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ABSTRACT

This study examined the classroom learning environment, achievement, and student and teacher attitudes associated with a 2-year mentoring program in science for 7 first-year, second-year, and third-year grade 3-5 teachers. The "What is Happening in This Class?" (WIHIC) questionnaire, assessing student perceptions of seven dimensions of the classroom learning environment, was modified and administered to 573 students in grades 3-5. Data analyses provided support for a six-scale version of the WIHIC in terms of its factor structure, internal consistency reliability, and ability to differentiate between classrooms. In terms of student outcomes, some changes in students' perceptions of their learning environment occurred between the pre-test and the post-test given in the second year of the mentoring program. Larger differences in student achievement in science and student attitudes about science were observed between pre-test and post-test. Also, student achievement in science was higher in classes with more Investigation and Equity, and student feelings about science were more positive attitudes about teaching science after completing the mentoring program. These data provided a starting point from which qualitative data-gathering methods (such as observations, interviews, and focus groups) were used to gain a more in-depth understanding of the changes in the attitudes of the mentored teachers and their students. (Contains 94 references.) (Author/MM)

The Role of Learning Environment, Achievement, and Student and Teacher Attitudes in a Science Mentoring Program for Beginning Elementary School Teachers

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Abstract

This study examined the classroom learning environment, achievement, and student and teacher attitudes associated with a mentoring program in science for seven first-year, second-year, and third-year grade 3-5 teachers. The *What is Happening in This Class?* (WIHIC) questionnaire, assessing student perceptions of seven dimensions of the classroom learning environment, was modified and administered to 573 students in grades 3-5. Data analyses provided support for a six-scale version of the WIHIC in terms of it's factor structure, internal consistency reliability, and ability to differentiate between classrooms. In terms of student outcomes, some changes in students' perceptions of their learning environment occurred between the pretest and the posttest given in the second year of the mentoring program. Larger differences in student achievement in science and student attitudes about science were observed between pretest and posttest. Also, student achievement in science was higher in classes with more Investigation and Equity, and student feelings about science were more positive in classes with more Cooperation. The seven beginning teachers reported more positive attitudes about teaching science after the two-year mentoring program. These data provided a starting point from which qualitative data-gathering methods (such as observations, interviews, and focus groups) were used to gain a more in-depth understanding of the changes in the attitudes of the mentored teachers and their students.

1.0 Introduction and Significance

Many urban school districts throughout the United States are confronted with unique challenges and issues of teacher shortages, inadequate training, and high turnover rates. These problems are compounded by the fact that, nationally in the USA, more than 20% of public school teachers leave their positions within three years and 9% leave before completing their first year of teaching. Teachers new to working with inner-city students in schools with large numbers of minority and lower-income students are especially prone to attrition. Because strong support systems for beginning teachers can potentially mean the difference between teachers staying in or leaving the profession, this study was undertaken to examine a two-year mentoring program in science for seven first-year, second-year, and third-year grade 3-5 teachers. In addition to a focus on students' perceptions of the learning environment, the study evaluated student achievement and student and teacher attitudes about science.

The research is distinctive in the study of learning environments because, first, it provides one of the few studies that have examined learning environment ideas in investigating the efficacy of mentoring programs for beginning teachers. Second, the researchers modified and validated the *What is Happening in This Class?* (WIHIC) questionnaire for use with elementary school students. Third, in addition to the student outcome measures of achievement in science and attitudes about science, the mentored teachers' attitudes about teaching science were also studied. This study adds to the research evidence suggesting that a program of support to assist teachers in making the transition from university to the elementary science classroom is vital in order to increase the positive effect of the first years of teaching.

2.0 Research Questions

The purpose of this study was to investigate students' perceptions of the classroom learning environment, student achievement in science, and students' and teachers' attitudes about science in the context of a two-year mentoring program in science for seven beginning third, fourth, and fifth grade teachers. The research questions that guided the study were:

1. What is the reliability and validity of the *What is Happening in This Class?* (WIHIC) learning environment questionnaire when modified for use with elementary students?

2. How does the mentoring program affect the students of the beginning teachers in terms of their perceptions of their classroom learning environment, achievement in science, and attitudes about science?

3. Are there associations between the students' perceptions of the learning environment and students' achievement and attitudes about science?

4. How does the mentoring program affect the teachers in terms of their level of confidence, knowledge, and valuing of teaching science, their active learning in science, their success in creating a positive classroom learning environment, and their reflective practice in teaching science?

3.0 Background

This section places the present study into context by providing a review of the literature on mentoring (section 3.1), learning environments (section 3.2), student achievement and attitudes about science at the elementary school level (section 3.3), and teacher attitudes about teaching science in the elementary grades (section 3.4).

3.1 Mentoring

Research evidence indicates that teacher recruitment and retention will be major concerns over the next decade (Fideler & Haselkorn, 1999; Gold, 1996). Although teacher shortages affect schools and districts across the United States to varying degrees, Fideler and Haselkorn (1999) conclude that low-wealth urban districts will need to hire 700,000 or more K-12 teachers over the next decade. Some of the factors given for this staggering hiring demand are rising student enrollments, accelerating teacher retirements, class size reductions and demanding working conditions.

More than half of the districts that responded to the Council of the Great City Schools Survey of the 57 large city school districts in the United States reported that they have an immediate demand for elementary school teachers (Fideler, Foster, & Schwartz, 2000). Elementary education is also one of the projected shortage areas in the large urban school district that was the setting for this research.

Attracting new teachers is only the first part of the solution. High rates of attrition among beginning teachers have been well documented in the literature (Gold, 1996; Harris & Associates, 1992, 1993; Schlechty & Vance, 1981, 1983). Nationally, more than 20% of public school teachers leave their positions within three years and 9% leave before completing their first year of public school teaching (Fideler & Haselkorn, 1999). Other sources, have estimated that nearly 40% leave the profession within their first five years of teaching (Harris, 1992, 1993; Heyns, 1988; Schlechty & Vance, 1981, 1983).

The problem of retaining beginning teachers is further compounded by the fact that new teachers are often unprepared to work with students in schools with large numbers of minority and lower-income students (Fideler & Haselkorn, 1999). Nationwide, urban schools educate between 40% and 50% of the students who are not proficient in English, about 50% of minority students, and 40% of the country's low-income students. These demographics are reflected in the school district that was the setting for the present study. According to the 2000-2001 School District Profiles, 22% of the 170,245 students in grades K-5 were classified as Limited English Proficiency, 89% were minorities, and 70.2% received a free/reduced-price lunch. Frequently, beginning teachers are given assignments that would challenge even the most skillful veteran teachers, making their first few years of teaching extremely frustrating and challenging (Huling-Austin, 1990). Placed in the most difficult assignments, beginning teachers begin to question their own effectiveness and their decisions to become teachers. These uncertainties and frustrating teaching situations often perpetuate rapid teacher turnover among even the most dedicated beginning teachers.

In a response to these demands, many state education agencies created induction programs in three main 'waves' – pre-1986, 1986-89, and 1990-96. The 57 large city school districts in the Council of the Great City School Collaborative report continued aggressive efforts to boost teacher retention rates. More than two-thirds offer induction/support programs to support, assist, and retain new teachers (Fideler, Foster, & Schwartz, 2000).

Broadly defined, an induction program is a planned program intended to provide some systematic and sustained assistance, specifically to beginning teachers for at least one school year (Huling-Austin, 1990). The need for support for beginning teachers has been well documented throughout the literature on teacher attrition and induction. A variety of factors provided the impetus for beginning teacher support – retention, performance, and professional well being.

The data unequivocally demonstrate the efficacy of induction programs in helping to reduce new teacher turnover. Inductees were effusive in their praise and appreciation for the support received during the difficult early months of teaching (Fideler & Haselkorn, 1999).

Despite the positive comments, many state induction programs have been eliminated due to funding cuts and/or legislative priorities. The capacity of induction programs is not keeping pace with rising numbers of newly-hired teachers, leaving many beginning teachers without support and guidance. As a result, many new teachers become disheartened or frustrated and leave the teaching profession, or stay on without appropriate training and view teaching as an undesirable career.

In view of these facts, a major challenge to educators today is providing to beginning teachers support that will assist them in making the transition from university to the classroom. This support should enable beginning teachers to sustain and expand upon what is learned in preservice teacher education programs and develop as proficient, knowledgeable, and successful teachers while confronting the adjustment difficulties of the first years in the classroom.

Offering high-quality support to beginning teachers is critical because the professional literature addresses the fact that lack of professional support is one of the most frequently-cited reasons why teachers leave teaching (Billingsley & Cross, 1991; Darling-Hammond, 1984; Gold, 1996; Gold & Roth, 1993).

Two major categories of support for novice teachers mentioned in the literature are (1) instructional-related support that includes assisting the novice with the knowledge, skills, and strategies necessary to be successful in the classroom and school, and (2) psychological support whose purpose is to build the protege's sense of self through confidence building, developing feelings of effectiveness, encouraging positive self-esteem, enhancing self-reliance, and learning to handle stress that is a large part of the transition period from teacher preparation programs to classroom teaching (Gold, 1996).

In offering instructional support to beginning teachers, many induction programs focus on issues such as classroom management, organization, structuring assignments, selecting and planning activities, and writing curriculum. While these are necessary and important to success in the classroom, a deeper understanding and analysis of the teaching and learning process could be desirable.

Shulman (1986) stressed the importance of the subject matter and 'pedagogical content knowledge' of teachers. Gold (1996) writes that induction programs should assist beginning teachers to transform their expertise in the subject matter into a form that their students can comprehend and to draw on expertise in the subject matter in the process of teaching. Based on Shulman's work (1986), Gold (1996) suggests considering four key questions when giving instructional support to beginning teachers. First, do the beginning teachers understand the structure of knowledge and how it is transformed into content knowledge? Do they understand the structures of the subject matter? Second, have beginning teachers been trained in process or pedagogical content knowledge that includes the most useful forms of representation of ideas, illustrations, examples, analogies, explanations, and demonstrations? Are they able to represent and formulate the subject matter so that it is comprehensible to their students? Third, are beginning teachers prepared to teach a particular subject and specific topics at a given level and to use a variety of instructional materials? Fourth, are beginning teachers thinking reflectively and critically about practice and how they can best impart academic content to their students?

The issue of psychological support is also critical in assisting beginning teachers. The first year of teaching can be traumatic and shocking for even the most competent new teacher. The beginning teacher's transition from university student to practicing teacher is almost always very stressful. Lack of self-confidence, conflicts between personal life and professional requirements, and an inability to handle stress have undermined many promising teachers. When teachers are personally insecure, lack confidence, or have a sense of not being in control of themselves or their environment, it is not likely that they can be successful at teaching regardless of how strong the instructional preparation has been (Gold, 1996).

One of the most widely used sources of individual support has been the use of *mentor teachers*. While much has been written about the roles of mentors and their functions, the concept of mentoring has been defined and operationalized in numerous ways. Mentors have been used in formal induction programs, as well as in less-organized support programs for beginning teachers. Although the educational community appears to recognize the positive effect the mentors have on teacher retention, there has been a lack of clarity about the purposes of mentoring. Questions remain about what mentors should do, what they actually do, and what novices learn as a result (Feiman-Nemser, 1996; Gold, 1996).

The literature reveals a shift away from the concept of a mentor teacher, who is considered to be the expert training a novice, to that of a support provider who offers assistance to a respected new professional colleague (Gold, 1996). Mentoring is widely respected, is cost-effective and has the potential to affect teacher retention, improve the attitudes and instructional strategies of novice teachers, and provide professional growth opportunities for the mentors. Outcomes for mentors are reported to be positive whether their professional growth is an intended or unintended consequence. Mentoring can address two serious problems in teaching – the abrupt and unsupported entry of novices into the field and the difficulty of keeping good, experienced teachers in the classroom (Feiman-Nemser & Parker, 1993).

The 'mentor phenomenon' is also related to the larger goals of improving teaching by transforming professional relations. Distinctions have been drawn between social support that puts beginning teachers at ease and professional support that advances knowledge and practice. The literature includes descriptions of programs in which there is ongoing conversation and reflection about how to help novice teachers to learn to teach and develop skills in critical reflective practice (Feiman-Nemser & Parker, 1993; Gold, 1996; Gratch, 1998; Hole & McEntee, 1999; Lucas, 1999). Support teachers should also be models of the belief that good teachers are also good learners. In learning to teach, experience is necessary but not sufficient. Good teachers continue to improve their teaching through reflection, experimentation, reading, and collaboration. When support teachers view themselves as learners, they encourage their clients to see teaching as a form of inquiry (Feiman-Nemser & Parker, 1993; Rowley, 1999).

The literature reports three perspectives on mentoring roles: *mentors as a local guides*; *mentors as educational companions*; and *mentors as agents of change*. Mentors as local guides try to assist the beginning teachers with their entry into teaching by explaining school policies and practices, sharing methods and materials, and solving immediate problems. Their foremost concern is to help novices to fit into a particular setting and to learn to teach with minimal disruption. While such mentors willingly offer advice, especially when asked, they do not have a long-term view of their roles. They usually decrease their involvement as the beginning teachers gain confidence and control. When mentors take on an educational role, they still help novices to cope with immediate problems, but they also focus on longer-term, professional goals such as helping the beginning teachers learn to uncover student thinking and develop sound reasons for their actions in the classroom. When mentors act as agents of change, they seek to break down the traditional isolation among teachers by fostering norms of collaboration and shared inquiry.

They build networks with novices and their colleagues. They create opportunities for teachers to visit each other's classrooms. They facilitate conversations among teachers about teaching and learning (Feimen-Nemser & Parker, 1993; Healy & Welchert, 1990; Huling-Austin, 1990; Little, 1990).

Given the potential value of mentoring beginning teachers, the present study was undertaken to investigate a two-year mentoring program in which the roles of the mentor teachers were conceptualized as *educational companions* and *agents of change*. The beginning teachers' attitudes about teaching science and the impact of the mentoring program on their students' perceptions of classroom environment, achievement, and attitudes about science were investigated.

3.2 Learning Environments

A great deal of research and evaluation in science education have been heavily dependent on measures of academic achievement and other learning outcomes; however, these measures cannot provide a complete description of the educational process. Over the past 30 years, significant progress has been made in assessing and investigating the learning environments of classrooms and schools. The field of learning environments has been well established in education and a wealth of studies specifically in science education are described in the literature (Fraser, 1994, 1998a; Fraser & Walberg, 1991).

