comparing the three learning environments were based on this sample of 575 students. Questionnaire validation was based on 702 students for UTeach and STEM data and on 575 students for FIELD data. Surveys from each semester were combined and aggregated to identify overall course trends as students progressed through the program. Because students were surveyed for four semesters of the eight-semester program, some individuals could have completed the surveys during as many as four different data-collection occurrences. Multiple input from individuals allowed trends to be traced over time.

The UTeach program is designed so that students take one course a semester, although many students double up in a single semester. Of these eight courses, only five have FIELD components: Step 1, Step 2, Classroom Interactions (CI), and Project-Based Learning (PBI) and Apprentice Teaching (AT). To be able to observe the changes over time across the UTeach program, only students who were surveyed in all four semesters were included in these data comparisons, thus reducing the number of students. For these calculations, the numbers of students were as follows: Step 1 = 27, Step 2 = 44, CI = 38, PBI = 20, and AT = 2. While these sample sizes are much smaller

and suggest a limitation of my study, they indicate a preliminary trend which could be used to drive further research based on the total numbers number of students in the higher-level courses of the UTeach program during this time frame.

3.4 LEARNING ENVIRONMENT INSTRUMENT

A multitude of instruments have been validated to investigate, assess, and evaluate students' classroom learning environment perceptions. Students in this study were surveyed in the UTeach program courses using a modified version of the Constructivist Learning Environment Survey (CLES) initially developed by Taylor and Fraser (1991). The CLES was designed "to enable researchers, teachers and teacher-researchers to monitor constructivist teaching approaches and to address constraints to the development of constructivist classroom climates" (Taylor, Fraser & Fisher, 1997, p. 293). The CLES has a focus on students as co-constructors of their own knowledge (Taylor, Dawson, & Fraser, 1995).

Chapter 2, Section 2.3.2.5 discussed the CLES and its validation in past studies in a variety of languages, and geographical locations around the globe. The actual and preferred forms of the CLES have been validated and found reliable across the world for a variety of school subjects and with samples, such as 494 13-year-old students in 41 science classes in 13 schools in Australia (Taylor, Fraser, & Fisher, 1997), 3,207 secondary-school business studies students in Singapore (Koh & Fraser, 2014), 1,083 Korean science students in 24 classes in 12 schools (Kim, Fisher, & Fraser, 1999), 1,081 students in 50 Australian classes and 1,879 students in 50 Taiwanese classes (Aldridge, Fraser, Taylor, & Chen, 2000), 1,864 4–6 grade mathematics students in 43 classes in South Africa (Aldridge, Fraser, & Sebela, 2004), 290 inservice and preservice science teachers in Minnesota (Johnson & McClure, 2004), and 1,079 science teachers in one study and 7 science teachers and 845 middle-school students in another study in Texas (Nix & Fraser, 2011; Nix, Fraser, & Ledbetter, 2005).

The established validity and usefulness of the CLES with teachers and a variety of students were important when selecting a learning instrument questionnaire to answer the research objectives of this study. In addition, the UTeach model of instruction and

FIELD work has a heavy emphasis on inquiry and the constructivist learning models, as discussed in Chapter 2 (Cavanagh, 2007).

Johnson and McClure (2004) developed and validated a shorter 20-question version of the CLES, namely, the CLES2. It was then adapted to form the comparative version of the CLES (CLES2-CS), in which statements are placed between two response columns headed THIS and OTHER. This comparative student “version of the CLES ... asks the student [preservice teacher responders] to provide perceptions not only of ‘THIS’ classroom environment (the student’s current class), but also of ‘OTHER’ classroom learning environments (other classes at the same school)” (Nix, Fraser, & Ledbetter, 2005, p. 116). Responses are on a frequency scale of 5=Almost Always, 4=Often, 3=Sometimes, 2=Seldom, and 1=Almost Never.

The CLES2-CS was revised in this current study to permit students to provide on one form their perceptions of each of the three learning environments to which they are exposed: UTeach preservice courses, university STEM courses, and their FIELD K–12 public school environment. These two versions were combined and slightly altered in these ways: THIS classroom and OTHER classroom were changed to UTeach classes and STEM classes, respectively; and a third column was added for FIELD classes. In addition, changes were made to questions to refer to ‘STEM,’ not just to ‘science’. An open-ended response section was added to the end of the CLES2-CS3 in order to gather brief responses regarding students’ ideas about their learning environments, UTeach vs STEM vs FIELD classes. Students were asked on the UTeach/STEM side-by-side comparison page to provide “**Comments about the learning environments in UTeach classes or your STEM classes**” and, on the FIELD page, students in a FIELD course were asked to provide “**Comments about the learning environments in your UTeach field course**”. Refer to Appendix C for the complete CLES2-CS3 survey. This newly-modified version was validated as part of this study and the results are in Chapter 4.

My decision to include some open-ended questions in my research was partly inspired by the way in which open-ended questions were used to explore students’ perceptions of learning environments in Hong Kong (Wong, 1993, 1996). In that study with ninth-grade mathematics students, it was found that many students identified the teacher as the most crucial element in a positive learning environment. Also in Hong Kong,

Cheung (1993) used multilevel approaches to determine the effects of learning environments on student learning to provide some insights regarding why Hong Kong was ranked so highly for physics, chemistry and biology in the International Association for the Evaluation of Educational Achievement - Second International Science Study (Cheung, 1993; IEA, 2011). Open-ended questions were also utilized in my study to further explore preservice teachers' perceptions of their multiple learning environments.

These UTeach preservice teachers are training to teach secondary-level science and mathematics. Furthermore, as Nix, Fraser, and Ledbetter (2005, p. 110) state "the five scales of the CLES directly support the goals of educational reform in science described in the Adolescence and Young Adulthood/ Science Standards...which states the primary goals for educational reform in the USA" (National Board for Professional Teaching Standards, 2001). Table 3.1 illustrates the consistency between the scales of the Constructivist Learning Environment Survey (CLES) with these Science Learning Environment Standards for educational reform in the United States. The CLES is discussed in depth in Section 2.3.2.5.

3.5 DATA-ANALYSIS METHODS

"Data Analysis is an attempt by the researcher to summarize collected data in a dependable and accurate manner...giving it an air of undeniability" (Gay, Mills & Airasian, 2006, p 467). This learning environments study involved both forced-choice and open-ended questionnaire components in answering my research objectives regarding preservice teachers' perceptions of different program settings. In Section 3.5.1, methods of analysis for the validity of the CLES2-CS3 survey are described. Section 3.5.2 describes the methods of analysis of the forced-choice questionnaire responses for comparing preservice teachers' perceptions of the three different learning environments. In Section 3.5.3, methods of analysing trends in questionnaire responses across the progression of the UTeach program are described. The approach to analysing the open-ended or qualitative portion of the questionnaire is described in Section 3.5.4.

Table 3.1 Consistency between Constructivist Learning Environment Survey (CLES) Scales and the Science Learning Environment Standards

CLES Scale	Science Learning Environment Standard Statement
Personal Relevance	“Teachers help students learn about and internalize the values inherent in the practice of science by relying on those values to shape the ethos of the learning community.”
Uncertainty of Science	“. . . they (the teachers) work diligently to establish a congenial and supportive learning environment where students feel safe to risk full participation, where unconventional theories are welcomed, and where students know that their conjectures and half- formed ideas will not be subject to ridicule.”
Critical Voice	“. . . teachers recognize that the emotional response of some students to a lively, argumentative, inquiry-based classroom might be never to venture an opinion or idea, thereby avoiding the risk of public failure.”
Shared Control	“Accomplished science teachers deliberately foster settings in which students play active roles as science investigators in a mutually supportive learning community.”
Student Negotiation	“They (the teachers) foster a sense of community by encouraging student interactions that show concern for others, by dealing constructively with socially inappropriate behavior, and by appreciating and using humor.”

Quoted from ‘Standard V: Learning Environments’ (National Board for Professional Teaching Standards, 2001, p. 25), Adapted from Nix, Fraser, & Ledbetter (2005, p. 111).

3.5.1 Methods of Analysis for Validity of CLES

This research used a modified version of the CLES2-CS with preservice teachers. To answer Research Objective 1, the validity of the CLES2-CS3 was checked using principal axis factor analysis with varimax rotation and Kaiser normalization to test the structure. “Factor analysis is a way to take a large number of variables and group them into a smaller number of clusters called factors” (Gay, Mills & Airasian, 2006, pp. 203-204). Separate factor analyses were calculated for UTeach responses ($N = 702$), STEM responses ($N = 702$) and FIELD responses ($N = 575$). Varimax rotation with Kaiser normalization is a statistical technique used to identify probable factors by maximizing the variance and then isolating the factors for identification; thus, it yields information about the internal structure of an instrument. Factor loadings for individual items, which are the correlation coefficients between the variables (items) and factors, were computed to determine whether the majority of items measured one and only one of the scales (Hanke, 2014). The criteria for retention of any item was that it must have

a factor loading of at least 0.40 with its own scale and less than 0.40 with each of the other four CLES scales. Refer to Appendix D for a complete listing of the CLES questions in each scale.

Internal consistency reliability is a measure of how well each item in a particular scale measures the same conceptual idea as the other items in the same scale. Cronbach's alpha coefficient was used to test for internal consistency reliability of each CLES scale. Alpha reliabilities greater than 0.9 are considered excellent, reliabilities greater than 0.8 are considered good, and reliabilities above 0.7 are considered acceptable (George & Mallery, 2003). The validity and reliability results are reported in Section 4.2.

3.5.2 Methods of Analysis for Comparison of the Three Learning Environments

One approach to answering Research Objective 2 involved analyzing 575 responses to the CLES2-CS3 survey's forced-choice responses in order to compare the three learning settings, namely, UTeach, STEM, and FIELD. In order to reduce the Type I error rate associated with initially conducting a separate significance test for each of the five CLES scales, a single One-way Multivariate Analysis of Variance (MANOVA) with repeated measures was conducted for the set of five CLES scales as the dependent variables. The independent variable was the 3-level instructional variable (UTeach, STEM, and FIELD classes). If the MANOVA yielded statistical significance results for the set of CLES scales using Wilks' lambda criterion, the univariate ANOVA would be interpreted for each individual CLES scale.

“Analysis of variance [ANOVA] is a way to statistically compare the ‘variance’ within groups to that between groups. In doing so, it enables a researcher to determine whether there are meaningful differences between groups on a variable of interest” (Tuckman & Harper, 2012, p. 302). Whereas a *t*-test allows only a comparison of two groups, an ANOVA allows for more than two at a time. For comparing three instructional groups, it was necessary to conduct post hoc significance tests for differences between each of the three pairs of instructional treatments (UTeach vs FIELD, FIELD vs STEM, UTeach vs STEM) for each CLES scale. This involved paired *t*-tests.

In order to estimate the magnitude of between-group differences, in addition to their statistical significance, effect sizes were calculated using Cohen's *d*. "This can be used when comparing two means, as when you might do a t-test, and is simply the difference in the two groups' means divided by the average of their standard deviations" (Walker, 2008, Effect Sizes, ¶ 4). These calculations comparing the learning environment of different settings are reported in Section 4.3.1.

3.5.3 Methods of Analysis for Changes over Time in Learning Environments

To examine the changes over time in preservice learning environments perceptions in the three settings (UTeach, STEM, and FIELD) as the students progressed through the program, additional analyses were performed to further answer Research Objective 2. Students were tracked to find those who participated for the greatest length of time within the study period. To be able to observe changes over time across the UTeach program, only students who were surveyed in every semester of the four-semester study period were included in these data comparisons.

These selected student data were divided by course sequence and CLES2-CS3 scale (see Figure 2.1 and/or Appendix B for UTeach course sequence and Appendix D for CLES scales). Only the UTeach courses with FIELD components [Step 1, Step 2, Classroom Interactions (CI), and Project-Based Instruction (PBI)] were included in these analyses. For trend comparison purposes in this study, the average means of the CLES2-CS3 scales were used. These results are illustrated and discussed in Section 4.3.2.

3.5.4 Methods of Analysis of the Open-Ended Questions

The CLES2-CS3 survey included an open-ended comment section for gathering further information about the three learning environments, UTeach classes, university STEM course, and the K–12 public school classes in which participants were observing and teaching (FIELD). Items for the UTeach/STEM side-by-side comparison conclude with provision for "**Comments about the learning environments in UTeach classes or your STEM classes**" and items for FIELD

classes conclude with “**Comments about the learning environments in your UTeach field course**”.

The survey comments were transcribed onto a spreadsheet separately for each course for each of the four semesters. Comments were then compared to investigate differences between the settings and perceptions of the preservice teachers; this further answered Research Objective 2. Comments were examined for patterns (e.g. prevalence of positive and negative words) across classes, courses, and the UTeach program. Comments that did not properly address the question, such as “This was fun,” were discarded. Comment pattern groups were identified, data were divided into these groups, and then further examined to determine consistency with quantitative results was undertaken. The analyses of these comments are addressed in Section 4.3.3.

3.6 SUMMARY OF RESEARCH METHODS

This chapter provided a description of the research methods used in conducting my study. It included the details of the study sample and site, a description of the survey instrument used, and explanations of procedures and data analysis methods used for assessing the effectiveness of the UTeach program by comparing the learning environments of the three settings, UTeach classes, STEM university classes, and FIELD classes.

In Section 3.2, the research objectives were reiterated: (1) to validate a modified version of the CLES-CS2 with preservice teachers; and (2) to evaluate the UTeach program in terms of preservice teachers’ perceptions of their learning environments in three different settings: their UTeach pedagogical content courses; their STEM core university courses; and the FIELD classes that they observe during assigned practice teaching within the public schools.

Section 3.3 provided details of the sample of students involved as well as some limitations of the sampling. The university setting, the FIELD setting, and details about students, including gender, university year levels, and content majors, were described to provide a background for the sample population. The sample consisted of 702 total UTeach student surveys across four semesters of the eight-course program, 575 of

which included all three learning environments. All 702 surveys were used when validating the questionnaire for the UTeach and STEM responses to answer Research Objective 1. For the validation of the FIELD sample, and for Research Objective 2 involving comparisons across all three settings, the 575 surveys that included the FIELD portion were used. For the changes over time, only students who were in FIELD courses for each semester of the four-semester study were included, thus reducing the numbers of surveys. The total number by UTeach course were as follows: Step 1 = 27, Step 2 = 44, Classroom Interactions = 38, and Project-Based Instruction = 20. This smaller subsample is a known limitation of the research, but it was still useful for preliminary research into the patterns.

Section 3.4 described the learning environment instrument used in this study to assess student perceptions of their multiple learning environments. The CLES2-CS3 survey was used based on the well-established CLES survey that was developed, validated, shortened, and modified for side-by-side comparisons on a page (Johnson & McClure, 2004; Nix, Fraser, & Ledbetter, 2005; Taylor & Fraser, 1991). This survey was also modified for 'STEM' instead of 'science' and for the three learning environments to be compared. In addition, an open-ended comment section was added at the end of this version of the CLES2-CS.

Section 3.5 outlined the various research methods and techniques of data analyses used to answer the two research objectives. To answer Research Objective 1 in Section 3.5.1, the validity of the CLES2-CS3 was determined using principal axis factor analysis with varimax rotation and Kaiser normalization. In addition, Cronbach's alpha coefficient was used to check the internal consistency reliability of each scale.

To answer the second research objective regarding comparing preservice teacher perceptions in their different learning environments, the methods of statistical analysis were described in Section 3.5.2 and 3.5.3. These included a MANOVA to reduce Type I errors; ANOVAs to identify differences among the three learning environment (UTeach, STEM classes, and the UTeach FIELD courses); and *t*-tests between each of the three pairs of instructional treatments (UTeach vs STEM, UTeach vs FIELD, FIELD vs STEM) for each CLES2-CS3 scale. The magnitude of between-group differences, in addition to their statistical significance, was also examined using effect sizes (Cohen's *d*).

In Section 3.5.3, the methods of analysis for the changes over time in learning environment perceptions across the program as students progress through the courses in the professional development sequence were described to further answer Research Objective 2. These methods involved students who had been in a FIELD course for each semester of the four-semester study. These were sorted by student, course, and then by CLES2-CS3 scale; means were calculated by UTeach program course. Finally, in Section 3.5.4, an explanation of the method for collection and examination of the open-ended survey comments was presented. These questions allowed student comments about the learning environments of UTeach vs STEM classes and their FIELD classes. These analyses were used to further answer Research Objective 2.

The results of these analyses, discussion of the results, and how they answer the research objectives are included in the following chapter (Chapter 4) of this thesis. Chapter 5 summarizes this thesis and its results and conclusions, as well as its limitations, including sample selection and time constraints. Implications and the significance of this study and suggestions for further research are also considered.

CHAPTER 4

ANALYSES AND RESULTS

“UTeach is ideal and STEM classes are poor. Field courses are a great experience for prospective teachers.” --a student in Classroom Interactions.

4.1 INTRODUCTION

The study focused on an evaluation of the UTeach teacher education program in terms of preservice teachers' perceptions of their classroom learning environments. Chapter 1 considered the background, context, and rationale for this study and defined the research objectives. Chapter 2 reviewed the literature in regards to preservice teachers, the UTeach program, and the history of research on classroom learning environments. Chapter 3 discussed the research methods used in this study.

The current chapter reports findings for each of my research objectives. The second section of this chapter (Section 4.2) focuses on validation of a modified version of the Constructivist Learning Environment Survey (CLES) with preservice teachers. Section 4.3 reports an evaluation of UTeach in terms of the learning environment perceptions of preservice teachers. Section 4.3.1 compares the learning environments of the following three settings: UTeach pedagogical content courses, STEM [science and/or mathematics] major (core) university courses, and science and mathematics classes that they teach/observe during assigned practice teaching within the K–12 public school system (FIELD). Section 4.3.2 reports differences over time in preservice teachers' perceptions of the learning environment in the three settings (UTeach courses, STEM courses, and FIELD classes). Finally, Section 4.3.3 provides further insights gleaned from open-ended questions in the modified CLES. Section 4.4 is a summary of the analyses and results.

As discussed in Chapter 3, this study focused on students enrolled in the UTeach teacher preparation program at a north Texas university over a four-semester period.

Before these preservice teachers' perceptions of their three different learning environments [UTeach, STEM, and FIELD] were investigated, first, my modified version of the CLES2, namely, CLES2-CS3, needed to be validated (see Section 4.2).

4.2 VALIDITY AND RELIABILITY OF THE CLES2-CS3

“Validity tells test users about the appropriateness of a test, and reliability tells about the consistency of the scores produced” (Gay, Mills, & Airasian, 2006, p 139). To answer the first research objective regarding the validity of a modified version of the Constructivist Learning Environment Survey (CLES) with preservice teachers, principal axis factor analysis with varimax rotation and Kaiser normalization was conducted to test the structure of the CLES2-CS3. A separate factor analysis was conducted for UTeach, STEM and FIELD classes. The criteria for retention of any item was that it must have a factor loading of at least 0.40 with its own scale and less than 0.40 with each of the other four CLES scales. Refer to Table 2.2 for the CLES scale names, descriptions, and sample questions. Refer to Appendix D for a complete listing of the CLES items for each scale. During the research timeframe, 702 CLES2-CS3 student surveys were collected from across the UTeach program courses, but only 575 were from students in courses with a FIELD component. The validation and reliability analyses were calculated using the UTeach and STEM settings ($N = 702$) and the FIELD setting ($N = 575$) (refer to Section 3.4 for further details regarding the sample selection).

Table 4.1 shows that these two criteria for item retention were satisfied (1) for all 20 items for the STEM sample, (2) for all items for the UTeach sample except Item US4 in Uncertainty (which had a factor loading of less than 0.40 on its own scale and greater than 0.40 on Critical Voice) and (3) for all items for the FIELD sample except Item CV1 (loading of over 0.40 with Uncertainty) and SC4 (loading of less than 0.40 on its own scale). The bottom of Table 4.1 shows that the proportion of variance accounted for by different CLES scales (1) ranged from 5.7% to 33.9%, with a total of 63.2%, for UTeach classes, (2) ranged from 5.7% to 34.5%, with a total of 67.9%, for STEM classes and (3) ranged from 6.2% to 38.2%, with a total of 68.5% for FIELD classes. The bottom of Table 4.1 also shows that scale eigenvalues ranged from 1.1 to 6.8 for

UTeach classes, from 1.1 to 6.9 for STEM classes, and from 1.2 to 7.6 for FIELD classes.

“Reliability is the degree to which a test consistently measures whatever it is measuring. The more reliable a test is, the more confidence we can have that the scores obtained from the test are essentially the that would be obtained if the test were readministered to the same test takers” (Gay, Mills, & Airasian, 2006, p. 139). The internal consistency reliability of each CLES2-CS3 scale was calculated by using Cronbach’s alpha coefficient. Scale reliabilities ranged from 0.68 to 0.85 for UTeach classes, from 0.72 to 0.92 for STEM classes, and from 0.76 to 0.88 for FIELD classes. According to George and Mallery (2003), alpha reliabilities greater than 0.9 are considered excellent, reliabilities greater than 0.8 are considered good and reliabilities above 0.7 are considered acceptable. Table 4.1 shows that for most of the CLES2-CS3 scales, the reliability fell in the good to excellent range according to these guidelines.

In prior research, the CLES has been consistently found to be valid and reliable. The CLES has been validated in multiple countries, languages and settings, including the USA by Nix, Fraser, and Ledbetter (2005), Long & Fraser (2015), South Africa by Aldridge, Fraser, and Sebela (2004), Australia and Taiwan by Aldridge et al. (2000), and Korea by Kim, Fisher, and Fraser (1999). This version of the CLES, CLES2-CS3, continues these validity and reliability findings with the use of preservice teachers thus answering Research Objective 1.

Table 4.1 Factor Analysis Results (Factor Loadings, % Variance, and Eigenvalues) and Reliability (Alpha Coefficient) for CLES Scales for Three Samples (UTeach Classes, STEM Classes, and FIELD Classes)

Item	Factor Loadings														
	Personal Relevance			Uncertainty of Science			Critical Voice			Shared Control			Student Negotiation		
	UTeach	STEM	FIELD	UTeach	STEM	FIELD	UTeach	STEM	FIELD	UTeach	STEM	FIELD	UTeach	STEM	FIELD
PR1	0.69	0.69	0.67												
PR2	0.65	0.72	0.75												
PR3	0.57	0.75	0.65												
PR4	0.64	0.78	0.77												
US1				0.52	0.63	0.54									
US2				0.62	0.52	0.69									
US3				0.52	0.52	0.57									
US4				–	0.43	0.45	0.49								
CV1						0.50	0.52	0.46	0.54						
CV2							0.47	0.48	0.52						
CV3							0.71	0.75	0.68						
CV4							0.68	0.74	0.77						
SC1										0.72	0.72	0.74			
SC2										0.75	0.63	0.71			
SC3										0.74	0.85	0.81			
SC4										0.42	0.44	–			
SN1													0.64	0.76	0.74
SN2													0.69	0.88	0.81
SN3													0.77	0.86	0.74
SN4													0.68	0.77	0.60
% Variance	6.5	12.0	9.2	5.7	5.7	6.2	9.2	6.4	7.1	7.9	9.5	7.8	33.9	34.5	38.2
Eigenvalue	1.3	2.4	1.8	1.1	1.1	1.2	1.8	1.3	1.4	1.6	1.9	1.6	6.8	6.9	7.6
α Reliability	0.80	0.86	0.86	0.68	0.72	0.76	0.74	0.79	0.80	0.81	0.08	0.88	0.85	0.92	0.86

N=702 (UTeach or STEM classes), *N*=575 (FIELD classes)

Factor loadings less than 0.40 have been omitted from table.