Fraser (1994) defines the classroom environment in terms of the shared perceptions of the students and teachers in that environment. This has the advantage of characterizing the setting through the eyes of the actual participants and capturing the data that the observer could miss or consider unimportant (p. 494). The classroom environment involves the many relationships that exist between the teacher and students or among students. The personal nature of the perceptions of those who are in the environment on a daily basis can provide a wealth of information and deeper insight into the classroom.

The research on learning environments over the past several decades shows that a distinctive feature is the availability of a variety of economical, valid and widely-applicable questionnaires for assessing student perceptions of classroom environments (Fraser, 1998a, 1998b). Few fields in education can boast of the existence of such a wide array of validated and robust instruments that have been used in so many research applications. Literature reviews trace the considerable progress in the conceptualization, assessment and investigation of learning environments over the previous quarter of a century (Fraser, 1994, 1998a; Fraser & Walberg, 1991). For example, the varied types of research on learning in science education include (1) investigations of open or individualized laboratory settings (Fisher, Henderson & Fraser, 1997; Fraser, Giddings & McRobbie, 1995; Fraser & McRobbie, 1995; Fraser, McRobbie & Giddings, 1993; Wong & Fraser, 1995), (2) evaluation of educational innovations and systemic reform (Fraser, Kahle, Scantlebury, 1999; Khoo & Fraser, 1997; Maor & Fraser, 1996; Teh & Fraser, 1994), (3) investigations of differences between student and teacher perceptions of experienced and perceived learning environments (Fisher & Fraser, 1983), (4) assessing the degree to which a classroom environment is consistent with constructivist epistemology (Aldridge, Fraser, Taylor & Chen, 2000; Taylor, Fraser & Fisher, 1997), (5) studies of changes in learning environments during the transition from elementary to high school (Ferguson & Fraser, 1999), and (6) assessing the interpersonal relationships between students and teachers (Wubbels & Levy, 1993).

One of the strongest traditions in past classroom environment research has involved investigations of associations between students' cognitive and affective learning outcomes and their perceptions of the learning environment. Numerous studies have established associations between classroom and school environment, achievement, and attitudes among samples of students of different ages and in different subject areas (Fraser, 1998a; Fraser & Fisher, 1982; McRobbie & Fraser, 1993; Wong, Young & Fraser, 1997). In analyses of large data bases collected as part of the National Assessment of Educational Progress, classroom and school environment was found to be a strong predictor of both achievement and attitudes (Fraser, Welch & Walberg, 1986). The present study adds to the data by examining the relationships between classroom environment and the achievement and attitudes in science among elementary school students.

Research has also been conducted to help teachers to improve the environments of their own classrooms (Fraser, 1991, 1998a). Feedback information, based on student perceptions reported on classroom environment surveys, can be used to reflect upon, discuss, and systematically improve classroom and school environments (Fraser, 1991, 1994, 1998a, 1999; Fraser & Fisher, 1986). These methods have been applied successfully in studies at the elementary level (Fraser, Docker & Fisher, 1988) and secondary levels (Thorp, Burden & Fraser, 1994; Woods & Fraser, 1996). Preservice teachers have also been involved in action research on their teaching practice in elementary school classes and in their university teacher education classes. Improvements were observed in the classroom environments, and the preservice teachers generally valued the opportunity to be involved in action research aimed at improving classroom environments (Yarrow, Millwater, & Fraser, 1997).

Most of the instruments used in the research applications mentioned were constructed for students at secondary levels or higher. The *My Class Inventory* (MCI) was created for 8-12 year old children by simplifying the *Learning Environment Inventory* (LEI) (Fisher & Fraser, 1981; Fraser & O'Brien, 1985). Although the MCI was developed originally for use at the elementary school level, it also has been found to be very useful with students in middle school, especially those who might experience reading difficulties with other instruments (Goh, Young & Fraser, 1995).

In an effort to provide an instrument that is more applicable in today's classroom settings, the *What is Happening in this Class?* (WIHIC) questionnaire was developed by combining scales from past questionnaires with contemporary dimensions to bring parsimony to the field of learning environments (Fraser, McRobbie & Fisher, 1996). The WIHIC has been found to be valid and useful in studies at various grade levels (Chionh & Fraser, 1998; Dorman, 2001; Moss & Fraser, 2001). Other studies have supported the validity of the WIHIC in numerous countries (Aldridge & Fraser, 2000; Aldridge, Fraser & Chionh, 2000; Fraser & Huang, 1999; Khine & Fisher, 2001; Margianti & Fraser, 2000; Riah & Fraser, 1998; Zandvliet & Fraser, 1998). The seven dimensions of the classroom environment that are assessed in the WIHIC are student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, and equity. However, this instrument was not originally designed for use with elementary school students. Therefore, our study employed a version of the *What is Happening in this Class?* questionnaire that was revised to be more easily understood by elementary age students in the United States.

The present study contributes to the field of learning environment because it provides one of the few studies that have incorporated learning environment ideas in investigating the efficacy of mentoring programs for beginning teachers.

3.3 Student Achievement and Attitudes in Science

Current reform efforts in science education have their roots in the report *A Nation at Risk* (Gardner & Others, 1983). The report was critical of education in the United States and raised concerns that national student achievement across core subjects was eroding. Some evidence for these deficiencies can be found in reports such as the National Assessment of Educational Progress (NAEP). These reports make information on student performance, in the United States, available to policymakers at the national, state, and local levels. Student performance in science has been tracked since 1969 in reports such as the *NAEP 1996 Trends in Academic Progress*.

The NAEP trend report revealed declines in the overall science performance of fourth grade students (9-year olds) during the late 1970s, followed by improvements in the 1980s. The average performance of the fourth-grade students continued to improve in the 1996 assessment (O'Sullivan, Weiss & Askew, 1998). The average science achievement levels showed no significant change for fourth-grade students from the 1996 to the 2000 assessments. While the science scores have improved, it is important to note that, in the 1996 NAEP, 33% of fourth grade students scored below the basic level, 38% at the basic level, 26% at the proficient level, and 3% at the advanced level. In the 2000 NAEP, 34% of fourth graders scored below the basic level, 37% at the basic level, 26% at the proficient level, and 3% at the advanced level (Weiss, Banilower, McMahon & Smith, 2001).

The findings of the Third International Mathematics and Science Study (TIMSS) examined the educational systems in a large number of countries in terms of student achievement, curriculum coverage, and teaching methodologies (Martin, Mullis, Beaton, Gonzalez, Smith & Kelly, 1997). At the fourth-grade level, results revealed that students in the U.S. performed above the international average in science and were outperformed only by students from Korea.

These important studies emphasize the necessity of maintaining a focus on student achievement in science. In an effort to improve learning and achievement for all students, the professional development of teachers, especially beginning teachers, takes on a central role. However, there is relatively little research that directly addresses the connection between the professional development of teachers and student learning (Loucks-Horsley & Matsumoto, 1999).

Many things beyond what teachers plan for their classes influence what students learn in school. Students' attitudes, the interest and involvement of parents, and school climate all can affect teaching and learning both positively and negatively, although it would be inadvisable to assume a causal connection between any single variable and a student's performance (O'Sullivan & Weiss, 1999). As part of the NAEP 1996 and 2000 science assessments, students were asked questions concerning their attitudes and beliefs about science. The TIMSS also asked students a series of questions about the importance and enjoyability of science and science subject areas. Students' perceptions about the value of learning the sciences can be considered as both an input and outcome variable, because their attitudes towards science subjects can be related to educational achievement in ways that reinforce higher or lower performance. That is, students who do well in the sciences generally have more positive attitudes towards science subjects, and thus tend to perform better (Martin, Mullis, Beaton, Gonzalez, Smith & Kelly, 1997).

In the 1996 NAEP, 'positive attitudes' and 'negative attitudes' refer to the way in which students responded to six of the eight statements. The positive attitudes consisted of the 'agree' responses to three statements – "I like science", "I am good at science", and "Science is useful for solving everyday problems" – and the 'disagree' responses to three statements – "Learning science is mostly memorizing", "If I had a choice I would not study any more science in school", and "Science is boring". Conversely, 'disagree' responses to the first three questions and 'agree' responses to the latter three questions were interpreted as negative attitudes. Among fourth-grade students, 67% said that they liked science and 64% said that they would continue to study it even though less than 45% believed that they were good at it. 84% of the students thought that everyone can do well in science if they try and 40% thought that science was mostly memorizing. 79% of the fourth grade students did not agree that science is boring (O'Sullivan & Weiss, 1999).

The 1996 NAEP results support the connections reported in the literature between positive student attitudes and higher achievement. At the fourth-grade level, students who said that they liked science or were good at science had higher scale scores and were more likely to perform at or above the Proficient level than those who said they were not sure or did not like science. Students who indicated that they were not sure if they were good at science outperformed those who did not think that they were good at it (O'Sullivan & Weiss, 1999).

The TIMSS reports similar results for fourth grade students in the United States. 91% of the students tested, agreed or strongly agreed that they did well in science, and these perceptions were supported by the science achievement results: those who agreed that they usually do well performed better, on average, than those who disagreed. Three statements reflecting student attitudes to science ("I like science", "I enjoy learning science", and "science is boring") were combined to form an index of overall attitude to science. 84% of the fourth grade students reported positive or strongly positive attitudes. A strong positive relationship between attitude to science and science achievement was also reported in the United States (Martin, Mullis, Beaton, Gonzalez, Smith & Kelly, 1997).

The current study places mentoring in the context of professional development for beginning teachers and investigates student outcomes of achievement in science and attitudes about science in order to study the impact of the mentoring program on the students of the beginning teachers.

3.4 Teacher Attitudes About Teaching Science

Research shows that, if teachers do not feel adequately prepared in a particular subject area, such as science, they could neglect this subject and focus on other academic areas in which they feel more comfortable (Brophy, 1991). This finding is of particular concern at the elementary school level, where most students are taught in self-contained classrooms and remain with the same teacher for most academic subjects. Teachers who held an undergraduate or graduate major in education taught 74% of the grade 4 students who participated in the 1996 NAEP. 10% of the fourth-grade students were taught by teachers who held a science or a science education degree (O'Sullivan, Weiss & Askew, 1998). While fourth-grade teachers might not be expected to have a degree in science, the lack of an academic concentration in science by fourth-grade teachers could be of some concern because research has shown that, without the essential base of subject matter knowledge, teachers could be unable to instruct effectively (Grossman, Wilson & Shulman, 1989; Lee, 1995). Research has also shown that, if teachers possess both subject matter expertise and the ability to present that subject matter to students, they are more likely to engage in activities that facilitate student learning (Tobin & Fraser, 1990).

Cochran and Jones (1998) explain that subject matter knowledge represents an umbrella conception, with four components nested within (1) content knowledge – the facts and concepts of the subject matter, (2) substantive knowledge – the explanatory structures or paradigms of the field, (3) syntactic knowledge – the methods and processes by which new knowledge in the field is generated, and (4) beliefs about the subject matter – learners' and teachers' feelings about various aspects of the subject matter. It is the fourth component of this conception that was investigated in this study.

The 2000 National Survey of Science and Mathematics Education, conducted by Horizon Research with a grant from the National Science Foundation, found that substantial portions of elementary teachers believe that they are not well qualified to teach science. 75% of the elementary teachers surveyed said they are 'very well qualified' to teach language arts/reading, and 60% felt 'qualified' to teach mathematics, but only about 25% think they are 'very well qualified' to teach science. The elementary teachers were also asked to rate their confidence in their preparation in different science disciplines. Only 29% of the teachers considered themselves 'very well qualified' to teach life science, 25% rated themselves 'very well qualified' to teach earth science, and only 18% considered themselves 'very well qualified' to teach physical science. The same survey also reports that the amount of time spent on K-6 reading dwarfs science instruction. In self-contained classes in grades 4-6, the average time spent teaching for reading/language arts was 96 minutes and only 31 minutes for science (Weiss, Banilower, McMahon, & Smith, 2001).

These findings support Brophy's (1991) findings that teachers might neglect the subjects that they feel less prepared to teach. It must also be noted, however, that many school districts mandate the time that must be spent on various subject areas and this could be reflected in the findings of the survey.

Preservice elementary teachers have less confidence in their ability to teach science than other subjects; however, it has been reported that these teachers also showed high levels of motivation to improve their knowledge for teaching science (Wenner, 1993). In view of this finding, it is understandable that many novice teachers maintain these beliefs in the early years of their teaching careers. It is well established in the literature that as teachers' subject matter increases, their confidence in their ability to teach that subject also increases. The literature also reports that the process of teaching itself increases teachers' subject matter knowledge, although we have very little information on how this occurs (Cochran & Jones, 1998).

Hauslein, Good, and Cummins (1992) suggest that the subject matter knowledge of experienced teachers should be a leading influence on the way in which preservice teachers are exposed to content fields. In addition, it has been suggested that science teacher preparation should include specially designed courses of study that meet the dual goals of building content knowledge and preparing preservice teachers to teach that content (Tobin, Kahle and Fraser, 1990). These findings seem to support the use of a mentor teacher to assist beginning teachers with their science instruction.

The current study adds to the research by investigating the effect of a two-year mentoring program on the beginning teachers' attitudes about teaching science.

4.0 Methodology

This section presents the methodology used in the study in terms of quantitative and qualitative methods (section 4.1), sample (4.2), mentoring program (4.3), assessment of classroom learning environment (4.4), assessment of student achievement and attitudes (4.5), and assessment of teacher attitudes (4.6).

4.1 Quantitative and Qualitative Methods

Quantitative and qualitative methods were combined in order to collect data from as many different sources as possible (Anderson, 1998; Erickson, 1998; Fraser, 1999; Fraser & Tobin, 1991; Punch, 1998; Tobin & Fraser, 1998). Multiple data sources from multiple perspectives allowed triangulation of interpretations (Denzin, 1989; Huberman & Miles, 1998; Miles & Huberman, 1994). Greater credibility can be placed in the findings of the research because common patterns emerged from data obtained using a range of different data collection methods (Fraser, 1994; Miles & Huberman, 1994). Data sources included collection of site documents (lesson analyses and evaluations, self-reflections and reflective journals), field notes of classroom observations, tape recordings and transcriptions of focus group discussions with project teachers. In addition to the quantitative student data, interviews with selected students of the mentored teachers were conducted to explore further their perceptions of the classroom environment and their feelings about science. As data analysis proceeded, hunches about patterns that developed on the basis of field notes were cross-checked and confirmed by reference to interview or focus group data and site documents (Anderson, 1998; Erickson, 1998; Miles & Huberman, 1994).