Principal axis factoring with varimax rotation and Kaiser normalization

Total variance = 63.2% (UTeach classes), 67.9% (STEM classes), 68.5% (FIELD classes)

4.3 EVALUATION OF UTEACH IN TERMS OF LEARNING ENVIRONMENT PERCEPTIONS

To answer the second research objective concerning the effectiveness of the UTeach program, the learning environment perceptions of preservice teachers' were assessed in the three settings: UTeach pedagogical content courses, STEM [science and/or mathematics] major (core) university courses, and science and mathematics classes that they teach/observe during assigned practice teaching (FIELD) within the K–12 public school system. Section 4.3.1 compares the learning environments in the three settings. Section 4.3.2 reports changes in learning environment over time in each of the three settings (UTeach courses, STEM courses, and K–12 FIELD classes). Then, Section 4.3.3 presents some data obtained from the open-ended questions included in the CLES2-CS3 survey.

4.3.1 Comparison of the Learning Environments of Three Settings

This section reports results for my second research objective involving an evaluation of UTeach by comparing the learning environments perceptions of preservice teachers' in the following three settings: UTeach pedagogical content courses, STEM [science and/or mathematics] major (core) university courses, and FIELD [the science and mathematics classes that they taught/observed during assigned practice teaching within the K–12 public school system]. Data analyses for overall comparisons of three learning environments were based on the sample of 575 students, for only those students surveyed that were in all three settings.

In order to reduce the Type I error rate that would be associated with conducting a separate significance test for each of the five CLES2-CS3 scales, I conducted a single One-way Multivariate Analysis of Variance (MANOVA) with repeated measures for the set of five CLES scales as the dependent variables. The independent variable was the 3-level instructional variable (UTeach, FIELD and STEM classes). Because MANOVA revealed significant instructional differences for the set of five CLES scales as a whole ($F = 89.39$, Wilks' lambda = 0.63, partial $\eta^2 = 0.98$), I was justified in interpreting the univariate ANOVA results separately for each CLES scale (see

Table 4.2). These significant results mean that there were differences between the learning environments of the three different settings.

Table 4.2 Statistical Significance (F) and Effect Size (Partial η^2) from MANOVA/ANOVAs with Repeated Measures for Overall Differences between Three Instructional Groups (UTeach, FIELD, STEM) for Five CLES Scales

CLES Scale	Overall Difference Between Three Groups	
	F	Partial η^2
Personal Relevance	96.58**	0.10
Uncertainty of Science	164.92**	0.16
Critical Voice	238.60**	0.22
Shared Control	449.99**	0.34
Student Negotiation	131.41**	0.13

MANOVA results: $F = 89.39^{**}$, Wilks' $\lambda = 0.63$, partial $\eta^2 = 0.98$

$N = 575$ in each group

** $p < 0.01$

Table 4.2 also shows the ANOVA results for each of the five CLES2-CS3 scales for the three-level instructional variable. Overall differences between instructional groups were statistically significant for every CLES scale and the proportion of variance accounted for (partial η^2) ranged from 0.10 for Personal Relevance to 0.34 for Shared Control (which is relatively large). Between-group differences were smallest for Personal Relevance, possibly because these STEM students were in coursework and a preservice teaching program of their choice rather than in required courses outside of their majors. Shared Control, which involves students helping to choose what they learn, had the largest between-group differences, possibly because of the manner in which the STEM courses are taught at the university level: instructors choose what topics and how these are taught in the courses.

Interpreting the significant differences reported in Table 4.2 for the overall comparison of three instructional groups necessitated conducting follow-up post hoc tests for the significance of differences between each of the three pairs of instructional treatments (UTeach vs FIELD, FIELD vs STEM, UTeach vs STEM) for each CLES scale. This involved paired t -tests as shown in Table 4.3. Differences between each pair of instructional treatments were significant for every CLES scale ($p < 0.01$). For almost every comparison, the perceived UTeach learning environment was significantly more positive than for STEM and FIELD classes; and perceptions of the FIELD setting (where applicable) were significantly more positive than for STEM courses.

Table 4.3 Effect Size (Cohen’s *d*) and Statistical Significance (Paired *t*-test Results) for Pairwise Differences between Three Instructional Groups (UTeach, FIELD, STEM) for Five CLES Scales

CLES Scale	Pairwise Difference between Three Groups					
	UTeach vs FIELD		FIELD vs STEM		UTeach vs STEM	
	<i>d</i>	<i>t</i>	<i>d</i>	<i>t</i>	<i>d</i>	<i>t</i>
Personal Relevance	0.13	3.16**	0.60	11.38**	0.77	13.50**
Uncertainty of Science	0.41	9.32**	0.63	12.83**	1.09	20.41**
Critical Voice	0.45	9.60**	0.78	15.70**	1.26	23.93**
Shared Control	0.72	16.19**	0.99	21.66**	1.83	34.99**
Student Negotiation	0.35	7.89**	0.96	10.64**	1.56	16.16**

N = 575

***p* < 0.01

d = Cohen’s effect size (difference between means divided by pooled SD)

Estimating the magnitude of between-group differences, in addition to their statistical significance, required calculation of effect sizes using Cohen’s *d*. This is a difference expressed in standard deviation units and it is calculated by dividing the difference between the means of two groups by the pooled standard deviation (see Table 4.4 for means and standard deviations). Table 4.3 shows that the effect sizes for between-group differences for different CLES scales ranged from 0.13 to 0.72 for the comparison of UTeach with FIELD classes, from 0.60 to 0.99 for the comparison of FIELD and STEM classes, and from 0.77 to 1.83 for the comparison of UTeach and STEM classes. “Cohen suggested that *d* = 0.2 be considered a ‘small’ effect size, 0.5 represents a ‘medium’ effect size and 0.8 a ‘large’ effect size. This means that if two groups’ means don’t differ by 0.2 standard deviations or more, the difference is trivial, even if it is statistically significant” (Walker, 2008, Effect size, para. 3).

Table 4.4 Item Mean and Standard Deviation for Three Instructional Groups (UTeach, FIELD, STEM Classes) for Five CLES Scales

CLES Scale	Mean			Standard Deviation		
	UTeach	FIELD	STEM	UTeach	FIELD	STEM
Personal Relevance	4.01	3.96	3.45	0.68	0.80	0.89
Uncertainty of Science	4.09	3.79	3.26	0.64	0.83	0.87
Critical Voice	4.52	4.22	3.57	0.55	0.75	0.91
Shared Control	3.82	3.20	2.27	0.78	0.94	0.91
Student Negotiation	4.26	3.99	3.44	0.73	0.81	1.05

N = 575

The item means in Table 4.4 were based on a frequency scale in which 1 = Almost Never, 2 = Seldom, 3 = Sometimes, 4 = Often, and 5 = Almost Always. Therefore, UTeach and FIELD means tended to fall in the *Often* range while means for the STEM classes were in the *Seldom* to *Sometimes* range, as shown in Table 4.4. These results are predictable because UTeach courses were based on the constructivist method. The FIELD classes, the K–12 observational settings, showed a positive learning environment in terms of CLES dimensions, although means were not quite as high as for UTeach classes. The STEM classes had a learning environment that was perceived as much less positive than the other two settings, perhaps because these classes were not taught by professional educators, but by research scientists and/or mathematicians.

Figure 4.1 is a visual representation of the group means in Table 4.4 across the three settings. The profiles of learning environment scores in Figure 4.1 highlight and illustrate the main differences between settings as reported in Table 4.4:

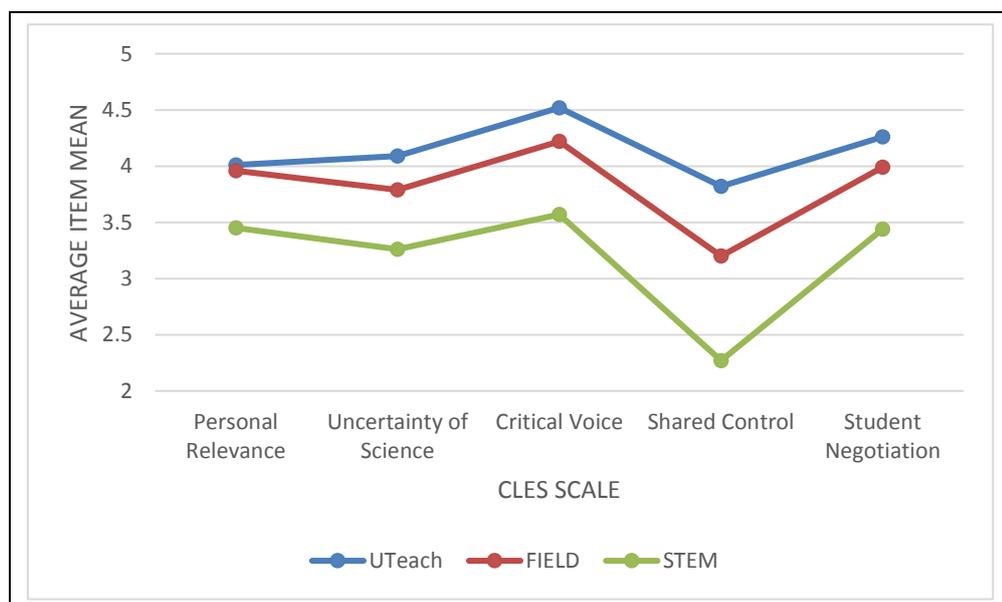


Figure 4.1 CLES Scale Means across the Three Learning Settings (UTeach, FIELD, STEM)

- The perceived learning environment was more positive for UTeach settings than for FIELD settings and STEM settings (with the exception of the Personal Relevance scale for UTeach and FIELD settings)

- The perceived learning environment was more positive for FIELD settings than for STEM settings.
- The differences between FIELD and STEM settings in learning environment were larger than the differences between UTeach and FIELD settings.

Shared Control was higher in UTeach classes probably because students chose which lessons to conduct, when they went out to the field to teach their practice lessons, and how to teach those lessons within a set lesson format. Students often had some choices in projects, which Texas state objectives to cover, lesson objectives, and other lesson items with their field classes, whereas most STEM classes allowed no choices in how or what students learn from their university professors.

4.3.2 Changes in Learning Environment Over Four Semesters

Another approach to answering my second research objective about the effectiveness of the UTeach program involved trends in the changes over time in preservice teachers' perceptions of the learning environment in each of the three settings (UTeach courses, STEM courses, and K–12 FIELD classes). The UTeach program has eight courses, or nine for mathematics majors, designed with one course to be taken each semester, although many students take two courses in a single semester. Of these eight courses, only five have FIELD components, namely, Step 1, Step 2, Classroom Interactions (CI), and Project-Based Learning (PBI), and Apprentice Teaching (AT).