The idea of 'grain sizes' (the use of different-sized samples for different research questions varying in extensiveness and intensiveness) in learning environment research (Fraser, 1999) has been used effectively in studies that combine different methodologies (Fraser & Tobin, 1991;

Tobin & Fraser, 1998), and was used to guide the collection of data for this study. Different sample sizes were used to answer different research questions in the main study.

Triangulation was used to strengthen the study design and data interpretation, to secure an in-depth understanding of the learning environment, and to provide richness to the whole. Member checks were used to strengthen the internal validity of the study (Gratch, 1998; Guba, 1981; Punch, 1998). Focus group transcripts were taken back to the participants to ensure that the records were accurate. In order to confirm, validate and verify the data, the teachers and students were asked to give feedback about the interpretation and representation of their words and thoughts throughout the project. Teachers were asked to review the preliminary interpretations of the data and to share their interpretations and insights with the researchers (Miles & Huberman, 1994).

4.2 Sample

Different sample sizes were used to answer different research questions. For the first research question involving the validation of the modified WIHIC, two different size samples were used. A larger sample (sample 2) of 573 students in 33 classes was used as well as a smaller sample (sample 1) of 169 students in 6 classes. From the initial groups of first-year and second-year K-5 teachers who participated in a five day professional development experience in science, seven grade 3-5 teachers of different genders, ethnic backgrounds, and ages – together with their 185 students – were selected for participation in the mentoring phase of this project. The sample used to answer the second, third, and fourth research questions consisted of these teachers and students. Selection of the teachers was based on the availability and location of the mentor teachers throughout the six regions of the school district. Several students in the mentored teachers' classes were selected for follow-up interviews about their perceptions of the classroom learning environment and their feelings about science.

4.3 Mentoring Program

The mentoring program designed in this study focused on developing the roles of the mentor teachers as *educational companions* and *agents of change* (Feiman-Nemser & Parker, 1993). Each of the seven beginning elementary teachers was paired with a veteran elementary science resource teacher. An orientation meeting was held at the beginning of each of the two years of the mentoring program to discuss and plan the mentoring program in detail. The teacher teams scheduled three days for the beginning teachers to work with their mentors in the mentor teachers' classrooms, and three days for the mentor teachers to work with the beginning teachers in the beginning teachers' classrooms. The teacher teams worked together to develop lesson plans for three science lessons that were taught during each of their visits. Some of the teacher teams planned full-day lessons while others taught half-day lessons and then assisted with lessons in other subject areas.

All of the beginning teachers responded to a questionnaire on a pre- and post-basis during the two years of the mentoring program, and all of the teachers kept reflective journals describing their experiences, feelings, and growth during the mentoring experience. Observations of the teacher teams were made throughout the two years of the mentoring program. At the end of each of the two years of the mentoring program, group interviews or 'focus groups' were conducted to discuss the teachers' perceptions of the mentoring experience (Fontanta & Frey, 1998). These group sessions were audiotaped and videotaped, and then transcribed. Student outcomes were not measured until the second year of the mentoring program in an effort to build trust and rapport between the beginning teachers and their mentors, and the researchers during the first year of the program.

4.4 Assessment of Classroom Learning Environment

The *What is Happening in This Class?* (WIHIC) was used to measure students' perceptions of their classroom environment and provide insight into some of the effects of the mentoring program. The WIHIC, developed by Fraser, McRobbie and Fisher (1996) to bring parsimony to the field of learning environments by combining the most salient scales from existing questionnaires with new dimensions of contemporary relevance, assesses the following seven dimensions of the classroom environment:

- *Student Cohesiveness* (extent to which students know, help and are supportive of one another)
- *Teacher Support* (extent to which the teacher helps, befriends, trusts and is interested in students)
- *Involvement* (extent to which students have attentive interest, participate in discussions, do additional work and enjoy the class)
- *Investigation* (emphasis on the skills and processes of inquiry and their use in problem solving and investigation)
- *Task Orientation* (extent to which it is important to complete activities planned and to stay on the subject matter)
- *Cooperation* (extent to which students cooperate rather than compete with one another on learning tasks)
- *Equity* (extent to which students are treated equally by the teacher).

The version of the WIHIC used in this study was revised to be more appropriate for use with grade 3-5 students. It was field tested with 10 grade 3-5 classes in eight different schools with different ethnic and cultural populations. In addition, individual students were interviewed to determine if the questions were understood in the context that the researcher intended. These interviews led to only slight modifications to a few items. Each of the 56 items was responded to using the three alternatives of Almost Never (1), Sometimes (2), and Almost Always (3). The researchers used a three-response model instead of the original five responses (i.e. Almost Never, Seldom, Sometimes, Often, and Almost Always) in order to make it easier for the elementary age students to respond to the questions.

The modified WIHIC was administered to 573 students at the beginning of the second year of the mentoring program. The Appendix contains the 43 items from the WIHIC that survived the factor and item analyses described later in this paper. The modified WIHIC was then administered to the students of the mentored teachers again at the end of the second year of the mentoring program. The pre- and post-data provided insights into the effect of the mentoring project on the students' perceptions of the classroom learning environment.

4.5 Assessment of Student Achievement and Attitudes

The 169 students (sample 1) of the mentored grade 3-5 teachers responded to an achievement test as a pretest and posttest during the second year of the mentoring program. The Science Achievement Test consisted of 27 of the 65 items released in June, 1997 from the 1995 Third International Mathematics and Science Study (TIMSS) science test for population 1 (students enrolled in the two adjacent grades that contained the largest proportion of 9-year-old students – grades 3 and 4 in many countries). The TIMSS tests were developed through an international consensus involving input from experts in science and measurement specialists. The TIMSS Subject Matter Advisory Committee, which included distinguished scholars from 10 countries, ensured that the test reflected current thinking and priorities within the field of science. The items underwent an iterative development and review process, with several pilot efforts and statistical item analysis of data collected in the pilot testing.

In the Science Achievement Test used in this study, 18 of the questions were in multiple-choice format and 9 questions were in free-response format, which required students to generate and write their own answers. For the multiple-choice items, a '1' was given for the correct answer and a '0' was given for an incorrect answer or no answer. For free-response questions, the TIMSS scoring rubric was used and a '1' was given for the correct answer and a '0' was given for an incorrect answer or no answer. The number of test items included in the four content areas were:

- Earth Science – 1 question
- Life Science – 5 question
- Physical Science – 18 questions
- Environmental Issues and the Nature of Science – 3 questions.

An emphasis was placed on physical science in this instrument because anecdotal evidence from the researchers' work with elementary school teachers suggested that many of the teachers felt uncomfortable when teaching physical science and tended not to emphasize physical science in their instruction with students. In the 2000 National Survey of Science and Mathematics Education, conducted by Horizon Research with a grant from the National Science Foundation, only 18% of the elementary teachers surveyed considered themselves 'very well qualified' to teach physical science, while 76% of the same teachers reported they are 'very well qualified' to teach language arts/reading (Weiss, Banilower, McMahon, & Smith, 2001).

To determine the internal consistency reliability of the original Science Achievement Test, Cronbach's alpha coefficient was calculated. 16 of the 27 original items on the test survived the analysis of internal consistency reliability.

The students (sample 1) of the mentored grade 3-5 teachers also responded to a survey of their attitudes about science in a pretest and posttest during the second year of the mentoring program. Students' perceptions about the value of learning the sciences are important because they can be related to educational achievement in ways that reinforce higher or lower performance. That is, students who do well in the sciences generally have more positive attitudes towards science subjects, and thus tend to perform better (Martin, Mullis, Beaton, Gonzalez, Smith, & Kelly, 1997).

Student attitudes were assessed using the Feelings About Science survey which consisted of the eight items that were used in the 4th grade student background questionnaire in the 1996 National Assessment of Educational Progress (NAEP). The NAEP background questions probed students' general backgrounds, their science experiences, and their motivations. The 1996 NAEP in science continues a 27-year mandate to report what students in grades 4, 8, and 12 know and can do in various subject areas. This report provided an opportunity to examine current policies and practices. It was intended primarily for policy makers, school administrators, and educators concerned with state or school-level policies. The results are presented using the students as the unit of analysis (O'Sullivan, 1998).

Several of the items on the Feelings About Science survey were also included in the Student Questionnaire for Population 1 in the 1995 IEA Third International Mathematics and Science Study (TIMSS) and will be included in the 2003 Trends in Mathematics and Science Study. In order to collect information on fourth-grade students' perceptions of science, students participating in TIMSS were asked a series of questions about the importance and enjoyability of science and science subject areas. Three statements reflecting student attitudes to science ("I like science," "I enjoy learning science," and "Science is boring") were combined to form an index of overall attitude to science (Martin, Mullis, Beaton, Gonzalez, Smith, & Kelly, 1997).

In the current study, the student attitude survey was given at the beginning and end of the second year of the mentoring program. The students of the mentored teachers responded to the eight items in the Feelings About Science survey using a three-point response scale of Agree (3), Not Sure (2), and Disagree (1). Following item analysis, two items were deleted from the 8 original items on the survey to improve the scale reliability.

To establish internal consistency reliability of the achievement and attitude pretest and posttest, Cronbach's alpha coefficient was calculated. Table 1 reports the internal consistency for the 16 items on the achievement test and the 6 items on the attitude survey. Using the individual as the unit of analysis, the alpha reliability coefficient for the Science Achievement Test was 0.75 for the pretest and 0.78 for the posttest. With the individual as the unit of analysis, the alpha reliability coefficient for the Feelings About Science attitude survey was 0.69 for the pretest and 0.63 for the posttest. Values greater than 0.70 are considered acceptable by most researchers for this measure. As expected, the small sample size resulted in somewhat lower alpha reliability values.

Table 1. Internal Consistency Reliability (Cronbach Alpha Coefficient) for the Achievement and Attitude Scales for the Pretest and Posttest with the Individual as the Unit of Analysis

Scale	No of Items	Alpha Reliability	
		Pre	Post
Science Achievement	16	0.75	0.78
Feelings about Science	6	0.69	0.63

The sample consisted of 169 students in 6 mentored teachers' classes.

4.6 Assessment of Teacher Attitudes

A questionnaire designed by the researchers was completed by the seven mentored teachers to provide data in the following areas: biographical information; teaching experience and preparation; and attitudes about science instruction. Teachers were asked to rate their level of confidence, knowledge, and valuing of (1) teaching science, (2) active learning in science, (3) positive classroom learning environments, and (4) reflective practice. Additionally, the teachers were asked to provide narrative responses about their strengths and weaknesses as science teachers. The questionnaire was given to the teachers at the beginning and end of each of the two years of the mentoring program. The teachers responded to the 12 items in the questionnaire using a five-point response scale of Very High (5), High (4), Average (3), Low (2), and Very Low (1).

The teacher questionnaire included items from two main sources. The biographical information and teaching experience and preparation items were used in the teacher background and science preparation section of the Mathematics and Science Teacher Questionnaire used in the 1996 National Assessment of Educational Progress (NAEP). The questionnaire also included conceptions of teaching underlying three teacher performance-based assessments described by Porter, Youngs, and Odden (1998). The assessments are from the Educational Testing Service (ETS), the Interstate New Teacher Assessment and support Consortium (INTASC), and the National Board for Professional Teaching Standards (NBPTS). The similarities between the conceptions included in these assessments are in the areas of (1) subject matter knowledge, (2) knowledge of students, (3) engaging students in active learning, (4) reflective practice, and (5) pedagogical content knowledge.

The questionnaire was given to the 100 first-year and second-year K-5 teachers on the first and last day of the initial five-day professional development experience and was used to pilot-test the questionnaire. As recommended by Anderson (1998), a group of 10 teachers were asked to write marginal comments on the actual questionnaire and then participated in a group discussion about the wording of the items and gave their overall reactions and comments about the length of the questionnaire. Minor modifications to the questionnaire were made as a result of this process.

5.0 Results

The analyses of the quantitative and qualitative information related to each of the research questions is reported below in terms of the reliability and validity of the WIHIC learning environment questionnaire (section 5.1), changes in classroom learning environment, student achievement, and student attitudes about science between pretest and posttest (section 5.2), associations between the students' perceptions of the learning environment and student achievement and attitudes (section 5.3), and changes in teachers' attitudes about teaching science (section 5.4).

5.1 Reliability and Validity of the What is Happening in This Class? (WIHIC) Questionnaire

Data collected from the study's two samples were analyzed in various ways to investigate the reliability and validity of the original seven-scale, 56-item version of the modified WIHIC questionnaire. Sample 1 consisted of the 169 grade 3-5 students of six mentored teachers in year two of the study, and sample 2 consisted of 573 grade 3-5 students in 23 classes, including the 169 students in sample 1. A principal components factor analysis followed by varimax rotation resulted in the acceptance of a revised version of the WIHIC instrument consisting of 43 items in six scales. There are 4 items in Student Cohesiveness, 7 items in Teacher Support, 8 items in Investigation, 8 items in Task Orientation, 8 items in Cooperation, and 8 items in Equity. These factor analyses led to the complete elimination of Involvement, as well as a total of 5 items from the other scales. Table 2 shows the factor loadings for each of the remaining 43 items for sample 1 and separately for sample 2. Loadings smaller than the conventionally accepted value of 0.30 have been omitted from the table.

Table 2 clearly shows that the *a priori* factor structure was replicated almost perfectly for the larger sample (sample 2) of 573 students. Each of the 43 items has a factor loading larger than 0.30 with its own scale. Moreover, with the exception of item 47 and the Task Orientation scale, all items have factor loadings smaller than 0.30 on all other scales except their *a priori* scales for sample 2.

As expected, the factor structure is not as strong for sample 1 as this has the relatively small sample size of only 169 students. Table 2 shows that three of the 43 items (items 7, 28 and 51) have a loading of less than 0.30 with their *a priori* scale. Moreover, Table 2 also shows that (out of a possible of 43 x 5 = 215 loadings with other scales), there are 9 cases for which an item has a loading of greater than 0.30 with a scale other than it's *a priori* scale.

The bottom of Table 2 shows that the percentage of variance for different scales ranges from 3.75% to 19.24% for sample 1 and from 3.40% to 24.88% for sample 2, with the total variance accounted for being 44.64% for sample 1 and 62.05% for sample 2. Eigenvalues for the different scales vary from 0.94 to 7.65 for sample 1 and from 0.84 to 10.48 for sample 2.