For the comparisons reported in this section, only the courses that have FIELD components leading up to Apprentice Teaching were used. In order to be able to observe trends, only students who were enrolled during all semesters of the four-semester study period were included in these data analyses. Unfortunately, this greatly reduced the number of students for analysis to: 27 students for Step 1; 44 students for Step 2; 38 students for CI; and 20 students for PBI. Because of the small sample size for the analyses reported in this section, any results or trends should be interpreted with caution and as being tentative. Based on student comments on the FIELD portion of the survey, many of the Apprentice Teachers surveyed referred to the FIELD experience as their own extended teaching practice in the FIELD, not what they were

observing from their mentor teaching throughout the semester. This gave insight into thoughts about their own teaching-learning environments for the prior data comparisons, but not as much for the overall trend calculations.

Figure 4.2 portrays changes in means for each of the five scales of the modified CLES (Personal Relevance, Uncertainty, Critical Voice, Shared Control, and Student Negotiation) over the four courses (Step 1, Step 2, CI, and PBI) for each of the three settings (UTeach, FIELD, and STEM).

As a whole set, these comparison figures show that:

- the differences between settings in Figure 4.2 are present at all four times.
- changes across time are relatively small, but differences widen somewhat over time.
- for Personal Relevance, the settings have relatively similar and positive learning environments at the beginning, but differences widen over time.

For Personal Relevance, which refers to learning about the world and how the class/topic fits into the ‘real world’, perception scores for UTeach increased across the four semesters, for FIELD classes stayed about the same, and dropped for STEM classes as students progressed through the courses. The drop for UTeach classes at the PBI level most likely occurred because of students not seeing PBI lessons as directly relevant to their everyday way of teaching or to what they were seeing most often in the FIELD; pre-college teachers lose the opportunity and time to have extended projects because of high-stakes testing demands. Personal Relevance was the lowest for STEM majors at the PBI level.

Uncertainty refers to the provisional status of knowledge of mathematics/science. Higher Uncertainty scores in UTeach classes than in either FIELD or STEM classes probably arose because UTeach classes encompass constructivist learning/teaching environments, FIELD classes involve constructivism as time permits, and STEM classes often present knowledge in the manner most comfortable to university instructors.

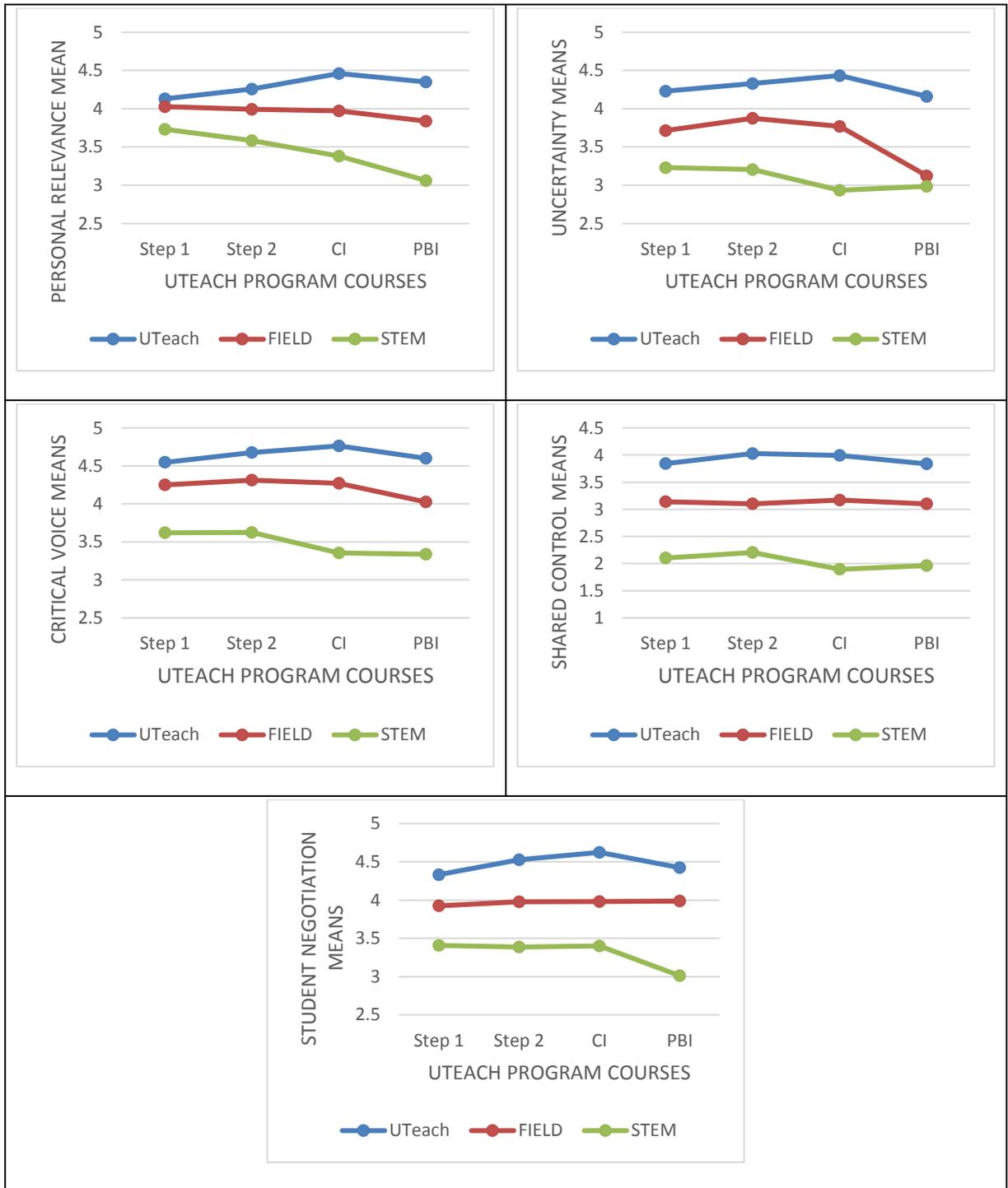


Figure 4.2 Changes in Learning Environment Over Four Semesters for Three Instructional Programs

Critical Voice is the likelihood that students can question the validity of what they are learning without fear of recompense. Across the four program courses, the mean score for this scale remained at about the same level for UTeach, decreased slightly for FIELD courses, and decreased for STEM classes. This is perhaps because students

felt more able to raise questions about their learning with their UTeach instructors than they did with their FIELD instructors and/or STEM instructors.

Shared Control refers to participation in planning, conducting, and assessing learning (e.g. “I help the teacher to plan what I’m going to learn”). Generally, there was negligible student participation in the design of STEM classes, a little more participation in FIELD classes, and frequent opportunity to be part of the learning process in UTeach classes. The mean for the Shared Control scale stayed fairly constant throughout progression through the program’s four courses for each of the three instructional settings.

Student Negotiation refers to involvement with other students in assessing the viability of new ideas (e.g. “I ask other students to explain their thoughts”). This sort of participation in the structure of learning occurred most frequently in UTeach classes and least frequently in STEM classes. Figure 4.2 shows that, over time, there was a small increase in Student Negotiation for UTeach and a small decrease for STEM classes.

4.3.3 Analysis of Students’ Open-Ended Comments

The third approach to answering my second research objective concerning the effectiveness of the UTeach program involved analysing students’ responses to the open-ended component of the questionnaire. The CLES2-CS3 questionnaire shown in Appendix C includes an opportunity to provide open-ended comments after completing each set of 20 closed-ended items. Items for the UTeach/STEM side-by-side comparison conclude with provision for “**Comments about the learning environments in UTeach classes or your STEM classes**” and items for FIELD classes conclude with “**Comments about the learning environments in your UTeach field course**”.

Overall 174 students provided comments about UTeach/STEM settings and an additional 82 comments were made about FIELD settings. Comments were transcribed onto a spreadsheet separately for different semesters and different courses. Each comment was inspected and coded for positive words (e.g. “safe learning environment”, “positive and rich atmosphere”, “inspire kids to learn”, etc.) or negative

words (e.g. “rigid”, “make me feel like an idiot”, “you get it or you don’t”, etc.). Some comments were classified as irrelevant (e.g. “Teaching at 7:30 in the morning makes me awkward and clumsy”).

Table 4.5 provides a sample of the comments made by students when comparing UTeach to STEM learning environments and a sample of the comments made about the FIELD learning environment.

Table 4.5 Sample of Student Comments about Different Settings (UTeach to STEM, FIELD)

Comments Comparing UTeach and STEM Classes	Comments about FIELD Classes
In STEM, teachers are rigid and don’t like to spend time going over material more than once. In UTeach, the teachers appreciate questions and will stop to take however long is necessary to explain.	They created a very safe learning environment where the students feel free to ask and answer questions.
I wish we had more collaborative learning in STEM classes. I feel more confident in my knowledge and have a lot more fun.	While in the classroom, the students help the teacher with how to teach more effectively, and the students teach the teacher things that relate to the task/lesson at hand.
I wish that we could have more flow of ideas and communication in my STEM courses like we do in UTeach courses!	The teacher provided a very positive and rich atmosphere for learning.
UTeach seems really open and STEM classes seem really closed and rigid. UTeach has more leeway than STEM classes.	I love how UTeach exposes us to new and innovative learning environments. I have thoroughly enjoyed the inquiry-based learning environments.
In UTeach, the learning environment is much more concentrated as many perspectives come together and we work on better teaching (learning) strategies. In STEM classes, it’s more direct teach, lectures, etc. and work like that done in UTeach has to be done outside of class when one finds time.	Very good learning environment that tries to inspire kids to learn. Very helpful and encouraging and overall very good for the students.
In UTeach classes, the environment is more open/interactive. UTeach is more enjoyable than STEM classes; not in terms of content, but in terms of how we learn the content.	The style in my mentor’s classroom is much more student-oriented. The students guide the classroom.
My physics classes make me feel like an idiot. Sometimes it’s because the homework is hard, and sometimes it’s because the teacher literally makes me feel stupid.	My field experience in PBI was an exemplary example of how authentic inquiry takes place.
UTeach feels like a learning environment where we learn more since lessons are more interactive and the focus is carrying the concept across – rather than in STEM where you get the lecture or you don’t.	Learning environments in the middle-school classes that we observed are very healthy in that the teachers put in a lot of effort as well as students. Students have a passion to learn/better themselves as teachers work to help students achieve their goals.

For each setting (UTeach, FIELD, STEM) and for each course (Step1, Step 2, CI, PBI, AT), the percentage of positive comments (as a ratio of all positive, negative, and irrelevant comments) was calculated and tabulated in Table 4.6. The percentage of positive comments for different semester courses ranged from 94% to 100% for UTeach, from 75% to 100% for FIELD classes, and from 0% to 9% for STEM classes. The percentage of negative comments for different semester courses ranged from 0% to 4% for UTeach, from 0% to 10% for FIELD, and from 60% to 100% for STEM classes. These percentages in Table 4.6 indicate a strong positive view of UTeach courses relative to STEM courses. Overall, the FIELD setting also received high percentages of positive comments, with the exception of a somewhat-smaller percentage of positive comments for CI classes. This could have been because this was the first field course for students in the high school (grades 9–12). Because the high-school setting often has more discipline and testing requirements than elementary and junior high-school classrooms, this could have led to less-positive views.

Table 4.6 Percentage of Students’ Positive and Negative Open-Ended Comments about Three Instructional Groups (UTeach, FIELD, STEM) for Five Courses

UTeach Program Course	Percentage of Positive Comments			Percentage of Negative Comments		
	UTeach	FIELD	STEM	UTeach	FIELD	STEM
Step 1	90%	87%	9%	4%	10%	69%
Step 2	100%	100%	6%	0%	7%	72%
CI	97%	75%	0%	3%	9%	60%
PBI	94%	92%	6%	0%	8%	88%
AT	100%	100%	0%	0%	0%	100%

Overall, based on the open-ended comments, students had highly-positive opinions about of their UTeach class settings, as well as quite-positive opinions of FIELD class settings. The positive opinions persisted as students progressed to higher-level classes. On the other hand, the percentage of positive comments about the STEM class setting was very low in the first semester course and remained very low throughout the remainder of the courses. These trends continued for the negative comments. The opinions expressed in the open-ended comments showed very few negative comments for the UTeach classes, and slightly more negative of the FIELD class settings. The negative opinions of the STEM courses persisted at a high level increasing as students

progressed to higher levels of STEM courses. Figure 4.3 portrays these trends in the comparative of the positive and negative student comments UTeach courses, FIELD courses to their STEM courses as students progressed through the program. These further illustrate the UTeach classes and FIELD classes as a more positive learning environments than the STEM classes. This supports the trends seen in the scale analyses of the CLES2-CS3 questionnaire.

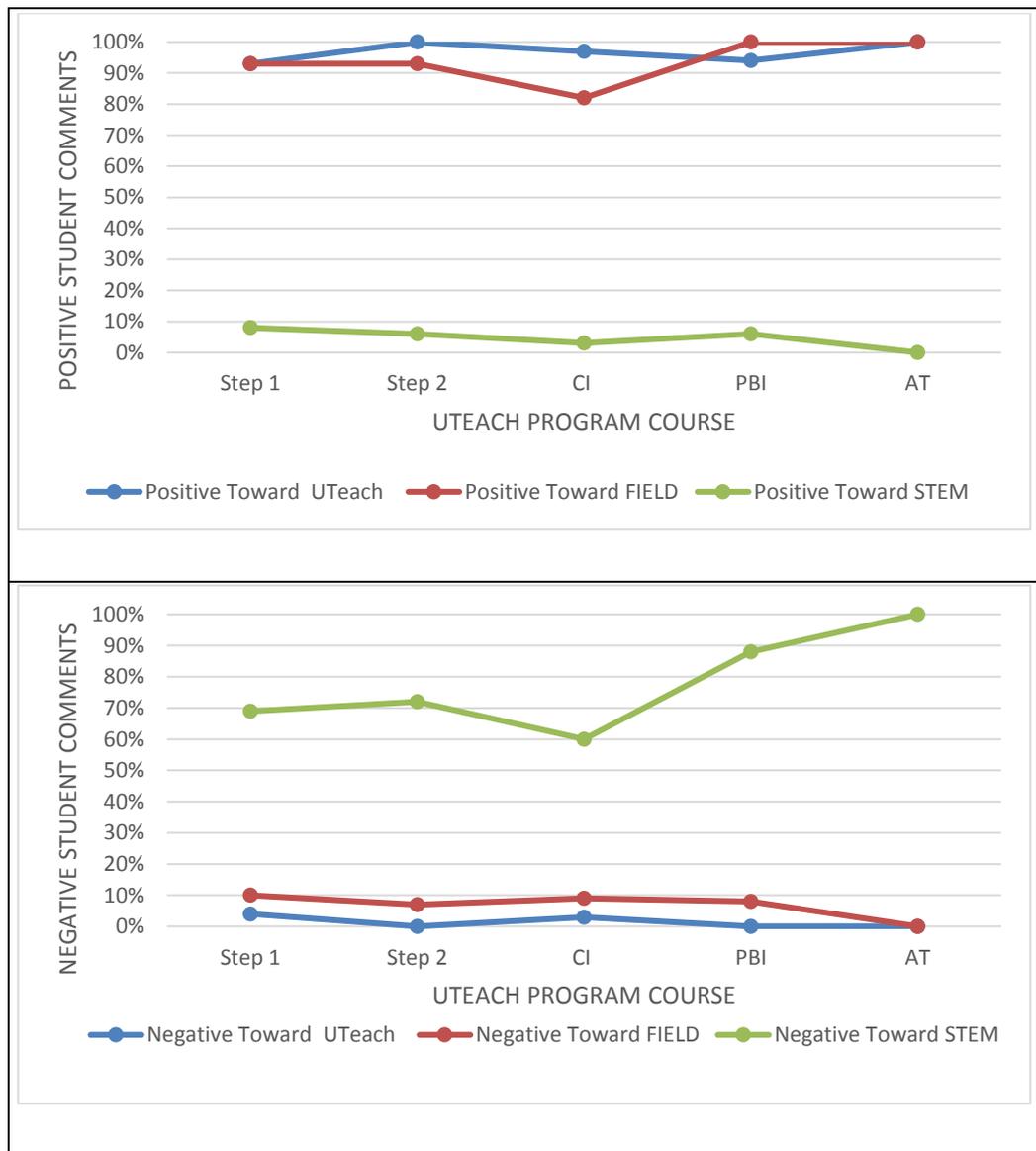


Figure 4.3 Trends in the Open-Ended Comments about Three Instructional Groups (UTeach, FIELD, STEM) for Five Courses

A few additional comments that reinforce the pattern seen with all three methods of Research Objective 2 are below:

- My STEM courses are not very friendly and they usually are boring because the professors are not good at making things/topics relatable. UTeach classes are amazing because it helps me understand, learn, and grow. (Step 1 student)
- This opened my eyes to see how others are taught and these classes are in the middle between my super free UTeach course and my super robotic and closed STEM classes. It lets the students express themselves. (Step 1 student)
- UTeach feels like a learning environment where we learn more since lessons are more interactive and the focus is carrying the concept across – rather than in STEM where the lecture and you get it or you don't. (Classroom Interactions student)
- In my UTeach classes there is a very safe learning environment where students are encouraged to participate and ask questions. In most of my Math courses most of the time everyone sits silently during lecture even though they don't understand most of it. (Research Methods student)
- UTeach is more collaborative and student-centered than my STEM classes. (Apprentice Teaching student)

4.6 SUMMARY

This study of the evaluation of the UTeach program had two main objectives. The first objective was to validate a modified version of the Constructivist Learning Environment Survey, CLES2-CS3, with preservice teachers. Secondly, I investigated the effectiveness of the UTeach program in terms of the learning environment perceptions of preservice teachers in three different settings (UTeach pedagogical

content courses; STEM science and/or mathematics major courses; and FIELD classes that they observed). This chapter reported the results to answer these two objectives.

First, the CLES2-CS3 (which evaluates Personal Relevance, Uncertainty of Science, Critical Voice, Shared Control, and Student Negotiation) was validated for use with preservice teachers for my sample of 702 students (UTeach and STEM) or 575 students (FIELD) to answer Research Objective 1 (Section 4.2). Questionnaire structure was tested with a separate principal axis factor analysis with varimax rotation and Kaiser normalization for UTeach, STEM and FIELD classes. For all 20 items for STEM sample, for all items for UTeach sample except Item US4 in Uncertainty (which had a factor loading of less than 0.40 on its own scale and greater than 0.40 on Critical Voice), and for all items for the FIELD sample except Item CV1 (loading of over 0.40 with Uncertainty) and SC4 (loading of less than 0.40 on its own scale), the criteria of a factor loading being at least 0.40 with its own scale and less than 0.40 with each of the other four CLES scales was satisfied. Variance proportions ranged from 5.7% to 33.9%, with a total of 63.2%, for UTeach classes; from 5.7% to 34.5%, with a total of 67.9%, for STEM classes; and from 6.2% to 38.2%, with a total of 68.5%, for FIELD classes. Cronbach's alpha coefficients for internal consistency reliability for scales were medium to large (from 0.68 to 0.85 for UTeach classes, from 0.72 to 0.92 for STEM classes, and from 0.76 to 0.88 for FIELD classes).

Second, I investigated differences between preservice teachers' perceptions of the learning environment in all three settings of the UTeach program: UTeach courses, STEM courses, and K-12 field classes, as well as how these changed over time as students progressed through the program. Section 4.3 covered these analyses for Research Objective 2 involving the effectiveness of the UTeach program based on perceptions of the preservice teachers of their learning environments.

In Section 4.3.1, MANOVA, ANOVAs and effect sizes were used to answer this research objective. Significant differences between the three instructional settings were tested further for each CLES2-CS3 scale using paired *t*-tests. Differences between each pair of instructional treatments were statistically significant for every CLES scale at the 0.01 level. Overall, the UTeach learning environment was significantly more positive than the STEM and FIELD components; and the FIELD setting (where applicable) was significantly more positive than the STEM courses

(Section 4.3.1). Cohen's d was used to calculate effect size of between-group differences for the CLES scales. The effect sizes ranged from 0.13 to 0.72 standard deviations for the comparison of UTeach with FIELD classes, from 0.60 to 0.99 for the comparison of FIELD and STEM classes, and from 0.77 to 1.83 for the comparison of UTeach and STEM classes. This suggests a small to medium effect difference between the UTeach and FIELD settings, medium to large difference between FIELD and STEM, and a large difference between UTeach and STEM classes.

An additional analysis for Research Objective 2, in Section 4.3.2, focused on trends in the changes over time in the preservice teachers' perceptions of the environment in each of the three settings (UTeach courses, STEM courses, and FIELD classes). Based on the CLES scales, differences between the settings were monitored throughout the four semesters. Changes across time were relatively small, but differences widened somewhat over time. Students' perceptions of the learning environments of the STEM classes started as less favorable than those of UTeach and FIELD classes, and continued to drop as students progressed through the program.

Students' comments based on the open-ended component of the questionnaire were analysed to further answer Research Objective 2. The trends shown in the CLES scale data were also evidenced in the comments from the students (Section 4.3.3). "UTeach classes modeled the inquiry and collaborative learning methods they are trying to teach us. My STEM classes were not necessarily the best learning environment", commented an AT student. Preservice teachers preferred the constructivist-based UTeach classes over their STEM classes. The FIELD classes also had similar positive learning environments to the UTeach classes and reinforced the UTeach pedagogical teachings.

Findings support the idea that learning environments can be measured and they can be assessed by the participants. This study's analyses showed that students viewed the classroom learning environments of their UTeach and FIELD settings more favorably than their STEM classroom environments. The magnitude of differences in their preferences among these settings increased as the preservice teachers progressed through the program, illustrating a connection between further pedagogical training and improved learning environments. This reinforces the idea that students have a more positive view of a constructivist learning environment over the traditional lecture

learning environment seen in most STEM courses. This is discussed further in Chapter 5.

The following chapter summarizes the thesis and conclusions of this study by discussing the educational significance and implications of this study, possible limitations, and suggestions for future research.

CHAPTER 5

CONCLUSIONS

5.1 INTRODUCTION

Research on any teacher preparation program must recognize the difficult situation that preservice teachers are in when they attempt to balance and combine theory from their coursework with what they are seeing in the field, and how these sometimes disparate schema can enhance or interfere with each other (Harrington & Enochs, 2009). This study was first conceptualized with these thought-provoking questions about students in the UTeach teacher development program: How does this affect their learning environment within the UTeach program courses? How does it affect the learning environment of their STEM major courses? Do these perceptions change as students progress through the program and learn more educational theory? As these preservice teachers cross the boundary from a student in UTeach pedagogy courses and STEM courses to ‘experimental’ teacher in their FIELD courses, these questions should be addressed.

This chapter provides a summary of my study involving the evaluation of the perceived learning environments of the UTeach program and discusses possible implications of findings, its limitations, and suggestions for future research. Section 5.2 provides a summary of the introductory chapter and literature reviewed in Chapter 2. Section 5.3 summarizes the research methods used in this study. Section 5.4 discusses the results of the analyses. Section 5.5 reviews limitations of my study and provides some suggestions for further research. Section 5.6 considers some implications of the findings and the significance of my study.