Table 2. Factor Loadings for the Modified WIHIC for Two Samples

Item No	Student Cohesiveness		Teacher Support		Investigation		Task Orientation		Cooperation		Equity	
	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
1	0.55	0.56										
2	0.32	0.34										
4	0.67	0.62										
7	–	0.50										
9			0.61	0.59								
10			0.54	0.60								
11			0.49	0.56								
12			0.39	0.55								
13			0.48	0.52								
14			0.49	0.50								
15			0.45	0.50								
25					0.54	0.46						
26			0.31		0.50	0.42						
27					0.53	0.57						
28			0.31		–	0.51						
29					0.41	0.49						
30					0.59	0.59						
31					0.57	0.65						
32					0.42	0.49						
33							0.66	0.44				
34							0.71	0.48				
35							0.57	0.50				
36							0.67	0.50				
37							0.56	0.53				
38							0.60	0.50				
39							0.38	0.38				
40							0.47	0.42				
41									0.45	0.49		
42									0.45	0.44		
43							0.33		0.31	0.38		
44									0.39	0.52		
45									0.50	0.45		
46									0.56	0.65		
47							0.36	0.34	0.47	0.50		
48									0.50	0.52		
49											0.47	0.54
50			0.34								0.53	0.59
51											–	0.51
52			0.36								0.61	0.56
53			0.36								0.38	0.58
54			0.42								0.34	0.56
55											0.43	0.53
56			0.33								0.45	0.56
% Variance	3.75	3.40	7.92	9.92	5.33	13.21	19.24	3.98	4.45	6.66	3.95	24.88
Eigenvalue	0.94	0.84	2.80	3.81	1.67	5.27	7.65	1.36	1.29	2.59	1.09	10.48

Factor loadings smaller than 0.30 have been omitted.
Sample 1 consisted of 169 students in 6 classes of 6 mentored teachers.
Sample 2 consisted of 573 students in 23 classes, including 6 classes of 6 mentored teachers.

To establish that each scale has satisfactory internal consistency, or that each item in a scale assesses a common construct, Cronbach's alpha reliability coefficient was calculated for sample 1 (169 grade 3-5 students in six mentored teachers' classes) and for sample 2 (573 grade 3-5 students in 23 classes, including the 169 students in sample 1). Table 3 reports the internal consistency for each of the six scales for the two samples using two units of analysis (the individual and the class mean). Using the individual as the unit of analysis, scale reliabilities for sample 1 (N=169) range from 0.57 to 0.82, and from 0.64 to 0.85 for sample 2 (N=573). Using the class mean as the unit of analysis, scale reliability estimates for sample 1 (N=169) range from 0.82 to 0.95 and 0.73 to 0.95 for sample 2 (N=573). As expected, reliability values are higher when the class mean is used as the unit of analysis as opposed to the individual student. Values greater than 0.70 are considered acceptable by most researchers for this measure. Generally the values of the alpha reliability for each scale of the modified WIHIC in Table 3 support the internal consistency of the WIHIC for both samples and for two units of analysis.

To determine the discriminant validity of the modified WIHIC, the mean correlation of each of the scales with the other five scales was calculated for sample 1 and sample 2 and is also reported in Table 3. Using the individual as the unit of analysis, mean correlations for sample 1 (N = 169) range from 0.25 to 0.48, and from 0.30 to 0.46 for sample 2 (N = 573). Using the class mean as the unit of analysis, mean correlations range from 0.39 to 0.58 for sample 1 (N = 169), and from 0.23 to 0.56 for sample 2 (N = 573). The mean correlations indicate that raw scores on these scales measure distinct though somewhat overlapping aspects of the classroom environment. However, the factor analysis results attest to the independence of factor scores on the scales of the WIHIC.

An analysis of variance (ANOVA) was used to determine the ability of each WIHIC scale to differentiate between the perceptions of students in different classes for the two samples. The eta^2 statistic was calculated to provide an estimate of the strength of association between class membership and the dependent variable (WIHIC scales). Table 3 presents the ANOVA results for the two samples. All six scales differentiated significantly between classes ($p<0.01$) for sample 2 (N = 573). For sample 1 (N = 169), five of the six scales differentiated significantly between classes ($p<0.05$). The Student Cohesiveness scale showed no significant difference between classes.

Table 3. Internal Consistency Reliability (Cronbach Alpha Coefficient), Discriminant Validity (Mean Correlation With Other Scales) and Ability to Differentiate Between Classrooms (ANOVA Results) for Two Units of Analysis for the modified WIHIC for Two Samples

Scale	Unit of Analysis	No of Items	Alpha Reliability		Mean Correlation with other Scales		ANOVA Eta²	
			Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
Student Cohesiveness	Individual	4	0.57	0.64	0.25	0.30	0.04	0.11**
	Class Mean		0.83	0.73	0.43	0.52		
Teacher Support	Individual	7	0.73	0.80	0.30	0.37	0.10**	0.24**
	Class Mean		0.82	0.91	0.46	0.46		
Investigation	Individual	8	0.77	0.80	0.42	0.46	0.15**	0.22**
	Class Mean		0.93	0.90	0.39	0.56		
Task Orientation	Individual	8	0.82	0.75	0.29	0.38	0.08*	0.11**
	Class Mean		0.95	0.81	0.58	0.41		
Cooperation	Individual	8	0.77	0.78	0.36	0.40	0.15**	0.13**
	Class Mean		0.92	0.88	0.57	0.23		
Equity	Individual	8	0.80	0.85	0.48	0.45	0.07*	0.20**
	Class Mean		0.90	0.95	0.53	0.52		

** $p<0.01$
* $p<0.05$
Sample 1 consisted of 169 students in 6 classes of 6 mentored teachers.
Sample 2 consisted of 573 students in 33 classes.
The eta^2 statistic (which is the ratio of 'between' to 'total sums of squares) represents the proportion of variance explained by class membership.

5.2 Changes in Classroom Learning Environment, Student Achievement, and Student Attitudes About Science Between Pretest and Posttest

The impact of the mentoring program on the students of the six mentored teachers was assessed in terms of changes in students' perceptions of the classroom learning environment, science achievement, and attitudes about science between pretest and posttest. The interval of eight months between pretesting and posttesting was when the mentored teachers implemented ideas from the professional development program and taught lessons with their mentor teachers during the second year of the mentoring program.

Table 4 shows the differences in average item mean classroom learning environment scores on the pretests and posttests given in year-two of the mentoring program. The average item mean, or the scale mean divided by the number of items in each scale, was used to allow meaningful interpretation of scale means and graphs for scales which contain different numbers of items. There was an increase in the average item mean scores on the posttest as compared to the pretest for five of the six WIHIC scales. The average item mean score decreased from the pretest to the posttest for the Teacher Support scale.

Effect sizes and paired t tests were calculated to investigate the differences between students' perceptions at the beginning and end of year-two. In order to estimate the magnitudes of the differences (in addition to their statistical significance), effect sizes were calculated as recommended by Thompson (1998a, 1998b). The effect size for the six scales of the WIHIC questionnaire range between 0.05 of a standard deviation and 0.26 of a standard deviation for average item means. These effect sizes suggest relatively little difference between pretest and posttest results on the learning environment scales. T tests for paired samples, using student scores as the unit of analysis, were used to investigate whether differences in scale scores between the pretest and posttest for the WIHIC were statistically significant. No significant differences were found between the pretest and posttest scores on environment scales.

Table 4 also shows the differences in average item mean science achievement scores and attitudes about science scores on the pretests and posttests given in year-two of the mentoring program. There was an increase in the average item mean scores on the posttest scores as compared to the pretest in both achievement and attitude. When effect sizes and paired t tests were calculated to investigate the differences between the pretest and posttest scores, the effect size for science achievement was more than half (0.60) of a standard deviation, and for attitude toward science was about one fifth (0.19) of a standard deviation. These effect sizes suggest a substantial difference between pretest and posttest results on the science achievement test and a smaller difference between pretest and posttest results on the attitude survey. T tests for paired samples, using the individual as the unit of analysis, were used to investigate whether differences in scores between the pretest and posttest for the achievement and attitude instruments were statistically significant. There was a statistically significant difference ($p<0.01$) for science achievement as well as for attitudes about science ($p<0.05$).

Figure 1 is a graphical representation of the average item mean scores on the pretest and posttest for the WIHIC, science achievement, and Feelings About Science scales. It is clear that, in the second year of the mentoring program, there were small positive increases in the students' perceptions of the classroom environment and their attitudes about science, and a larger increase in the students' science achievement scores during the same period of time.

A notable point is that information from the students' interviews was consistent with their perceptions as described by the WIHIC questionnaire. The questionnaire data appear to provide a basis for measuring students' perceptions of the learning environment at the elementary school level. The interviews suggested that students interpreted items in ways that were reasonably consistent with meaning intended by the questionnaire developers. The student interviews also suggest that students accurately reported their perceptions of the learning environment on the WIHIC survey. A second notable point is that, when the students were asked to describe their attitudes about science, their comments were consistent with their responses on the Feelings About Science survey.

Table 4. Average Item Mean, Average Item Standard Deviation and Difference between Pretest and Posttest (Effect size and *t* Test for Paired Samples) for the WIHIC, Achievement Test and Attitude Scale Using the Individual as the Unit of Analysis

Scale	Average Item Mean		Average Item Standard Deviation		Differences	
	Pretest	Posttest	Pretest	Posttest	Effect Size	*t*
<u>WIHIC</u>						
Student Cohesiveness	2.48	2.58	0.37	0.40	0.26	1.84
Teacher Support	2.43	2.41	0.40	0.45	0.05	-0.34
Investigation	2.23	2.31	0.41	0.46	0.18	1.46
Task Orientation	2.74	2.75	0.29	0.30	0.03	0.31
Cooperation	2.38	2.42	0.37	0.36	0.11	1.02
Equity	2.45	2.51	0.43	0.47	0.13	0.96
Science Achievement	1.71	2.10	0.69	0.60	0.60	6.80*
Feelings About Science	2.57	2.64	0.36	0.37	0.19	2.28**

** $p<0.01$
* $p<0.05$
N= 169 students in 6 classes
The science achievement score was multiplied by 3 to bring it in line with other scores.

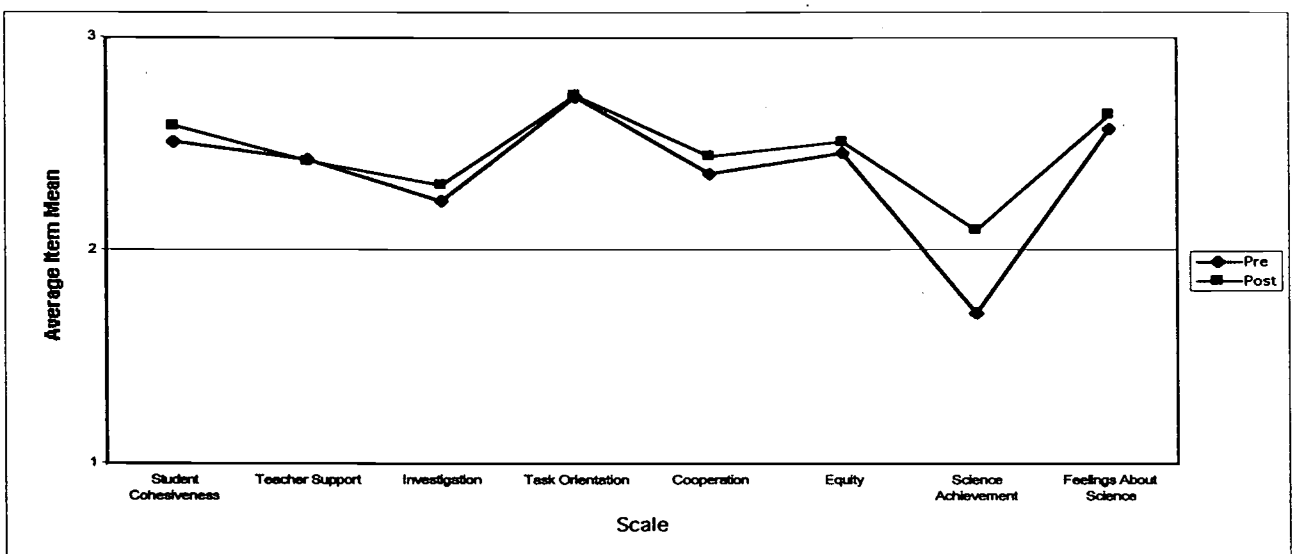

Figure 1. Average Item Mean on the Pretest and Posttest for the WIHIC, Student Achievement, and Feelings About Science

5.3 Associations Between Students' Perceptions of the Learning Environment and Student Achievement and Attitudes

Associations between the six classroom environment scales and the two student outcomes of achievement and attitudes were investigated using simple correlation and multiple correlation analyses using the student as the unit of analysis (N = 149). The sample size (N = 6) was too small to generate dependable statistics for class means. Table 5 reports the strength of the associations between the set of six WIHIC scales and student outcomes (science achievement and attitudes about science). The simple correlation (r) represents the bivariate association between each outcome measure and each classroom environment scale. The multiple regression analyses reduce the Type I error rate associated with the simple correlation analysis and provide information about the joint influence of correlated environment variables on student outcomes. Using the standardized regression coefficients (β), the WIHIC scales which contributed uniquely and significantly to the explanation of the variance in student outcome scores were identified. For example, in the case of the attitude survey, the standardized regression coefficients serve to identify the specific WIHIC scales that make significant contribution to explaining the variance in the attitudinal outcomes when the other environment scales are mutually controlled.

With the student as the unit of analysis, simple correlations with achievement ranged from -0.14 and 0.22 for different environment scales. There was a significant simple correlation (r) ($p<0.05$) between Investigation and science achievement. For attitudes about science, simple correlations ranged from -0.05 to 0.20 for different environment scales. A significant simple correlation (r) ($p<0.05$) was found between Cooperation and attitudes about science.

The multiple correlation analyses for each student outcome involved the association of outcome scores with the whole set of six environment scales, using the individual student as the unit of analysis. Table 5 shows that the significant multiple correlation (R) ($p<0.01$) between science achievement and the set of the WIHIC scales was 0.44. Table 5 also shows that the multiple correlation (R) between feelings about science and the set of the WIHIC scales was 0.30, but was not statistically significant.

With the individual student as the unit of analysis, Table 5 shows four significant standardized regression coefficients (β) for achievement and one for attitudes. In terms of science achievement, Investigation and Equity were significant and positive independent predictors ($p<0.01$), whereas Teacher Support and Cooperation were negative and significant independent predictors ($p<0.05$). Table 5 also shows that a positive and statistically significant association ($p<0.05$) was found between Cooperation and student attitudes about science when the other WIHIC scales were mutually controlled.