5.2 SUMMARY OF INTRODUCTORY CHAPTER AND LITERATURE REVIEW

UTeach preservice teachers are in high demand and replication of the UTeach program continues to grow rapidly. Therefore, this study attempted to ascertain whether these

students are learning in a positive and satisfactory environment in their three learning environment settings: (1) their UTeach pedagogical content courses; (2) their STEM, science and mathematics major core, courses; and (3) the FIELD classes that they teach during assigned practice teaching within the public school K–12 science and mathematics classes. This study also aimed to validate a modified version of the Constructivist Learning Environment Survey (CLES) for use with STEM preservice teachers and in three different learning environment settings. Once validated, this instrument could be used for not only UTeach but also with other teacher preparation programs.

Chapter 1 introduced the growing UTeach teacher certification program, including the roles and experiences of preservice teachers. It continued with an introduction to the field of learning environments, the importance of preservice teachers' learning environments, and how students' perceptions can be used to evaluate educational programs. Additionally, this chapter stated the two research objectives, namely, to validate the modified CLES and evaluate UTeach in terms of students' learning environment perceptions, and discussed why students' perceptions of the learning environments in this UTeach program are significant.

Chapter 2 reviewed literature related to teacher education in the United States, the importance of secondary teachers being knowledgeable, and constructivist learning environments for preservice teachers in Section 2.2. The chapter continued with the background and development of the UTeach program, how it differs from traditional programs, and the importance of preservice teachers and the unique role that they have in evaluating learning environments as either students at the university or novice teachers during field experiences.

Chapter 2 also reviewed the history and progression of the field of learning environments, beginning with the early work of Lewin (1936) and Murray (1938) and encompassing the development of the many varied and widely-validated survey instruments over the last 40 years, such as the LEI, QTI, WIHIC and CLES (Section 2.3). This section continued by reviewing the adaptation and modification of these instruments to suit research needs, especially modifications to the Constructivist Learning Environment Instrument (CLES) used in this study. In addition, past learning

environments research was reviewed, with particular attention to the use of learning environment assessments in the evaluation of educational programs.

5.3 SUMMARY OF RESEARCH METHODS

This section summarizes Chapter 3, including the methods for validating the newly-modified version of the CLES, CLES2-CS3, and its use to evaluate the UTeach teacher development program. The site for this study was a university in North Central Texas, located in a metropolitan area, and was one of the first replication sites of the UTeach program (Section 3.3). FIELD experiences occurred in K–12 public schools geographically close to the university. The research sample included prospective UTeach science and mathematics teachers who were monitored during their university program in terms of their perceptions of their multiple learning environments. The sample for questionnaire validation consisted of 702 UTeach student surveys, 702 STEM student surveys, and 595 FIELD student surveys across four semesters of the eight-course program. Therefore, the sample available for comparing the three settings was 575 student surveys.

The learning environment instrument used in this study to assess student perceptions of their multiple learning environments was described in Section 3.4. The CLES2-CS3 survey used was based on the well-established CLES survey that was developed, validated, and then modified to be shorter and for the comparisons to fit side-by-side on a page (Johnson & McClure, 2004; Nix, Fraser, & Ledbetter, 2005; Taylor & Fraser, 1991). This survey was also modified for ‘STEM’ instead of ‘science’ and for three learning environments to be compared. The names of the scales Personal Relevance, Uncertainty of Science, Critical Voice, Shared Control, and Student Negotiation, in addition, an open-ended comment section was added to end of this version of the CLES2-CS.

The methods used to determine validity and reliability of the CLES2-CS3 involved principal axis factor analysis with varimax rotation and Kaiser normalization to test the structure. The criteria for retention of any item was that it must have a factor loading of at least 0.40 with its own scale and less than 0.40 with each of the other four

CLES scales. In addition, Cronbach's alpha coefficient was used to check the internal consistency reliability of the scales (see Section 3.5.1).

Section 3.5 described the methods used to answer Research Objective 2 regarding evaluating the UTeach program in terms of the learning environments. Preservice teacher perceptions were compared in their different learning environments using: MANOVA to reduce Type I errors; ANOVAs to analyse differences among the three learning environments (UTeach, STEM classes, and the UTeach FIELD courses); and post hoc *t*-tests between each of the three pairs of instructional treatments (UTeach vs STEM, UTeach vs FIELD, FIELD vs STEM) for each CLES2-CS3 scale. The magnitudes of between-group differences, in addition to their statistical significance, were also examined using Cohen's *d* effect size (which expresses a difference in standard deviation units).

The methods of analysis for the changes over time in learning environment perceptions across the program as students' progressed through the courses in the professional development sequence were described to further answer Research Objective 2 in Section 3.5.3. These methods involved only the subsamples of students who had been in a FIELD course for each semester of the four-semester study. Surveys were sorted by student, UTeach course, and then by CLES2-CS3 scale; scale means were calculated by course. The CLES scale means were graphed for each of the four semesters of the study to track changes across the program; the graphs and the interpretation of them were provided in Section 4.3.2.

To further answer Research Objective 2, an explanation and justification of the method for collection and examination of the open-ended survey question comments were presented in Section 3.5.4. These questions allowed comments about the learning environments of the UTeach vs STEM classes, and about the learning environments of their FIELD classes. The results of these analyses, discussion of the results, and how they apply to the research objectives were described in Section 4.3.3.

5.4 SUMMARY OF RESULTS

This section provides a summary of the results of the data analyses used to answer my two research objectives of this study. First, the results of the validity and reliability analyses of the CLES2-CS3 are discussed in Section 5.4.1 for Research Objective 1. The results of the various analyses for Research Objective 2 are summarized in Section 5.4.2. For this study, the sample for validating questionnaire comprised either 702 students (UTeach or STEM) or 575 students (FIELD), with 575 of these students providing their perceptions all three learning environments so that Research Objective 2 could be answered.

5.4.1 Validity and Reliability of the CLES2-CS3

The CLES2-CS3 was validated for use with preservice teachers to answer Research Objective 1 (see Section 4.2 and Table 4.1). Principal axis factor analysis with varimax rotation and Kaiser normalization was conducted separately for UTeach, STEM and FIELD classes to test the structure ($N=702$ for UTeach and STEM, $N=575$ for FIELD). All 20 items for the STEM sample, all items for UTeach sample (except Item US4 in Uncertainty), and all items for the FIELD sample (except Item CV1 for Uncertainty and SC4 for Shared Control) had a factor loading of at least 0.40 with their own scale and less than 0.40 with each of the other four CLES scales. Variance proportions ranged from 5.7% to 33.9%, with a total of 63.2%, for UTeach classes; from 5.7% to 34.5%, with a total of 67.9%, for STEM classes; and from 6.2% to 38.2%, with a total of 68.5%, for FIELD classes.

Cronbach's alpha coefficient, which was used to estimate the internal consistency reliability of all scales, ranged from 0.68 to 0.85 for UTeach classes, from 0.72 to 0.92 for STEM classes, and from 0.76 to 0.88 for FIELD classes. Table 4.1 shows that, for most of the CLES2-CS3 scales, the reliability fell in the good to excellent range (George & Mallery, 2003). In prior research, the CLES has been consistently found to be valid and reliable for multiple countries, languages and settings, including the USA by Nix, Fraser and Ledbetter (2005) and Long and Fraser (2015), South Africa by Aldridge, Fraser, and Sebela (2004), Australia and Taiwan by Aldridge et al. (2000), and Korea by Kim, Fisher, and Fraser (1999). My modified version of the

CLES, CLES2-CS3 was cross-validated with preservice teachers, thus answering Research Objective 1.

5.4.2 Evaluation of UTeach in Terms of Learning Environment Perceptions

Differences between preservice teachers' perceptions of the learning environment in three settings (UTeach, STEM, and K–12 field classes) were investigated for Research Objective 2. As noted above in Section 5.3, MANOVA, ANOVAs and effect sizes were used to answer this research objective. When differences between the three instructional settings were tested for each CLES2-CS3 scale using paired *t*-tests, differences between each pair of instructional treatments were significant for every CLES scale. Overall, the UTeach learning environment was significantly more positive than for the STEM and FIELD components; and the FIELD setting (where applicable) was significantly more positive than for the STEM courses (see Section 4.3.1, Table 4.3 and Table 4.4, and Figure 4.1). The effect sizes ranged from 0.13 to 0.72 for the comparison of UTeach with FIELD classes, from 0.60 to 0.99 for the comparison of FIELD and STEM classes, and from 0.77 to 1.83 for the comparison of UTeach and STEM classes. This suggested a small to medium effect for differences between the UTeach and FIELD settings, a medium to large effect for differences between FIELD and STEM, and a large effect for differences between UTeach and STEM classes.

Changes in the learning environment over four semesters were analyzed to further answer Research Objective 2 (see Section 4.3.2 and Figure 4.2), for those students who were in FIELD courses for each semester of the four-semester study. The numbers of students in these subsamples for each UTeach course were quite small: Step 1 = 27, Step 2 = 44, Classroom Interactions = 38, and Project-Based Instruction = 20. Analyses of these changes over time showed that the overall assessment based on the CLES scales regarding the UTeach courses and the FIELD courses remained fairly consistent as students progressed through the program, with an exception for Uncertainty for FIELD classes. Learning environment perceptions for the STEM classes started less positive than for UTeach and FIELD classes and continued to drop as students progressed through the program.

Research Objective 2 was investigated with a third approach involving the utilization and analysis of the open-ended components of the CLES2-CS3 questionnaire. Overall 174 students provided comments about UTeach/STEM settings and an additional 82 comments were made about FIELD settings. Table 4.5 provided a sample of the comments made by students when comparing UTeach to STEM learning environments and a sample of the comments made about the FIELD learning environment.

The pattern seen across all three methods of testing Research Objective 2 was that students' perceptions for the UTeach courses showed highly-positive perceptions about the UTeach course settings, as well as quite-positive perceptions of the FIELD class settings throughout the four semesters of the study. However, perceptions of the STEM course settings were much less positive, and continued with this lower trend throughout the study time frame.

5.5 LIMITATIONS OF THE STUDY

Every effort was made to follow rigorous educational research protocols and analyses. However, as with any educational research, there were limitations in my study. The first limitation was that students were not fully tracked from entry into the program until completion of the program. As graduation rates can vary from four to six years, this was just not feasible within a reasonable time frame for research purposes. By not tracking students from start to finish, my investigation of patterns of change over time was necessarily based on much smaller subsamples than for most analyses.

An additional limitation was that this evaluation of the UTeach program involved a sample at only one university. Although the demographics of the students in this program are similar to the demographics of students in UTeach programs at other universities, including more UTeach teacher development program sites would have strengthened my study's rigour and generalizability.

Another limitation of this study was that my evaluation of UTeach only involved learning environment perceptions as criterion variables. Even though the learning environment has been described as a determinant of learning and the strongest predictor of attitudes toward science (Fraser, 1994; Talton & Simpson, 1987), using

other evaluation criteria, such as attitudes and achievement, would have added to the study.

Although the inclusion of open-ended questions in my study enhanced understanding of preservice teachers' perceptions of the three UTeach program learning environments, interviews with both students and instructors, along with documented classroom observations, could have improved the insights obtained. As learning environments research has progressed, combining quantitative and qualitative methods has illuminated the experiences of key participants from different theoretical frames to allow more authentic and credible outcomes (Dorman, Fraser, & McRobbie, 1994; Fraser & Tobin, 1991; Maor & Fraser, 1996; Tobin & Fraser, 1998; Tobin, Kahle, & Fraser, 1990). Qualitative data, including teacher and student interviews and classroom observations have been collected in previous research in order to identify patterns and differences (Fraser, 1998a). For example, Nix, Fraser, and Ledbetter (2005) combined quantitative and qualitative methods in investigating whether changing teachers' learning environments led to changes in their students' learning environments.

5.6 SUGGESTIONS FOR FUTURE RESEARCH

The overwhelming result of this study was that students' perceptions were more positive for their UTeach courses and FIELD classes relative to their STEM courses. Future research could include surveying STEM course students not enrolled in the UTeach programs using the CLES2-CS questionnaire to provide a broader understanding of what is happening in the STEM classrooms.

Future research on the trend comparisons could include the ability to follow students from initial enrollment in the UTeach program through to graduation and completion of the program. This would allow a more complete picture of the patterns that emerged in this study. Additionally, this study could be expanded to other UTeach replication sites to compare results of this evaluation of the UTeach program with evaluations across universities. In future research, having larger samples would improve the statistical power of analyses and having broader and more representative samples would enhance the generalizability of results.

Other future studies could involve the differential effectiveness of the UTeach program for different subgroups differing in gender, ethnicity, or major subject (e.g. mathematics vs. science).

In my study, the types of statistical analysis used (e.g. exploratory factor analysis and MANOVA) were quite suitable and revealed interesting results. However, in future research, it could be illuminating also to conduct alternative forms of statistical analysis such as confirmatory factor analysis, structural equation modelling (SEM) or hierarchical linear model (HLM) analysis. Uncommon non-parametric tests could also be utilized to dig deeper into the survey data with analysis such as Friedman Rasch models, providing further information about the perceptions of the students.

Although the use of learning environment variables as criteria of effectiveness proved valuable in my study, nevertheless, future studies could be expanded to involve other equally-valuable criteria. These could include students' achievement, attitudes or career success, as well as instructors' job satisfaction.

For various reasons, the inclusion of qualitative methods of data gathering was beyond the scope of my study. In future research, as recommended by Tobin and Fraser (1998), the combination of quantitative and qualitative research methods is likely to yield richer insights than using one approach alone.

5.7 IMPLICATIONS AND SIGNIFICANCE OF STUDY

This study drew on the well-used and widely-validated CLES instrument and advanced it by further validating it with preservice teachers. In addition, this study evaluated multiple learning environments, namely, UTeach courses, STEM courses, and K-12 FIELD courses, over four semesters, thus allowing the monitoring of changes over time in preservice teachers' perceptions of the varied learning environments as they learned more educational theory. My finding that UTeach was effective suggests that it can be recommended for wider uptake.

This is the first known study to use an adapted version of the CLES2-CS to evaluate three different settings at the same time. Therefore, validation of this version of the

CLES (CLES2-CS3) is a significant contribution to the field of learning environments research.

The study's analyses of FIELD classes showed positive perceptions throughout the UTeach program. This is consistent with the goal of the FIELD classes to act as preservice laboratories rather than unrelated, disjointed, and confusing 'real world' examples (Harrington & Enochs, 2009). Therefore, the FIELD experiences in multiple courses of the UTeach program reinforces the UTeach constructivist learning model and program design.

This study's analyses showed that students had more positive perceptions of the classroom learning environments of their UTeach and FIELD settings than for their STEM classroom environments. This could suggest that students react more positively to a constructivist learning environment than to the traditional lecture learning environment existing in most STEM courses. Based on these results, it appears that UTeach learning environments could be meeting the needs of the students better than STEM courses. Professional development for STEM professors is recommended in an attempt to improve the learning environment and therefore learning in STEM courses.

This study also indicated that, as students progressed through the teacher preservice program and become more knowledgeable about educational pedagogy, they perceived the learning environments of their STEM courses less favourably. This suggests that, as preservice teachers learn and obtain pedagogical skills, they become more observant and critical of their instructors' teaching and learning environments. University staff should enhance their upper-level courses to include constructivist methods to improve the learning not only of their preservice teachers, but of all of their students. High-level UTeach preservice teachers could also be used as evaluators of other courses to supplement the opinions of students with those of constructivist-taught novice teachers (Montgomery & Urquhart, 2012).

A more positive learning environment in STEM courses at the university level could help in recruiting students and retaining them through these difficult courses. Increasing positive perceptions of the students in the STEM courses is likely to lead to attracting, maintaining, and keeping a diverse population of students in a field that often has lower graduation rates than for other majors. Because women and minorities

are commonly turned off by STEM courses due to the learning environment, promoting positive environments could help to attract a more-diverse population to STEM courses.

5.8 CONCLUDING REMARKS

As with other modifications and adaptations of the CLES, the CLES2-CS3 used in my study builds on and advances the field of learning environments. Because this questionnaire was found to be a valid and effective in my study, it has the potential for use in future studies with both preservice and STEM classes, as well as with programs involving three learning environment settings.

Because UTeach preservice teachers are in a unique role as both students and teachers, their perceptions of the learning environments of their courses have the potential to enhance our understanding of the UTeach program and core STEM courses. This study suggests that the UTeach program provided a relatively positive learning environment in pedagogy and FIELD courses in which students are placed, but that the learning environment of numerous university STEM courses could be improved.

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APPENDIX A

UTeach National Replication

Expansion Snapshot

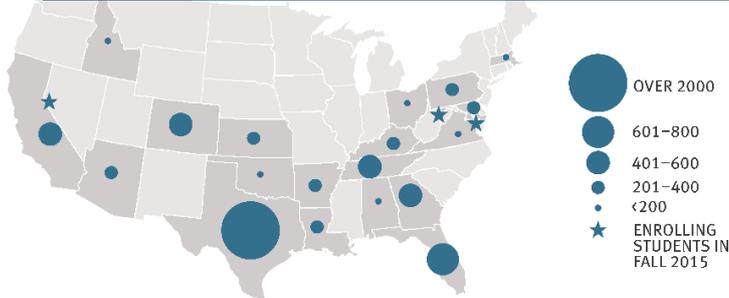
UTeach National Expansion

UTeach answers the challenge for universities to train more science, mathematics, computer science, and engineering teachers by enabling students studying these disciplines to earn teaching credentials without additional time or cost beyond their degrees. A unique collaboration among colleges of science, education, and liberal arts, UTeach prepares teachers with deep content knowledge and proficiency with pedagogical strategies that promote student mastery of science, technology, engineering, and mathematics (STEM) principles and concepts.

UTeach programs are currently active at 44 universities in 21 states and the District of Columbia, with a total enrollment of more than 6,800 students. Graduates of these programs are projected to teach more than 5 million secondary STEM students by 2020.



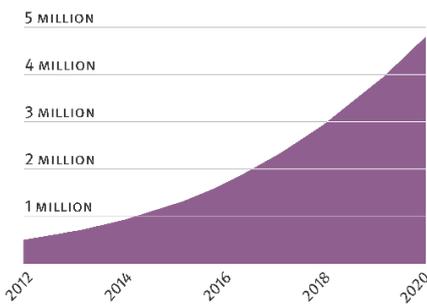
UTEACH NATIONAL EXPANSION PROGRAM ENROLLMENT SPRING 2015: 6,892



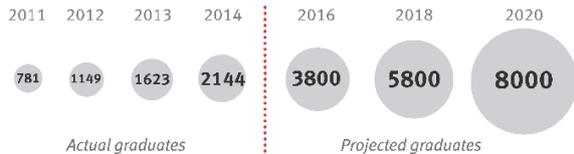
UTEACH STUDENT ENROLLMENT BY MAJOR

- MATHEMATICS 27%**
- BIOLOGY 24%**
- OTHER STEM 10%**
- CHEMISTRY 6%**
- ENGINEERING 6%**
- PHYSICS 3%**
- COMPUTER SCIENCE 1%**

PROJECTED NUMBER OF SECONDARY STEM STUDENTS TAUGHT BY UTEACH GRADUATES



UTEACH PROGRAM GRADUATES (CUMULATIVE COUNT)



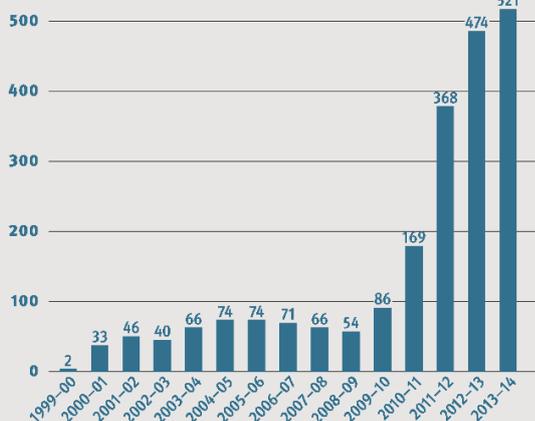
The UTeach Institute was established in 2006 at UT Austin to support replication of the UTeach secondary STEM teacher preparation program at universities across the country and to lead efforts toward continuous improvement of the UTeach model.

The University of Texas at Austin | College of Natural Sciences | info@uteach-institute.org | www.uteach-institute.org

“To continue to cede our leadership in education is to cede our position in the world...America’s leadership tomorrow depends on how we educate our students today, especially in science, math and engineering.”

Remarks by President Obama on the “Educate to Innovate” Campaign and Science Teaching and Mentoring Awards. January 6, 2010.

ANNUAL UTEACH GRADUATES NATIONWIDE



Cumulative national UTeach graduates	2,144
Graduates identified as underrepresented minorities	17%
Graduates entering teaching	87%
Graduates retained in teaching	76%
Graduates currently teaching in K–12 schools with a majority low-income population	66%

Based on 94% of the 2,144 UTeach graduates through Spring 2014 for whom information was available. Schools with a majority low-income population are defined as schools deemed eligible for Title I funding according to the National Center for Education Statistics, Elementary/Secondary Information System (ELSI). ELSI data were available for 81% of schools where UTeach graduates were employed.

UTEACH GRADUATES TEACHING BY SUBJECT AREA (n=1,330)*

MATHEMATICS 758

SCIENCE 457

UNKNOWN SUBJECT 277

OTHER 148

* Graduates teaching multiple subjects are counted once per subject area.

UTEACH PROGRAMS NATIONWIDE

Boise State University • Cleveland State University
Columbus State University • Drexel University •
Florida Institute of Technology • Florida International
University • Florida State University • George
Washington University • Louisiana State University •
Louisiana Tech University • Middle Tennessee State
University • Northern Arizona University • Oklahoma
State University • Old Dominion University • Southern
Polytechnic State University • Temple University •
Towson University • University of Alabama at
Birmingham • University of Arkansas, Fayetteville •
University of Arkansas at Little Rock • University of
California, Berkeley • University of California, Irvine •
University of Central Arkansas • University of Colorado
at Boulder • University of Colorado at Colorado Springs •
University of Florida • University of Houston • University
of Kansas • University of Maryland, College Park •
University of Massachusetts, Boston • University of
Massachusetts, Lowell • University of Nevada, Reno •
University of North Texas • University of Tennessee,
Chattanooga • University of Tennessee, Knoxville •
University of Texas at Arlington • University of Texas at
Austin • University of Texas at Brownsville • University
of Texas at Dallas • University of Texas-Pan American •
University of Texas at Tyler • University of West
Georgia • Western Kentucky University • West Virginia
University



UTeach Expansion Funding

The UTeach Institute’s work is supported through a variety of strategic partnerships at the national, state, and local levels. The UTeach Institute partners with the National Math + Science Initiative and the states of Arkansas, Florida, Georgia, Maryland, Massachusetts, Tennessee, and Texas. For a complete list of strategic partners, see <http://uteach-institute.org>.