Table 5. Simple Correlation and Multiple Regression Analyses for Associations Between Student Outcomes (Student Achievement and Feelings About Science) and Dimensions of the Modified WIHIC for the Posttest Using the Student as the Unit of Analysis

Scale	Outcome – Environment Association			
	Science Achievement		Feelings About Science	
	r	*β*	*r*	*β*
Student Cohesiveness	0.01	0.01	0.09	0.03
Teacher Support	-0.11	-0.27*	0.03	-0.06
Investigation	0.22*	0.33**	-0.05	-0.23
Task Orientation	0.02	-0.13	0.14	0.05
Cooperation	-0.14	-0.22*	0.20*	0.24*
Equity	0.18	0.32**	0.10	0.18
Multiple Correlation (*R*)		0.44**		0.30

** $p<0.01$
* $p<0.05$
N= 149 students in 6 classes.
The sample size (N=6) was too small to generate dependable statistics for class means.

5.4 Changes in Teachers' Attitudes About Teaching Science

The impact of the mentoring program on the seven mentored teachers' attitudes about teaching science was measured by the teacher questionnaire. Teachers were asked to rate their level of confidence, knowledge, and valuing of (1) teaching science, (2) active learning in science, (3) positive classroom learning environments, and (4) reflective practice. Additionally, the teachers were asked to provide narrative responses about their strengths and weaknesses as science teachers. The questionnaire was given to the mentored teachers at the beginning and end of each of the two years of the mentoring program. The teachers responded to the 12 items in the questionnaire using a five-point response scale of Very High (5), High (4), Average (3), Low (2), and Very Low (1). The sample size (N=7) was too small to generate dependable statistical analyses, so the mean questionnaire scores for each teacher was examined.

Figure 2 shows the mean scores on the questionnaire for five of the seven mentored teachers on the four dates it was given. Results are not shown for two of the teachers because they did not complete the entire two-year mentoring program. Teacher A began with a mean of 3.67 at the beginning of year one and, by the end of year two, the mean had increased to 4.92. Teacher B's score increased from 3.92 to 4.75. Teacher C began and ended the project with a mean score of 5.00. Teacher D began with a mean of 3.92 and increased to 4.50. Teacher E went on maternity leave and did not complete the second year of the project, and Teacher F only participated in the second year. The mean score for Teacher G increased from 3.25 to 4.75 during the two years of the project.

From Figure 2, it appears that the attitudes about teaching science changed toward the positive for four of the five teachers who completed both years of the mentoring project. The fifth teacher's score showed no change, maintaining the high score throughout the project.

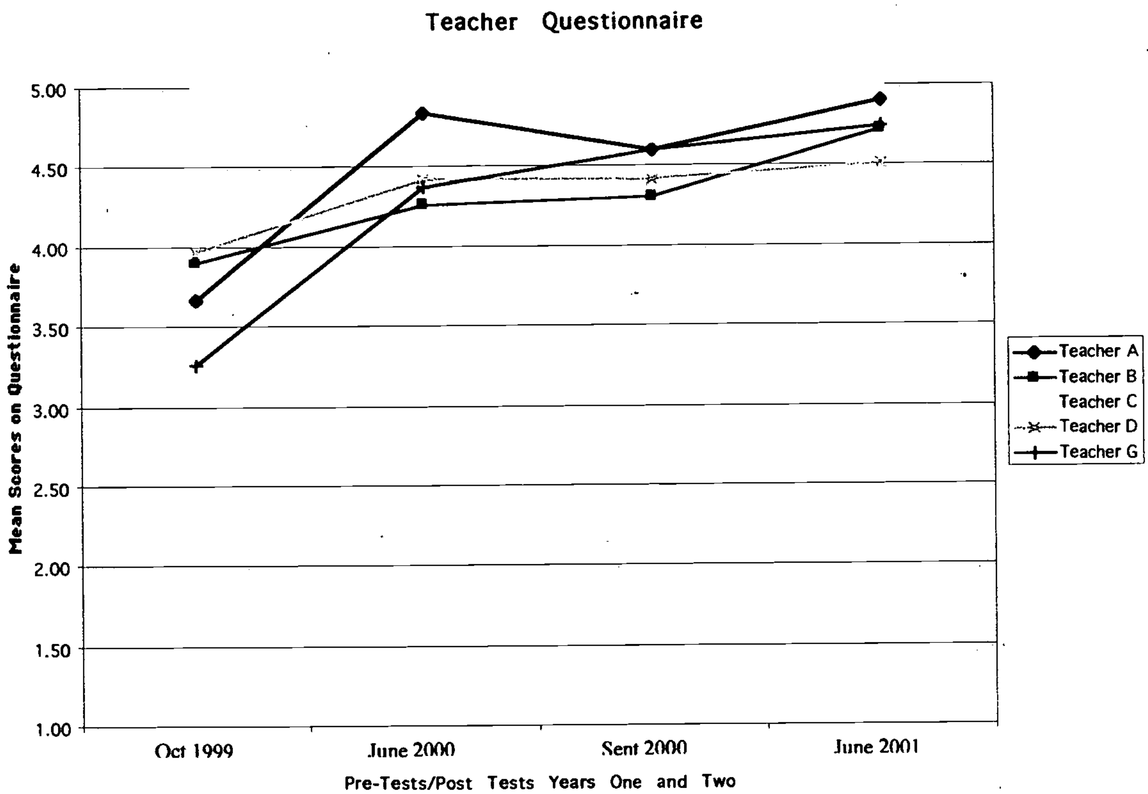

Figure 2. Mean scores on the Pretests and Posttests for the Teacher Questionnaire

6.0 Using Qualitative Methods to Explore Teachers' Attitudes About Teaching Science and the Mentoring Program

While the mean questionnaire scores showed an improvement in the teachers' attitudes about teaching science, the researchers drew upon qualitative information to further understand the changes in the beginning teachers' attitudes during the two-year mentoring project. Two classroom observations of all teams of beginning teachers and mentor teachers were undertaken during both years of the mentoring project. Detailed field notes were kept and student interviews were conducted. All of the participating teachers kept a reflective journal and completed a lesson analysis, activity evaluation, and reflection on three of the science lessons taught each year. Two questions on the beginning teacher questionnaire were written so as to elicit extended responses. All teachers met together at the beginning of years one and two, and focus groups with the beginning and mentor teachers were conducted at the end of each year. The focus groups were taped and transcribed.

The seven beginning teachers are referred to below by their pseudonyms: Teacher A – Julie, Teacher B – Terri, Teacher C – Mark, Teacher D – Lynne, Teacher E – Kathy, Teacher F – Annie, and Teacher G – Denise. All of the teachers were educated at universities in the United

States. Mark has a Master's degree in Elementary Education with a Bachelor's Degree in History and Language. All of the other teachers have Bachelor's degrees in Elementary Education, and Annie's degree includes specialization in Specific Learning Disabilities. Julie, Terri, Lynne, and Kathy are Hispanic and speak English and Spanish. Mark is a white American and speaks German, Arabic, Spanish, and English. Denise is African-American and speaks English. Annie describes herself as mixed ethnicity and speaks English. In the first year of the mentoring project, Julie, Terri, Mark, and Kathy were in their second year of teaching, while Lynne and Denise were first-year teachers. Annie, a second-year teacher, did not participate until the second year of the mentoring project and Kathy did not complete the second year of the project due to a maternity leave from teaching. She delivered fraternal twins, but one of the babies did not survive. She has since returned to teaching and seems to be successfully dealing with the loss of her child. Although Mark was only a second year teacher, he is 'older' than the other teachers are. Before teaching, Mark worked in government service in the Middle East and then as a building contractor in different areas of the United States. He frequently speaks of how happy he is to be a teacher and what a satisfying career it is. Julie, Terri, Mark, and Denise all have children and are learning to fulfill their family responsibilities while coping with the pressures of beginning teaching. Lynne recently became engaged and is making wedding plans. Annie is married and her husband is also a teacher. The second year of the mentoring project was very difficult for Denise because her father was murdered in a robbery at his place of business. After taking a couple of weeks off, Denise returned to work but was distracted by the criminal investigation and trial, and the effect of this tragic event on her family. Denise become engaged soon after her father's death and was married during the year. Denise finished the year on a positive note and is enjoying teaching second grade this school year.

Julie and Lynne work in the same school, but in different grade levels. Julie and her mentor teacher are on the fourth grade team and plan together on a regular basis. Lynne teaches third grade and her mentor teacher taught at a different school during the first year of the mentoring project, and worked as an educational specialist assisting teachers in ten different schools during the second year of the project. Denise and her mentor teacher worked together on the fifth grade team in the same school. Terri, Mark, and Kathy, all fifth grade teachers, and Annie, a fourth grade teacher, all had mentor teachers from different schools. Kathy and Annie teach different grade levels in the same school and had the same mentor teacher. Table 6 provides: the number of years of teaching experience that each teacher had at the beginning of the project, the grade level taught during year two of the project, the number of students in the teachers' classes in year two of the project, the total number of students in each teacher's school, and a demographic description of the student population in each school.

Table 6. Summary of Descriptive Information about Teachers, Classes, and Schools

Teachers	Number of Years Teaching at Start of Project	Grade Level Taught	Class Size	Total School Enrollment	Student Population of School (%)			
					Free/ Reduced Lunch	LEP	Black/ Non-Hispanic	Hispanic
A – Julie	2	4	19	1663	46%	15%	29%	57%
B – Terri	2	5	30	2096	47%	27%	9%	75%
C – Mark	2	5	23	1327	74%	52%	1%	90%
D – Lynne	1	3	35	1663	46%	15%	29%	57%
E – Kathy	2	5	35	1334	36%	24%	7%	70%
F – Annie	2	4	28	1334	36%	24%	7%	70%
G – Denise	1	5	25	1447	85%	48%	2%	92%

The teachers were asked to keep a reflective journal and to comment on their progress in the following areas: their level of confidence, knowledge, and valuing of teaching science; their active learning in science; their creating a positive classroom learning environment; their reflective practice in teaching science; and their overall impressions of the mentoring experience. The focus group discussions with the teachers at the end of years one and two of the mentoring project also centered on the same themes. The teachers' narratives on each of these themes are discussed in turn.

6.1 Level of Confidence, Knowledge, and Valuing of Teaching Science

All seven teachers wrote about and discussed an increase in their confidence and knowledge about teaching science. Lynne wrote:

> I developed my confidence as a science teacher. This has been the most worthwhile experience that I have had as a first year teacher. The mentoring project provided me with the resources, support, and motivation to become a more effective teacher. My knowledge about science topics and science process skills has grown and improved. This experience has provided me with the beginning of a bank of materials and ideas from which to scaffold for future use.

Julie, Terri, Mark, and Denise discussed their growth in confidence and knowledge in an interesting way. All said that they no longer felt pressured to "know everything". They talked about their willingness to take a risk and teach new topics in science. In the first year of the project, Mark talked about his fear that the students would find his flaws or discover that he "didn't know what he was talking about". At the end of the project, he wrote that he learned from his mentor that "if the students are left to their own devices in the classroom and if there is a creative environment and a teacher who is interested in learning and is excited about teaching, then the students will be fine, and will discover and learn". Julie wrote:

> I learned that it is okay not to know everything in science. I have given myself permission not be perfect all of the time. You don't have to know everything in science in order to take a chance and teach science. I think that a lot of times we're afraid to

teach science because you think you have to be a scientist in order to do science activities with kids. I'm no longer afraid to try new things and research the things that I don't know about. The students see me learning along with them. And when they see that, they say, "Hey, she doesn't know everything, so I guess it's okay". And if you're not afraid to take a chance, the students won't be afraid to take a chance. By the end of the second year, I felt like an expert. I take a lot more chances when I do science activities now.

Each of the teachers commented on their feelings that teaching science had become more important to them and that they valued the time spent doing science activities with their students. Some attributed this to their increased confidence in science and their observations that the students 'loved science' and looked forward to science activities and investigations. Annie said:

> The science activities help my students act good so they can go to the science lab. Some of the parents told me that it's the first time their kids have wanted to come to school. One student told his mother that the only reason why he wanted to come to school one particular day was because we were going to do a science experiment. I really felt like I made a difference because I'm a better science teacher now.

The teachers described their feelings that teaching science is valuable, but only when science instruction included active learning experiences for students. This theme is discussed in the next section.

6.2 Active Learning in Science

A common theme about which the teachers wrote and talked is moving away from a dependence on a science textbook for science instruction to a more activity-oriented science program. All of the teachers are required to teach a series of state grade-level expectations and district science competencies. However, the choice of which of the recommended science textbooks will be used, and how the state and district competencies will be met is made at the school level. In some schools, grade-level teams might agree upon a common curriculum while, in other schools, individual teachers make the decisions about what science activities to include in their science program. A great deal of the teachers' written comments and group discussions centered on the science textbooks and how much the textbook should be used in their science lessons. A common theme was a decreased dependence on the textbook in the teachers' science instruction.

At the end of the first year of the mentoring project Terri wrote:

> My first year teaching was straight from the book. I was scared to do anything else. I was bored and, if I'm bored, I know my children are bored. I knew that the students needed something else to motivate them in science. Last year, I started doing more hands-on activities and now my students love science. I think that they learn a lot more when they do hands-on activities than from just a lesson in a book. I find that I added activities that I would not have done before this project.

Lynne commented:

> I had a problem with science at the beginning of the first year because I was relying on my textbook. Because I am a first year teacher, I was told: "here's the textbook, use it". It was so old and boring and I think that I probably used it when I was in school. Now that I've been in the mentoring project for a year, most of the science lessons that I do are hands-on.

Kathy echoed this feeling: "As a result of this program, I allow the students to do more hands-on projects in science. I am doing with the students science activities which I would never have dreamed of doing before this experience. I've learned to let the students engage more with one another, and they help me learn as well." At the end of the first year of the project, Denise wrote: "At the beginning of this year I was afraid of science. But this program gave me a chance to work with a lot of hands-on activities and I really liked it. Before I would have just read the book with the students and gone over the questions but, as far as activities, I had no ideas of what to do. So, as a first year teacher, this program really helped a lot." By the end of the second year of the project, Denise expressed her growing confidence in active learning in science when she wrote: "I feel that this program has really helped me to become a better science teacher. I have found myself doing more hands-on activities which enable my students to become more engaged and more interested in science."

In her journal during the first year of the project, Julie wrote:

> I learned that students learn more by doing science experiments than by reading about them. Students enjoy science more and understand more of the concepts being taught when they do hands-on activities. Students experience more success in my classroom because I give them the opportunity to become actively involved in fun science activities and more time to come up with their own conclusions about the activities that we do. The students seem to feel more confident in their ability to learn.

At the end of the second year, Julie commented:

> The kids expect active lessons now. It's more interesting. The activities make me love to teach science because the kids love it. Their parents also noticed a difference between my class and how they learn in other classes without the hands-on activities. The kids tell their parents that they don't want to go to some of the special area classes because they don't want to miss the hands-on activities that they do in my class.

Mark discussed moving away from 'textbook science' and providing more active learning experiences in science for his students:

> We got a new science textbook this year, but I didn't really like it because I felt that the lessons were too abstract for my students. The kids didn't really understand the point of the activities. So, I had to think of other activities to do with the kids. I looked at examples that they gave in the book and adapted things from my own experiences to develop activities for the kids. I also tied the science activities to other areas of the curriculum. I think that, before the mentoring program, I wouldn't have had as much confidence in my ability to do this with my science lessons.

A frequent complaint from most elementary teachers is how to fit all of the required subjects and programs into a six and one-half hour day. Some elementary teachers are 'departmentalized' and teach only one or two subjects (i.e. science and mathematics), while others are expected to teach science, mathematics, language arts, and social studies. In addition to these subjects, the district curriculum requires instruction in special areas (i.e. physical education, music, art, Spanish) and numerous special programs (i.e. gifted, exceptional student education). Many teachers integrate other subjects with their science activities in an effort to use time more efficiently. In the focus group at the end of the second year, Mark gave an example of this type of interdisciplinary activity-based science lesson:

> I've always believed that active learning in science was important but, now that I've been in the mentoring program, I think it's even more important that I base most of my activities on books and then use what the characters do to develop my science activities. For example, we also read *The Great Raft Race* and then we made a list of materials on the board that would be useful for building rafts. Each student volunteered to bring in 25 of each item listed so that every student could take home a bag of the materials to use for building their rafts. That way, everyone had the same materials to use in the construction of their rafts. When the students brought in their completed rafts, we discussed each design. We took a field trip to a park with a big pond. We assumed that the pond was round and made measurements of the pond. From there, we determined the diameter, radius, circumference, and area of the pond. By doing this, we were doing important mathematics skills that weren't based on a lesson in the textbook. We had a contest to determine whose raft could make it across the pond fastest. Based on the measurements that we had made and using our stopwatches, we were able to determine the speed of each raft. We had prizes for the raft that made it across the pond fastest, the raft that made it across the fastest using the least amount of materials, and the raft with the greatest number of materials. The kids learned a lot of science as well as mathematics and, by reading the book, we also learned history and social studies.

In the focus group at the end of the second year of the mentoring program, Lynne summarized what she learned about connecting science to other subject areas:

> The mentoring program really increased my motivation and excitement about teaching science. I used to see science as separate, but now I have enough confidence to connect it to other areas and to expand on the textbook. It also helped me with time management. Now I know how to fit everything in.

In the focus group discussion at the end of the second year, the teachers concluded that the active learning strategies that they used for science positively impacted the learning environment in their classrooms. Annie commented: "Doing science activities with my students had an impact on the total classroom environment because the students behaved better because they want to participate in the science experiments or go to the lab." The theme of developing positive classroom learning environments is discussed in the section that follows.

6.3 Positive Classroom Learning Environments

Five of the beginning teachers agreed that the *What Is Happening In This Class?* (WIHIC) survey was useful for providing a view of their classrooms through their students' eyes. In the focus group at the end of the second year of the project, Terri said: "The classroom environment survey was really helpful to me because it helped me think more about what I do every day". Julie concurred: "The survey really made me look at my classroom through the students' eyes. I put myself in their little chairs and reexamined what I do."

All of the teachers wrote about the effect of obtaining feedback from the *What Is Happening In This Class*? (WIHIC) on their teaching behaviors. Lynne expressed her viewpoint:

> The classroom environment survey made me analyze what I do, and I was able to correct it by doing something that's so simple. For example, several students said that I didn't talk with them. When we discussed their answers, they clarified that I don't come to their desks to talk with them. They said that they don't like me to talk to them or always give them directions from across the room. I didn't know that they felt like that because I knew that I was making eye contact with them and talking to them. So, I changed my proximity to the kids and made sure that I went to each child and talked with him/her or touched him/her sometime during the day. I also developed strategies to ensure that every student responds to something every day. The students responded positively to these changes and it really made a difference in my classroom. Who would have thought that changing such simple little things could have made such a difference?

In the focus group at the end of the second year, Terri talked about many of her students, on the WIHIC, expressed the feeling that she was not interested in their problems. She explored their perceptions to determine if they felt that she was not interested in their learning problems or their personal problems. Following the determination that the students felt that she wasn't interested in their personal problems, Terri started asking her students more questions about their personal lives to show them that she really was interested in them as people. The students responded quite positively to this behavior change and told Terri that "she was a lot nicer now". Terri also discussed how the students' answers about investigations made her realize that she didn't spend enough time on science during the second year of the project. She explained: "I know that they were cheated in science because we had to spend so much time preparing them for the mathematics on the state test. It's sad because they love the time that they had in science, but it was mostly after the state tests were over."

Annie commented on how the classroom learning environment survey directly affected her science instruction:

> When I read the students' answers on the survey about doing investigations, it made me realize that I had to develop more strategies to help my ESE students with constructing and understanding graphs. The questions about equity motivated me to change my questioning strategies in the classroom. I had already started working on this because of wanting the students to think more about what they were doing in science, but the questions on the survey reminded me to include everyone in my questions. I also had the students start responding to many of my questions by using their dry erase response boards. This helps me to include all of the students in our discussions.

Mark's students' responses reinforced his efforts to establish a collaborative environment in his classroom. Mark wrote: "When we talk about our science activities, I try to make it a positive exploration. We try to explore all of the students' ideas and, even when things go wrong in an activity, we learn from that." Julie concurred with this approach: "In my classroom, it is important to create a positive learning environment where students are not afraid to take chances and learn through trial and error."

Lynne expressed a belief that the WIHIC helped her students reflect about themselves, in a way similar to what she does as a teacher. She wrote that "it was good for them and helped them to realize that, when I tell them that they need to improve on certain things, I'm also thinking about the things on which I need to improve too". This theme, reflective practice, is discussed in the next section.

6.4 Reflective Practice

In this study, reflective practice was understood to be a form of self-reflective inquiry undertaken to improve both the practice of teaching science and the teacher's understandings of teaching science (Dana & Tippins, 1998). The beginning teachers' reflections were structured around a Lesson Analysis, Activity Evaluation, and Questions for Self-Reflection on Science Activities for the lessons that they taught in their own classrooms, as well as lessons that they taught in their mentor teacher's classroom. The use of reflective journals also contributed to the teachers' thinking about their science teaching. The teachers' reflections were centered on two main themes: improving their science teaching practices and increasing student learning in science. These themes are discussed in turn below.

In her journal, Annie wrote:

> I really enjoyed the mentoring program experience. It gave me a chance to reflect on my teaching. I think that sometimes we forget that reflection is a very important part of the teaching and learning process. When I first started teaching, I really never reflected about what I was doing. This program taught me to think about what I do and how to do it better.

Terri wrote about a similar viewpoint:

> The mentoring program taught me to look at every lesson. Now I'm always thinking and evaluating what I'm doing and I didn't really do that as much before. Because of the mentoring project, I tend to re-think a lot and change things in order for all of my students to be successful. Teaching is ever changing. It seems that, with every new school year, you have to open up to new ideas. I feel that's where reflective practice comes into play. I know that I have to learn to look at every lesson and, even when the lesson is being carried out, I have to change things. My mentor helped me to see this and look at myself and what I am doing.

Lynne's view of reflection is summarized by her comment: "Doing the journals helped me to reflect on what worked and what didn't work and why. I learn more every year." Julie's perception of reflection is a bit different: "Mentoring gave me the opportunity to watch my mentor teach the lessons and reflect about how I could improve the lessons when I taught them in my class."

Mark's comments about reflection are more student-centered and focused on student learning:

> It's not only thinking about what you're planning, because you can plan a great lesson, but you need to get feedback from the students about how it affected them and if your objectives were accomplished. It's not only reflecting on what you did, but how it affected the students and what they got from the lesson. In the classroom, you know right away if an activity is working with the students or not. I'm very aware that if I need to change things mid-stream, I think that I am a lot better at coming up with something else to do on the spur of the moment than I was before the mentoring project.

Mark also expressed how important it is for the students to reflect on their own learning. In the focus group at the end of the first year, Mark said:

> I learned that kids will share with each other if they have their own reflecting time. They need time to think about what they have just learned or been exposed to, or discovered, and they get a lot of that from talking to each other. It's not just you up at the front of the classroom running the show. I've learned to let the kids do more. It was hard to turn more control over to the kids because, as teachers, we want to have control.

It appears that the reflective journals, discussions with mentor teachers, and focus groups provided a structure for the teachers to develop a critical understanding of their development as science teachers. Through reflective practice, the teachers represented their unique constructions of what it means to teach science in ways which permit them to analyze, discuss and evaluate their own teaching practices and professional growth (Dana & Tippins, 1998). The teachers' journal reflections and focus group discussions did not end with the four areas suggested by the researchers and measured in the written teacher questionnaire. All of the teachers offered insightful comments about their participation in the two-year mentoring experience, which are discussed in the next section.

6.5 Teachers' Impressions of the Mentoring Experience

In each of the focus groups, the teachers were asked to discuss if the mentoring project was different from what they expected it to be and to explain how they thought the mentoring project affected their development as a science teacher. Most of the teachers discussed their feelings that the mentoring project was quite different from what they had expected it would be. At the beginning of the project, the teachers thought that it would be a typical 'observational' experience. They thought that their mentor teacher would watch them teach, review their lesson plans and then give them feedback about the strengths and weaknesses of the lesson. However, at the end of the project, the teachers commented about being pleasantly surprised by how much they learned along with their mentor teacher during the project. For example, Julie explained:

> When I first heard mentoring, I thought that my mentor would be in charge and I would follow. I thought that I was going to observe her and that I was going to have to do the things that she did. But it turned out to be the other way around. We learned from planning, observing and working with each other. I was easy and really comfortable. It wasn't just her coming in and saying that "this is what we should do". It was really easy to sit down and plan, and it worked out great. We came up with similar ideas. We

> each have our own teaching style, but we learned things by watching and working with each other. During the second year of the project, we were so comfortable working together that we were able to get everyone else on our grade level team motivated about trying some of the things that we were doing.

Terri expressed a similar viewpoint:

> The mentoring program turned out differently from what I expected. When I first heard about it, I expected somebody to come in and look at my lesson plans and tell me if I'm on the right track or if I'm doing something wrong. It was totally opposite because it seemed like my mentor was learning right along with me. I learned so much from her, but it was a give-and-take situation. When I went into her classes after we had done a lesson in my classroom, I saw little things that I do in my class. So, it really made me feel good that as a second year teacher, I was doing okay.

Lynne echoed these feelings and also commented on the team teaching style that she and her mentor teacher developed:

> At first, I was a little intimidated because a stranger was going to be coming into my class, you know, a first-year teacher working with a thirty-year teacher. I thought that my mentor was going to notice everything that I do wrong. I thought that I'd be taking notes about what she did and she would take notes about what I did, and it wasn't like that at all. My mentor gave me more confidence and reassurance that I was doing okay. We learned from each other. When I went to her class, I did some parts of the lesson and she did some parts of the lesson. When she was doing something, I walked around and worked with the kids. If she missed something, I would jump in and add to it and she would do the same in my class. It was really team teaching.
>
> This year was my second year of teaching and working with my mentor and I was much more comfortable. We scheduled two extra days to work together this year, so now, instead of having three days to work with her, I had five days. Because my mentor didn't have her own class this year, it was different from the first year. I went with her to the different classrooms in which she was working and worked with her. So, it worked out well and I learned a lot from working with someone else's class. We also did the three days of teaching in my classroom and it was great.

The theme of team teaching and working with another teacher is something on which all of the teachers comment. This supports the concept of the mentor teachers as *educational companions* and *agents of change* that was the focus of the mentoring program in this study. Most of the teachers discussed the isolation that they sometimes feel as classroom teachers, and how they enjoyed the experience of working so closely with another teacher in their classroom. Annie wrote: "I enjoyed working in a co-teaching situation with my mentor teacher. I feel that my students have a better chance of learning when they hear things and do things in more than one way." Terri also discussed this feeling in her journal:

> I have grown a lot and could not have done it by myself. Most teachers are in their own little worlds once the bell rings. If you don't have the background in science or have someone guiding you, you really don't pick up many new ideas. Some teachers seem to feel that there is a competition going on and are afraid to share their ideas with you. I

really don't believe that it's done intentionally, but teaching can be a sink or swim situation. Either you take it upon yourself to try to do better for yourself and your students, or you get into a routine in which no new ideas are tried out and you do the same thing year after year without looking for alternatives. I really don't think that I can ever thank my mentor enough. She opened up to me and answered all of the questions that I asked. She shared a lot of techniques and opened up her classroom to me so that I could see how she allowed her students to learn from one another.

Mark, Terri and Annie wrote about their organizational skills during the mentoring project. Annie wrote: "I used to be disorganized. The mentoring project showed me how to be better organized in my teaching." Terri expressed a similar feeling: "The mentoring program helped me become more organized. I learned how to get everything ready ahead of time and then we don't have to stop during the lesson. So we had more time to learn." Mark also wrote: "I think that my organization and planning is a lot better. I can look farther forward and develop learning experiences for the students to reach the learning goals that I have set for them."

Mark brought up another theme that several of the teachers wrote about, namely, learning how to step back and allow the students to take a more active role in the teaching and learning process:

> I have learned how to do more inquiry with the students and develop learning experiences for the kids to allow them to discover more for themselves. I've also learned to have the kids do the work – everything from bringing in materials for activities, setting up the materials, working through the investigations, gathering and interpreting their results, and conducting scientific discussions and debates about their findings. Before, I was inclined to do too much for the students, and the mentoring project has taught me how to step back and allow the students to do more work for themselves. As a result, they learned more and there was less pressure on me. Before the mentoring program, I sometimes hesitated to do an activity because it was so much work to set up everything and get things organized. Now I don't hesitate to do the investigations because I can think about how much fun they are instead of thinking about all of the work that I have to do.