UTeach National Expansion Snapshot provided by the UTeach Institute, UTeach Impact, Numbers side section (2015a) Retrieved from <https://institute.uteach.utexas.edu/uteach-impact>

APPENDIX B

UTeach Course Sequences

Entry Points into UTeach and Suggested Course Sequences

YEAR 1 / Freshman		YEAR 2 / Sophomore		YEAR 3 / Junior		YEAR 4 / Senior		
Semester 1	Semester 2	Semester 3	Semester 4	Semester 5	Semester 6	Semester 7	Semester 8	
STEP 1	STEP 2	Knowing & Learning	Classroom Interactions	Perspectives	Research Methods	Project-Based Instruction	Apprentice Teaching/Seminar	
2 nd Sem Freshman Pathway: (7 sem)	STEP 1	STEP 2 + Knowing & Learning	Classroom Interactions	Perspectives	Research Methods	Project-Based Instruction	Apprentice Teaching/Seminar	
	Suggested Sophomore Pathway: (6 semesters)		STEP 1	STEP 2 + Knowing & Learning	Classroom Interactions	Research Methods + Perspectives	Project-Based Instruction	Apprentice Teaching/Seminar
		Suggested 2nd Semester Sophomore Pathway: (5 semesters)		STEP 1 + Perspectives	STEP 2 + Knowing & Learning	Research Methods + Classroom Interactions	Project-Based Instruction	Apprentice Teaching/Seminar
				Suggested 1st Semester Junior Pathway: (4 semesters)		Perspectives + Project-Based Instruction	Apprentice Teaching/Seminar	
				STEP 1 + STEP 2 + Knowing & Learning	Classroom Interactions + Research Methods			

Adapted from the UTeach Austin course sequence (2012). Retrieved from austin.uteach.utexas.edu/current-students/advising.

APPENDIX C

**Constructivist Learning Environments Survey-
Comparative Form for Students – Three Setting STEM-UTeach version
(*CLES2-CS3*)**

Constructivist Learning Environment Survey Comparative Form for Students

This voluntary survey contains 20 statements about practices that could take place in a school. You are being asked to indicate how often you think that each practice occurs in THIS UTeach class and in OTHER STEM classes. Please decide if these occur 'Almost Always', 'Often', 'Sometimes', 'Seldom' or 'Almost Never' by choosing the best answer. Your choices include:

⑤ = Almost Always, ④ = Often, ③ = Sometimes, ② = Seldom, and ① = Almost Never

There are no 'right' or 'wrong' answers. We want to know how you feel about each statement.

- First, read the statement. Don't worry if some of the statements sound the same.
- Next, think about THIS UTeach class right now and mark the one best response in the left side.
- Then, think about the OTHER science/math classes you're taking and indicate the one best response in the right side. They may be the same or different.
- Please use pencil and completely fill in the appropriate circle for your response. If you change your mind, just erase your first mark and fill in another circle.

For example, if you think something almost never happens in THIS class, but happens sometimes in OTHER classes; mark your paper like this.

	In UTeach classes . . .		In my STEM classes . . .							
Some statement about a classroom practice.	⑤	④	③	②	<input checked="" type="radio"/>	⑤	④	<input checked="" type="radio"/>	②	①

THIS IS NOT GRADED. YOUR TEACHER WON'T EVEN LOOK AT YOUR RESPONSES!

For our information, please give us:

Today's date = _____ UTeach Course = _____ University Classification = _____ Your gender = <input type="radio"/> Female <input type="radio"/> Male University = _____ Student ID = _____	Your ethnicity = <input type="radio"/> African American <input type="radio"/> Asian <input type="radio"/> Hispanic or Latino <input type="radio"/> Native American <input type="radio"/> Pacific Islander <input type="radio"/> White <input type="radio"/> Mixed <input type="radio"/> Other Major = <input type="radio"/> Math <input type="radio"/> Science
--	---

⑤ = Almost Always, ④ = Often, ③ = Sometimes, ② = Seldom, and ① = Almost Never

	In UTeach classes . . .	In my STEM classes . . .
I learn about the world in and outside of school.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
New learning relates to experiences or questions I ask about the world in and outside of school.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
I learn how science or math is a part of life in and outside of school.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
I learn interesting things that apply to the world in and outside of school.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
	In UTeach classes . . .	In my STEM classes . . .
I learn that there are not always answers to problems.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
I learn that explanations have changed over time.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
I learn that ideas are influenced by other people’s cultural values and opinions.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
I learn that there are many ways to raise questions and seek answers.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
	In UTeach classes . . .	In my STEM classes . . .
It is OK for students to question the way they are being taught.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
I feel I learn better when students are allowed to question what and how they are learning.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
It is OK for students to ask for clarification about activities that are confusing.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
It is OK for students to express concern about anything that gets in the way of their learning.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
	In UTeach classes . . .	In my STEM classes . . .
Students help plan what they are going to learn.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
Students help decide how well they are learning.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
Students help decide which activities work best for them.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
Students let the teacher know if they need more or less time to complete an activity.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
	In UTeach classes . . .	In my STEM classes . . .
Students talk with other students about how to solve problems.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
Students explain their ideas to other students.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
Students ask other students to explain their ideas.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①
Students ask me to explain my ideas.	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①

Comments about the *learning environments* in UTeach classes or your STEM classes:

If you are enrolled in a UTeach FIELD course, please answer the following questions for your field observation (mentor) classroom:

	In FIELD classes . . .
I learn about the world in and outside of school.	⑤ ④ ③ ② ①
New learning relates to experiences or questions I ask about the world in and outside of school.	⑤ ④ ③ ② ①
I learn how science or math is a part of life in and outside of school.	⑤ ④ ③ ② ①
I learn interesting things that apply to the world in and outside of school.	⑤ ④ ③ ② ①
	In FIELD classes . . .
I learn that there are not always answers to problems.	⑤ ④ ③ ② ①
I learn that explanations have changed over time.	⑤ ④ ③ ② ①
I learn that ideas are influenced by other people's cultural values and opinions.	⑤ ④ ③ ② ①
I learn that there are many ways to raise questions and seek answers.	⑤ ④ ③ ② ①
	In FIELD classes . . .
It is OK for students to question the way they are being taught.	⑤ ④ ③ ② ①
I feel I learn better when students are allowed to question what and how they are learning.	⑤ ④ ③ ② ①
It is OK for students to ask for clarification about activities that are confusing.	⑤ ④ ③ ② ①
It is OK for students to express concern about anything that gets in the way of their learning.	⑤ ④ ③ ② ①
	In FIELD classes . . .
Students help plan what they are going to learn.	⑤ ④ ③ ② ①
Students help decide how well they are learning.	⑤ ④ ③ ② ①
Students help decide which activities work best for them.	⑤ ④ ③ ② ①
Students let the teacher know if they need more or less time to complete an activity.	⑤ ④ ③ ② ①
	In FIELD classes . . .
Students talk with other students about how to solve problems.	⑤ ④ ③ ② ①
Students explain their ideas to other students.	⑤ ④ ③ ② ①
Students ask other students to explain their ideas.	⑤ ④ ③ ② ①
Students ask me to explain my ideas.	⑤ ④ ③ ② ①
Comments about the <i>learning environments</i> in your UTeach FIELD course:	

This version of the Constructivist Learning Environment Survey (CLES) was adapted from Taylor and Fraser (1991), Johnson and McClure (2004), and Nix, Fraser, & Ledbetter (2005). This questionnaire's scales and items were used in my study and included in this thesis with the permission of their authors.

APPENDIX D

**Items on the Constructivist Learning Environment Survey –
Comparative Student Form-UTeach (CLES2-CS3)
Grouped by Scale**

**Items on the Constructivist Learning Environment Survey –
Comparative Student Form-UTeach (CLES2-CS3) Grouped by Scale**

Item Statement

Personal Relevance (*Learning about the world*)

- 1 I learn about the world in and outside of school.
- 2 New learning relates to experiences or questions I ask about the world in and outside of school.
- 3 I learn how science or math is a part of life in and outside of school.
- 4 I learn interesting things that apply to the world in and outside of school.

Uncertainty of Science/Math (*Learning about science/math*)

- 5 I learn that there are not always answers to problems.
- 6 I learn that explanations have changed over time.
- 7 I learn that ideas are influenced by other people's cultural values and opinions.
- 8 I learn that there are many ways to raise questions and seek answers.

Critical Voice (*Learning to speak out*)

- 9 It is OK for students to question the way they are being taught.
- 10 I feel I learn better when students are allowed to question what and how they are learning.
- 11 It is OK for students to ask for clarification about activities that are confusing.
- 12 It is OK for students to express concern about anything that gets in the way of their learning.

Shared Control (*Learning to learn*)

- 13 Students help plan what they are going to learn.
- 14 Students help decide how well they are learning.
- 15 Students help decide which activities work best for them.
- 16 Students let the teacher know if they need more or less time to complete an activity.

Student Negotiation (*Learning to communicate*)

- 17 Students talk with other students about how to solve problems.
- 18 Students explain their ideas to other students.
- 19 Students ask other students to explain their ideas.
- 20 Students ask me to explain my ideas.

Adapted from Taylor & Fraser (1991) and Johnson & McClure (2004)

APPENDIX E

Student Participant Consent Form

Curtin University
Science and Mathematics Education Centre

Student Participant Consent Form

-  I understand the purpose and procedures of the study.
-  I have been provided with a *Student Participant Information Sheet*.
-  I understand that the study itself may not benefit me.
-  I understand that my involvement is voluntary and that I can withdraw from participating at any time without penalty or problems.
-  I understand that no personal identifying information, such as my name and address, will be used in any published materials.
-  I understand that all information related to this study, including completed questionnaires, will be securely stored for a period of five (5) after which it will be destroyed.
-  I have been given the opportunity to ask questions about this research.
-  I agree to participate in the study outlined to me.

Name (Print)

Signature

Date

Student ID Number

APPENDIX F

Student Participant Information Sheet

Curtin University
Science and Mathematics Education Centre

Student Participant Information Sheet

The goal of this study is to see how pre-service teachers' perceptions and satisfaction of their STEM classes change as they progress through a teacher preparation program. Before taking part in this study, please read the consent to participate section below. By completing the survey you understand the statements and freely consent to participate in the study. The study is being conducted by Kim Distin to complete her research for degree of Doctor of Philosophy at Curtin University in Perth, Western Australia.

Consent to Participate

This study involves a survey once a semester for several semesters throughout your UTeach career designed to measure your attitude toward your UTeach classes compared with your core STEM major classes, and your mentor teacher's class if in a field class this semester. No deception is involved, and the study involves no more than minimal risk to participants (i.e., the level of risk encountered in daily life).

Participation in the study typically takes about 10 minutes and is strictly anonymous.

If you are 18 years of age or older, understand the statements in this sheet and freely consent to participate in the study, please continue to the next page.

Confidentiality

All responses are treated as confidential, and in no case will responses from individual participants be identified to anyone outside of the investigator. Rather, all data will be pooled and published in aggregate form only.

Participants will not receive any reimbursement for participation in this study. Participation is voluntary, refusal to take part in the study involves no penalty or loss of benefits to which participants are otherwise entitled, and participants may withdraw from the study at any time without penalty or loss of benefits to which they are otherwise entitled. These questionnaires will be kept in a locked cabinet for five (5) years at which point they will be destroyed.

Further Information

This research has been reviewed and given approval by the Curtin University Human Research Ethics Committee (Approval Number XXXXXX). The University of XXXXXXXXX Institutional Review Board has also reviewed and approved this research (Approval Number XXXXXX). If participants have further questions about this study, they may contact the principal investigator, Kim Distin, M.A.T. at kimd@utdallas.edu or 972-883-6415. Alternatively, you may contact my supervisor, Professor Barry J. Fraser, at B.Fraser@curtin.edu.au.

Should participants wish to make a complaint on ethical grounds, please contact the Human Research Ethics Committee Secretary at hrec@curtin.edu.au or via post at Office of Research Development, Curtin University, GPO Box U1987, Perth, Western Australia 6845.

Thank you for your involvement in this research. Your participation is greatly appreciated.