Lynne's journal writings summarize many of the comments made by all of the teachers about the impact of the mentoring project on their teaching. At the end of the first year, Lynne wrote:

> My experience with the mentoring project has been priceless. I have met the most genuine, caring, and giving people. They have inspired me to be the best teacher I can be by providing me with encouragement, teaching strategies, and lessons. At the beginning of the year, it was basically sink or swim. I had only a kindergarten internship as my experience in a classroom to fall back on; yet, I was assigned a fifth grade teaching position. Having a mentor teacher like I did is one of the most worthwhile experiences that a beginning teacher can have. I gained a wealth of knowledge that could never be learned in a university classroom or internship. First, the relationship built with the seasoned teacher is precious and brings you the most practical kind of guidance. Secondly, my mentor gave me encouragement, hope, and support in this crucial beginning year of teaching. Finally, my mentor teacher provided me with insight on how children learn best, effective teaching strategies, and a wealth of resources and creative ideas that will allow me to grow professionally. This experience has been valuable in laying a foundation for the teacher whom I hope to

become. I have learned how to integrate science into all of the other subjects that I have to teach. I have also learned to have confidence in myself as a teacher. Now I am willing and motivated to provide even better learning experiences for my students.

At the end of the second year, Lynne wrote:

> As a result of participating in the mentoring program, I have grown as a teacher and better understand the importance of teaching science. I have a lot more confidence in my ability to teach science because my mentor provided me with the tools to be successful: confidence, materials and resources, and effective teaching strategies. As a result of the program, I know how to engage students in active learning experiences in science that are motivating and worthwhile. I also learned how to make learning more relevant and meaningful to children by planning science activities that integrate all subjects. My mentor enlightened me with a wealth of knowledge about the grade-level expectations and content that I am required to have my students learn in order to do well on the state tests that they will have to take.
>
> More importantly, due to the mentoring program, I have used inquiry-based activities to foster a positive classroom learning environment in which study is child-centered and driven by the students' own curiosity to learn. Empowering students with the science process skills and concepts that are needed to discover ideas and understanding independently is the most valuable teaching strategy that I acquired in my experience in this project.

The qualitative data provided the researchers with a deeper understanding of the changes in the beginning teachers' attitudes during the two years of the mentoring project. Through the use of classroom observations, reflective journals, and focus group discussions, the teachers' attitudes were understood in the context of their experiences as beginning teachers. The qualitative data appeared to support the questionnaire scores indicating the teachers' attitudes toward teaching science increased toward the positive. Apparently, during the two-year mentoring project, the seven mentored teachers experienced growth in the areas of: level of confidence, knowledge, and valuing of teaching science; active learning in science; positive classroom learning environment; and reflective practice in teaching science. It is interesting to note that, while Mark rated himself at the highest levels in the written questionnaire in all four of the measurements, he wrote and talked about the growth that he experienced during the mentoring project. All seven teachers reported positive feelings about their participation in the mentoring program and their narratives provide support for the positive effect of the mentoring experience on their development as science teachers. It might be important to note that the role of the mentor teacher in this research was as an *educational companion* and *agent of change*. These roles seemed to have a positive effect on the beginning teachers' attitudes toward teaching science and they support the quantitative data from the teacher questionnaire.

7.0 Conclusions

The research described in this paper is distinctive in the study of learning environments because it provides one of the few studies that have examined learning environment ideas in investigating the efficacy of a two-year science mentoring program for beginning elementary school teachers. This study used a multimethod approach in which the use of qualitative research methods (observations, interviews and reflective journals) augmented questionnaire data to provide richer interpretations and insights into student and teacher outcomes.

The quantitative data, collected using the modified *What is Happening in this Class?* (WIHIC) questionnaire, achievement, and attitude scales in the first phase of this study supported the reliability and validity of the scales. The final 43-item, six-scale version of the classroom environment questionnaire assessed Student Cohesiveness, Teacher Support, Investigation, Task Orientation, Cooperation, and Equity. The WIHIC was used to investigate students' perceptions of the classroom environment with two different-sized samples. The *a priori* factor structure for the larger sample was replicated with nearly all of the items loading on its own factor and no other factor. The smaller sample was not large enough to provide strong factor analysis results.

Internal consistency (alpha reliability) for the WIHIC for two units of analysis was found to be satisfactory, with the internal consistency being stronger when class mean was used as the unit of analysis. The ability to differentiate between classrooms was strongly supported for the larger sample and was satisfactory for the smaller sample. Overall, the study provides strong support for the reliability and validity of the learning environment questionnaire for use with elementary students. Moreover, this finding further supports the wide applicability of the WIHIC in different school subjects and grade levels (Chionh & Fraser, 1998; Dorman, 2001; Moss & Fraser, 2001) and in different countries (Aldridge & Fraser, 2000; Aldridge, Fraser & Chionh, 2000; Aldridge, Fraser & Huang, 1999; Fraser & Chionh, 2000; Fraser & Huang, 1999; Margianti & Fraser, 2000; Riah & Fraser, 1998; Zandvliet & Fraser, 1998).

The impact of the mentoring program on the students of the mentored teachers was assessed in terms of the students' perceptions of the classroom learning environment, achievement in science, and attitudes about science. The findings suggest that there was little difference between pretest and posttest scores on the learning environment scales. However, there were substantial, positive and statistically significant differences in science achievement and students' attitudes about science when the pretest was compared to the posttest.

An investigation of associations between the six classroom environment scales and student outcomes (science achievement and attitudes about science) revealed that Investigation showed a positive simple correlation with science achievement and that Cooperation showed a positive simple correlation with attitudes about science. The multiple regression analyses, using the student as the unit of analysis, showed a significant association with the set of WIHIC scales for science achievement but not for student attitudes about science. In particular, Investigation and Equity were positively linked with science achievement. Whereas Teacher Support and Cooperation were negatively linked with science achievement, Cooperation was positively linked with student attitudes about science.

Overall, it appears that, to enhance achievement in science, an emphasis should be placed on Investigation and Equity. To understand why Teacher Support was negatively linked with science achievement, it could be useful to consider that, during the course of a school year, teachers usually encourage students to develop more independence and assume more responsibility for their own learning. Perhaps the students realized that they were receiving less support from their teachers and reported these perceptions on the WIHIC. It also appears that, to promote positive attitudes about science, an emphasis should be placed on Cooperation. This study replicates some of the findings from past studies which have reported associations between student outcomes and classroom environment (Fraser, 1998a; Fraser & Chionh, 2000; McRobbie & Fraser, 1993).

The findings related to changes in the mentored teachers' attitudes about teaching science, using the teacher questionnaire, indicate that the teachers felt more positively about teaching science at the end of the mentoring program when compared to the beginning of the program. Five of the seven teachers completed the two-year project and four of these teachers' scores on the questionnaire increased throughout the mentoring experience. The fifth teacher began the mentoring program with an extremely positive attitude about teaching science and maintained this level throughout the two years of the study.

While the quantitative data collected about teachers' attitudes about teaching science, using the teacher questionnaire, made an important contribution to the researchers' understanding of how the teachers' attitudes changed during the mentoring program, it was only a starting point in the study. The generation and analysis of the qualitative data allowed the researchers to explore the teachers' attitudes more deeply throughout the mentoring program.

All of the mentored teachers reported an increase in their confidence and knowledge about teaching science. The teachers seemed to be less concerned with 'knowing everything' in science and seemed to be more willing to take risks in their science instruction. Teachers also reported a feeling that teaching science had become more important to them and that they valued the time spent doing science activities with their students. The teachers also reported an increase in incorporating active learning experiences in their science instruction. There was less of a dependence on the science textbook in the teachers' lessons and most attributed this to their increased confidence in teaching science. The teachers found that the students enjoyed active science learning activities more than when they are taught 'from the textbook.' These observations were supported by the student interviews done by the researchers. The teachers reported that providing more active learning experiences for the students seemed to have a positive effect on their classroom learning environments, and that using the WIHIC provided them with a method of improving their classroom environments. This finding supports the research on how classroom environment surveys can be used by elementary school teachers to reflect, discuss, and systematically improve their classroom environments (Fraser, Docker & Fisher, 1998; Thorpe, Burden & Fraser, 1994; Yarrow, Millwater & Fraser, 1997). The use of the reflective journals seemed to provide a structure for the teachers to develop a critical understanding of their development as science teachers. The importance of self-reflection was also seen by the teachers as a valuable skill to teach to their students

The teachers' overall impressions of the mentoring program were extremely positive and all were pleasantly surprised by how much they learned throughout the two-year project. The experience of working closely with another teacher seemed to have provided the teachers with invaluable insights into the science teaching-learning process, but it also reinforced their own feelings of confidence and self-worth as science teachers. It is interesting to note that, when the mentored teachers were asked if they would like to mentor other beginning teachers in the future, all enthusiastically agreed to do so and urged that the mentoring program be expanded to include more beginning teachers. This supports the literature describing the praise and appreciation expressed by teachers who participated in induction programs during their early years of teaching (Fideler & Haselkorn, 1999). It also supports the positive effects of mentoring programs described in the literature (Feiman-Nemser & Parker, 1993; Gold, 1996; Gratch, 1998; Hole & McEntee, 1999; Lucas, 1999).

Overall, the qualitative information supported the effectiveness of the mentoring program in promoting student achievement and positive attitudes about science among both students and teachers. Furthermore, the qualitative information supports the questionnaire data about teachers' attitudes about teaching science and strongly attests to the teachers' favorable opinions about the mentoring program.

References

Aldridge, J. M. & Fraser, B.J. (1999, March). *A cross-national study of classroom environments in Taiwan and Australia.* Paper presented at the annual meeting of the National Association for Research in Science Teaching, Boston.

Aldridge, J. M. & Fraser, B. J. (2000). A cross-national study of classroom environments in Taiwan and Australia. *Learning Environments Research: An International Journal, 3*, 101-134.

Aldridge, J. M., Fraser, B. J. & Huang, T.-C. I. (1999). Investigating classroom environments in Taiwan and Australia with multiple research methods. *Journal of Educational Research, 93*, 48-62.

Aldridge, J. M., Fraser, B. J., Taylor, P. C., & Chen, D.-C. (2000). Constructivist learning environments in a cross-national study in Taiwan and Australia. *International Journal of Science Education, 22*, 37-55.

Anderson, G. (1998). *Fundamentals of educational research.* London: The Falmer Press.

Billingsley, B.W., & Cross, L.H. (1991). Teachers' decisions to transfer from special to general education. *The Journal of Special Education, 24*, 496-511.

Brophy, J. (1991). *Teachers' knowledge of subject matter as it relates to their teaching practice* (Advances in Research on Teaching, Vol. 2). Greenwich, CT: JAI Press.

Chionh, Y. H. & Fraser, B. J. (1998). *Validation and use of the 'What is Happening in this Class (WIHIC) questionnaire.* Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Cochran, K. F. & Jones, L. J. (1988). The subject matter knowledge of preservice science teachers. In B. J. Fraser and K. G. Tobin (Eds.), *The international handbook of science education* (pp. 707-718). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Dana, T. & Tippins, D. (1998). Portfolios, reflection and educating prospective teachers of science. In B. J. Fraser and K. G. Tobin (Eds.), *The international handbook of science education* (pp. 719-732). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Darling-Hammond, L. (1984). *Beyond the commission reports: The coming crisis in teaching.* Santa Monica, CA: Rand Corporation.

Denzin, N. K. (1989). *The research act* (3rd ed.). Englewood Cliffs, NJ: Prentice Hall.

Dorman, J. P. (in press). Associations between classroom environment and academic efficacy. *Learning Environments Research: An International Journal.*

Erickson, F. (1998). Qualitative research methods for science education. In B. J. Fraser and K. G. Tobin (Eds.), *The international handbook of science education* (pp. 1155-1173). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Feiman-Nemser, S. (1996). Teacher mentoring: A critical review. *ERIC Digest, 95(2)*, ERIC Document Reproduction Service No. ED397060. ERIC Clearinghouse on Teaching and Teacher Education, Washington, DC.

Feiman-Nemser, S. & Parker, M.B. (1993). Mentoring in context: A comparison of two U.S. programs for beginning teachers. *International Journal of Educational Research, 19*, 699-718.

Ferguson, P. D., & Fraser, B. J. (1999). Changes in learning environment during the transition from primary to secondary school. *Learning Environment Research: An International Journal, 1.*

Fideler, E., Foster, E., & Schwartz, S. (2000). *The urban teacher challenge: Teacher demand and supply in the great city schools.* Belmont, MA: The Urban Teacher Collaborative.

Fideler, E. & Haselkorn, D. (1999). *Learning the ropes: Urban teacher induction programs and practices in the United States.* Belmont, MA: Recruiting New Teachers, Inc.

Fisher, D. L. & Fraser, B. J. (1981). Validity and use of my class inventory. *Science Education, 65*, 145-156.

Fisher, D. L., & Fraser, B. J. (1983). A comparison of actual and preferred classroom environment as perceived by science teachers and students. *Journal of Research in Science Teaching, 20*, 55-61.

Fisher, D., Henderson, D. & Fraser, B. J. (1997). Laboratory environments and student outcomes in senior high school biology. *American Biology teacher, 59*, 214-219.

Fontana, A. & Frey, J. H. (1998). Interviewing: The art of science. In N.K. Denzin and Y.S. Lincoln (Eds.), *Collecting and interpreting qualitative materials* (pp. 47-78). Thousand Oaks, CA: Sage Publications.

Fraser, B.J. (1991). Two decades of classroom environment research. In B. J. Fraser and H. J. Walberg (Eds.), *Educational environments: Evaluation, antecedents and consequences* (pp. 3-27). Oxford, England: Pergamon Press.

Fraser, B. J. (1994). Research on classroom and school climate. In D. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 493-541). New York: Macmillan.

Fraser, B. J. (1998a). Science learning environments: Assessment, effects, and determinants. In B. J. Fraser and K. G. Tobin (Eds.), *The international handbook of science education* (pp. 527-564). Dordrecht, The Netherlands: Kluwer AcademicPublishers.

Fraser, B. J. (1998b). Classroom environment instruments: Development, validity and applications. *Learning Environment Research: An International Journal*, *1*, 7-33.

Fraser, B. J. (1999). "Grain Sizes" in learning environment research: Combining qualitative and quantitative methods. In H. C. Waxman and H. J. Walberg (Eds.), *New directions for teaching practice and research* (pp. 285-296). Berkeley, CA: McCutchan.

Fraser, B. J. & Chionh, Y. H. (2000, April). *Classroom environment, self-esteem, achievement, and attitudes in geography and mathematics in Singapore.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

Fraser, B. J., Docker, J. G. & Fisher, D. L. (1988). Assessing and improving school climate. *Evaluation and Research in Education, 2*, 109-122.

Fraser, B. J. & Fisher, D. L. (1982). Predicting students' outcomes from their perceptions of classroom psychosocial environment. *American Educational Research Journal, 19*, 498-518.

Fraser, B. J. & Fisher, D. L. (1986). Using short forms of classroom climate instruments to assess and improve classroom psychosocial environment. *Journal of Research in Science Teaching*, *5*, 387-413.

Fraser, B. J., Giddings, G. J., & McRobbie, C. J. (1995). Evolution and validation of a personal form of an instrument for assessing science laboratory classroom environments. *Journal of Research in Science Teaching*, *32*, 399-422.

Fraser, B. J., Kahle, J. B., & Scantlebury, K. (1999, March). *Classroom, home and peer environment influences on student outcomes: An analysis of systemic reform data.* Paper presented at the annual meeting of the National Association of Research in Science Teaching, Boston, MA.

Fraser, B. J. & McRobbie, C. J. (1995). Science laboratory classroom environments at schools and universities: A cross-national study. *Educational Research and Evaluation, 1*, 289-317.

Fraser, B. J., McRobbie, C. J., & Fisher, D.L. (1996, April). *Development, validation and use of personal and class forms of a new classroom environment instrument*. Paper presented at the annual meeting of the American Educational Research Association, New York.

Fraser, B. J., McRobbie, C. J., & Giddings, G. J. (1993). Development and cross-national validation of a laboratory classroom environment instrument for senior high school science. *Science Education*, *77*, 1-24.

Fraser, B. J., & O'Brien, P. (1985). Student and teacher perceptions of the environment of elementary-school classrooms. *Elementary School Journal*, *85*, 567-580.

Fraser, B. J., & Tobin, K. (1991). Combining qualitative and quantitative methods in classroom environment research. In B. J. Fraser and H. J. Walberg (Eds.), *Educational environments: Evaluation, antecedents and consequences* (pp. 271-292). Oxford, England: Pergamon Press.

Fraser, B. J., & Walberg, H. J. (Eds.). (1991). *Educational environments: Evaluation, antecedents and consequences*. Oxford, England: Pergamon Press.

Fraser, B.J., Welch, W. W., & Walberg, H. J. (1986). Using secondary analysis of national assessment data to identify predictors of junior high school students' outcomes. *Alberta Journal of Education Research*, *32*, 37-50.

Gardner, D. P. & Others. (1983). A nation at risk: The imperative for educational reform. An open letter to the American people. A report to the nation and the Secretary of Education. ERIC Document Reproduction Service No. ED226006. ERIC Clearinghouse on Education and Teacher Education, Washington, DC.

Goh, S. C., Young, D. J. & Fraser, B. J. (1995). Psychosocial climate and student outcomes in elementary mathematics classrooms: A multilevel analysis. *Journal of Experimental Education, 64*, 29-40.

Gold, Y. (1996). Beginning teacher support: Attrition, mentoring, and induction. In J. Sikula (Ed.), *Handbook of research on teacher education* (2nd ed.; pp. 548-594). New York: Macmillan.

Gold, Y. & Roth, R. A. (1993). *Teachers managing stress and preventing burnout: The professional health solution*. London: Falmer Press.

Gratch, A. (1998). Beginning teacher and mentor relationships. *Journal of Teacher Education, 49*, 220-226.

Grossman, P. L., Wilson, S. M. & Shulman, L. S. (1989). Teachers of substance: Subject matter knowledge for teaching. In M. C. Reynolds (Ed.). *Knowledge base for the beginning teacher* (pp. 23-36). Oxford: Pergammon.

Guba, E. G. (1981). Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Communication and Technology Journal, 29*, 75-92.

Harris, L., and Associates. (1992). *The Metropolitan Life survey of the American teacher. The second year: New teachers' expectations and ideals.* New York: Metropolitan Life Insurance.

Harris, L., and Associates. (1993). *The Metropolitan Life survey of the American teacher: Violence in America's public schools.* New York: Metropolitan Life Insurance.

Hauslein, P. L., Good, R. G. & Cummins, C. L. (1992). Biology content cognitive structure: From science student to science teacher. *Journal of research in science teaching, 29*, 939-964.

Healy, C. C., & Welchert, A. J. (1990). Mentoring relations: A definition to advance research and practice. *Educational Researcher, 19*(9), 17-21.

Heyns, G. (1988). Educational defectors: A first look at teacher attrition in the NLS-72. *Educational Researcher*, *17*(3), 24-32.

Hole, S. & McEntee, G.H. (1999). Reflection is at the heart of practice. *Educational Leadership, 56*(8), 34-37.

Huberman, M. A. & Miles, M. B. (1998). Data management and analysis methods. In N.K. Denzin and Y.S. Lincoln (Eds.), *Collecting and interpreting qualitative materials* (pp. 179-210). Thousand Oaks, CA: Sage Publications.

Huling-Austin, L. (1990). Teacher induction programs and internships. In W.R. Houston, M. Huberman, & J. Sikula (Eds.), *Handbook of research on teacher education* (pp. 535-548). New York: Macmillan.

Khine, M. S. & Fisher, D. L. (2001, December). *Classroom environment and teachers' cultural background in secondary science classes in an Asian context.* Paper presented at the annual conference of the Australian Association for Research in Education, University of Notre Dame, Fremantle, Western Australia.

Khoo, H. S. & Fraser, B. J. (1997). *The learning environments associated with computer application courses for adults in Singapore.* Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Lee, O. (1995). Subject matter knowledge, classroom management, and instructional practices in middle school science classrooms. *Journal of Research in Science Teaching*, *32*, 423-440.

Little, J. W. (1990). The mentoring phenomenon and the social organization of teaching. *Review of research in education* (Vol. 16, pp. 297-351). Washington, DC: American Educational Research Association.

Loucks-Horsley, S., & Matsumoto, C. (1999). Research on professional development for teachers of mathematics and science: The state of the scene. *School Science and Mathematics, 99*, 258-270.

Lucas, C.A. (1999). Developing competent practitioners. *Educational Leadership, 56*(8), 45-48.

Maor, D., & Fraser, B.J. (1996). Use of classroom environment perceptions in evaluation inquiry-based computer assisted learning. *International Journal of Science Education, 18*, 401-421.

Margianti, E. S. & Fraser, B. J. (2000, January). *Learning environment, mathematical ability and students' outcomes in university computing courses in Indonesia.* Paper presented at the Second International Conference on Science, Mathematics and Technology Education, Taipei, Taiwan.

Martin, M. O., Mullis, I.V., Beaton, A. E., Gonzalez, E. J., Smith, T. A., & Kelly, D. L. (1997). *Science achievement in the primary school years: IEA's Third International Mathematics and Science Study (TIMSS)*. Chestnut Hill, MA: Boston College.

McRobbie, C. J., & Fraser, B. J. (1993). Associations between student outcomes and psychosocial science environment. *Journal of Educational Research, 87*, 78-85.

Miles, M.B. & Huberman, A.M. (1994). *Qualitative data analysis*. Thousand Oaks, CA: Sage Publications.

Moss, C. H. & Fraser, B. J. (2001, April). *Using environment assessments in improving teaching and learning in high school biology classrooms*. Paper presented at the annual meeting of the American Educational Research Association, Seattle, WA.

O'Sullivan, C. Y., & Weiss, A. R. (1999). *Student work and teacher practices in science.* Washington, DC: U. S. Department of Education, Office of Educational Research and Improvement, National Center for Educational Statistics.

O'Sullivan, C. Y., Weiss, A.R., & Askew, J.M. (1998) *Students learning science: A report on policies and practices in U.S. schools.* Washington, DC: U. S. Department of Education, Office of Educational Research and Improvement, National Center for Educational Statistics.

Porter, A. C., Youngs, P., & Odden, A. (1998). Advances in teacher assessments and their uses. In V. Richardson (Ed.), *Handbook of research on teaching* (4th ed.; pp. 259-297). New York: Macmillan.

Punch, K. F. (1998). *Introduction to social research.* London, England: Sage Publications.

Riah, H., & Fraser, B. J. (1998, April). *Chemistry learning environment and its association with students' achivement in chemistry.* Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Rowley, J. (1999). The good mentor. *Educational Leadership, 56*(8), 20-22.

Schlechty, P. C., & Vance, V. S. (1981). Do academically able teachers leave education? The North Carolina case. *Phi Delta Kappan, 63*, 106-112.

Schlechty, P. C., & Vance, V. S. (1983). Recruitment, selection and retention: The shape of the teaching force. *Elementary School Journal, 83*, 469-487.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Teh, G., & Fraser, B. J. (1994). An evaluation of computer-assisted learning in terms of achievement, attitudes and classroom environment. *Evaluation and Research in Education, 8*, 147-161.

Teh, G., & Fraser, B. J. (1995). Development and validation of an instrument for assessing the psychosocial enviironment of computer-assisted learning classrooms. *Journal of Educational Computing Research, 12*, 177-193.

Thompson, B. (1998a). Review of 'what if there were no significance tests?' *Educational and Psychological Measurement, 58*, 334-346.

Thompson, B. (1998b). *Five methodology errors in educational research: The pantheon of statistical significance and other faux pas*. Invited address presented at the annual meeting of the American Educational Research Association, San Diego.

Thorpe, H., Burden, R. L. & Fraser, B. J. (1994). Assessing and improving classroom environment. *School Science Review, 75*, 107-113.

Tobin, K., & Fraser, B. J. (1990). What does it mean to be an exemplary science teacher? *Journal of Research in Science Teaching, 27 (1)*, 3-25.

Tobin, K., & Fraser, B. J. (Eds.). (1998). Qualitative and quantitative landscapes of classroom learning environments. In B. J. Fraser and K. G. Tobin (Eds.), *The international handbook of science education* (pp. 623-640). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Tobin, K., Kahle, J. & Fraser, B. J. (Eds.). (1990). *Windows into science classrooms: Problems associated with higher-level cognitive learning.* London: Falmer Press.

Wallace, J. & Louden, W. (2000). *Teacher's learning: Stories of science education.* Dordrecht, The Netherlands: Kluwer Academic Publishers.

Weiss, I. R., Banilower, E. R., McMahon, K. C., & Smith, P. S. (2001). *2000 national survey of science and mathematics education.* Chapel Hill, NC: Horizon Research.

Wenner, G. (1993). Relationship between science knowledge levels and beliefs toward science instruction held by preservice elementary teachers. *Journal of Science Education and Technology, 2*, 461-468.

Woods, J. & Fraser, B. J. (1996). *Enhancing reflection by monitoring students' perceptions of teaching style and preferred learning style.* Paper presented at the annual meeting of the American Educational Research Association, New York.

Wong, F. F. L. & Fraser, B. J. (1995). Cross-validation in Singapore of the science laboratory environment inventory. *Psychological Reports, 76*, 907-911.

Wong, A. F. L., Young, D. J., & Fraser, B. J. (1997). A multilevel analysis of learning environments and student attitudes. *Educational Psychology, 17*, 449-468.

Wubbels, Th., & Levy, J. (Eds.). (1993). *Do you know what you look like?: Interpersonal relationships in education.* London: Falmer Press.

Yarrow, A., Millwater, J., & Fraser, B. J. (1997). Improving university and elementary school classroom environments through preservice teachers' action research. *International Journal of Practical Experiences in Professional Education, 1* (1), 68-93.

Zandvliet, D.B., & Fraser, B. J. (1998, April). *The physical and psychosocial environment associated with classrooms using new information technologies.* Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

What is Happening in this Class?

Elementary Version

SC		Almost Never	Some-times	Almost Always
1.	I make friends with other students in this class.	1	2	3
2.	I know other students in this class.	1	2	3
3.	I am friendly to students in this class.	1	2	3
4.	Other students in this class are my friends.	1	2	3
5.	I work well with other students in this class.	1	2	3
6.	I help other students in this class who are having trouble with their work.	1	2	3
7.	Students in this class like me.	1	2	3
8.	In this class, other students help me with my work.	1	2	3
TS		**Almost Never**	**Some-times**	**Almost Always**
9.	The teacher takes a personal interest in me.	1	2	3
10.	The teacher tries very hard to help me.	1	2	3
11.	The teacher cares about my feelings.	1	2	3
12.	The teacher helps me when I have trouble with my work.	1	2	3
13.	The teacher talks with me.	1	2	3
14.	The teacher is interested in my problems.	1	2	3
15.	The teacher comes to my desk to talk with me.	1	2	3
16.	The teacher's questions help me understand my work.	1	2	3
IV		**Almost Never**	**Some-times**	**Almost Always**
25.	I do investigations in this class.	1	2	3
26.	My teacher asks me to think about the evidence to support statements.	1	2	3
27.	I do investigations to answer questions that we talk about in class.	1	2	3
28.	I explain what different statements, pictures and graphs mean.	1	2	3
29.	I do investigations to answer questions that interest me.	1	2	3
30.	I do investigations to answer the teacher's questions.	1	2	3
31.	I find out answers to questions by doing investigations.	1	2	3
32.	I answer questions by using information I get from my own investigations.	1	2	3

TO		Almost Never	Some-times	Almost Always
33.	Getting a certain amount of work done is important to me.	1	2	3
34.	I finish my assigned work in this class.	1	2	3
35.	I know the goals for this class.	1	2	3
36.	I am ready to start this class on time.	1	2	3
37.	I know what goals I am trying to achieve in this class.	1	2	3
38.	I pay attention during this class.	1	2	3
39.	I try to understand the work in this class.	1	2	3
40.	I know how much work I have to do.	1	2	3
CO		**Almost Never**	**Some-times**	**Almost Always**
41.	I cooperate with other students when doing assigned work.	1	2	3
42.	I share my books, materials, and supplies with other students when doing assignments.	1	2	3
43.	When I work in groups in this class, we work as a team.	1	2	3
44.	I work with other students on assignments in this class.	1	2	3
45.	I learn from other students in this class.	1	2	3
46.	I work with other students in this class.	1	2	3
47.	I cooperate with other students on class activities.	1	2	3
48.	Students work with me to achieve class goals.	1	2	3
E		**Almost Never**	**Some-times**	**Almost Always**
49.	The teacher gives as much attention to my questions as to other students' questions.	1	2	3
50.	I get the same amount of help from the teacher as other students.	1	2	3
51.	I have the same amount of say in this class as other students.	1	2	3
52.	I am treated the same as other students in this class.	1	2	3
53.	I receive the same encouragement from the teacher as other students do.	1	2	3
54.	I get the same opportunity to contribute to class discussions as other students.	1	2	3
55.	My work receives as much praise as other students' work.	1	2	3
56.	I get the same opportunity to answer questions as other students.	1	2	3

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