Science and Mathematics Education Centre

THE EFFECTIVENESS OF A CONSTRUCTIVIST LEARNING ENVIRONMENT ON LEARNING IN THE HIGH SCHOOL SCIENCE CLASSROOM

Vera Wooten

"This thesis is presented as part of the requirements for the award of the Degree of Doctor of Science Education of the Curtin University of Technology"

May 1999

ABSTRACT

This study hypothesized that students in a constructivist classroom would perform better academically than students in a traditionalist classroom. The methodology used was a multi-method approach utilizing both quantitative and qualitative techniques.

Two separate classrooms of students in a 10th grade general science program were selected to serve as the experimental and control groups. One group was taught the material using traditional teaching methods in a traditional learning environment, functioning as the control group. The second group was taught the same basic material using constructivist methods in a constructivist learning environment.

The most significant finding of the study was that students in the constructivist classroom scored higher on the achievement test than students in the more traditional classroom, even though constructivist approaches tend to focus on different assessment tools. Although the study lends support to the major hypothesis, it should be noted that further research must be conducted in this area. Samples of larger than 23 would ideally be chosen and more classes in multiple schools should be used. The use of a convenience sample, such as was done in this study, tends to limit the implication of the results, because the findings can only be strictly said to be true for classes in this particular school.

ACKNOWLEDGEMENTS

I extend a special thanks to all the great professors at Curtin University. I wish to express my gratitude to my supervisors Dr. Darrell Fisher and Dr. Barry Fraser, and also to Dr. John Wallace for serving as chairperson for the thesis committee. Further, I want to thank Dr. Robert Yager for sending me materials for my thesis. And lastly, thank-you to my wonderful husband William for all his encouragement and support.

CONTENTS

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

1.1 Overview

According to Phillips (1995), constructivism has taken on the aspect of a secular religion, a "powerful folk-tale about the origins of human knowledge" (p. 5). This does not mean, Phillips noted, that he finds constructivist views unattractive or unacceptable, simply that it has taken on elements of infallibility that are unwarranted. What is required, he asserted, is for constructivism to clarify its understanding of the role in the construction of knowledge without descending into a relativism that makes all assertions of knowledge equal, and all a matter of sociopolitical process or consensus.

Constructivism is an outgrowth of the progressivism of such thinkers as John Dewey. It is a philosophy that leads to a certain type of epistemology, or conceptualization of how we know. This epistemology has been used to develop pedagogies that have become increasingly popular in the developed world. The intent in this study is to look more clearly at the impact of constructivism practice on student satisfaction with different learning environments and student learning outcomes.

1.2 Background of the Study

As Fraser (1989) has noted, students spend an inordinate amount of time in the school environment, an environment over which they have no control. During the years of their basic schooling, hours in the classroom environment amount to more than 15,000. Therefore, as he noted, the quality of the environment of these classrooms has great significance.

What exactly is the classroom or school environment? Fraser (1994) noted that the concept of an educational environment is quite a subtle one. Essentially, educational environments are the social-psychological contexts or determinants of learning. Teaching is one aspect of the context and influences the environment, but is not the sole determinant. Other aspects include such things as the relationships between the students in the classroom, the freedom of student participation, the student/teacher views about education and feelings toward the process, and the degree of cooperation and collaboration in the classroom, or lack of it.

In the research studies on learning environments, classroom and school environments have been conceptualized differently. The school environment, which also involves the social-psychological context for learning, is larger and more global than the classroom environment. For example, Fraser (1994) indicated that the school environment includes relationships between the teachers and between the teachers and the principals, while the classroom environment is primarily concerned with relationships between the students and between the students and teacher. In addition, Fraser noted that in the research, classroom environment is generally measured by using either student or teacher perceptions, while school environment is assessed primarily in terms of teacher perceptions.

The learning environment, which is another common term, may include only the classroom environment or the classroom environment and school environment combined. There are several different instruments which have been devised for assessing the classroom environment, including the *Learning Environment Inventory* (Fraser & Walberg, 1991), the *Classroom Environment Scale* (Moos & Trickett, 1974), the *My Class Inventory* (Fraser, 1989), the *Constructivist Learning Environment Survey* (Taylor, Fraser, & Fisher, 1997), and the *Science Laboratory Environment Inventory* (McRobbie & Fraser, 1993). For school-level environment, the main instrument is the *School Learning Environment Questionnaire* (Fraser & Fisher, 1986), although the *Work Environment Scale* (Moos, 1986), which was designed for any work milieu, has been adapted to use for assessing school learning environment.

The basic assumption in research dealing with classroom environments is that differences in classroom environment lead to different results in student learning. Fraser (1991) has done considerable work in exploring the associations between student outcomes and classroom environment, including a review of some of the fundamental literature on the subject.

There are a number of trends that Fraser explored in his discussion of desirable future directions. For example, he noted that classroom environment and school-level environment research have generally been kept separate and distinct. However, he thought that some recent work using both classroom and school environment measures in the same study proved fruitful and represented a desirable pathway for the future.

Another recommendation of Fraser's was combining qualitative and quantitative methods in the research. Much of the research on classroom environment and student outcomes has used quantitative measures to assess student outcomes and qualitative measures to assess the learning environment. Fraser indicated that while this is useful, it is also possible to use qualitative methods to assess the learning environment by using one of the available instruments.

Finally, Fraser recommended using learning environment research more intentionally to improve teacher education and teacher practice. For example, learning environment questionnaires can be utilized within a study to provide feedback to a teacher, allowing the teacher to make pedagogical adjustments, and then reused to determine if the teacher's changes have indeed altered the classroom learning environment.

1.3 Rationale for the Study

Given the increasing popularity of constructivist pedagogy, it is important to continue to gather information about its appropriate use and the results obtained after students are taught by constructivist techniques. There are two basic claims in discussions of constructivist teaching. First, that constructivist teaching creates improved learning environments that students perceive as more open and more conducive to learning. The second general assertion is that constructivist teaching leads to better understanding of the material being taught to the students. It is not clear that this improved understanding will always be measurable by standardized tests. However, both assertions need to be repeatedly tested in order to provide support for the continuing introduction of constructivist methodologies into school systems. This study is of particular significance because it explores both of these issues and tries to interrelate them. The intention is to see if student satisfaction levels are directly tied to student outcomes in both constructivist and traditional classrooms.

1.4 Theoretical Framework

In response to the research on the relationship between classroom environment and student outcomes, theorists and researchers have attempted to create models of classroom environments that would enhance the potential for positive student outcomes both cognitively and affectively. One of the models that has been put forth as addressing many of the important issues of a supportive learning environment is the constructivist model. This model has been designed to address many of the current problems in the school system, including the call for a more value-laden education.

1.4.1 *The constructivist model*

Constructivism is an epistemology. An epistemology is a conceptualization of how people know what they know. Epistemology focuses on how people learn in the global sense, rather than looking at any specific subject. The basic epistemological question is "How do we know?" rather than "What do we know?" Epistemologies are concerned with the origins, nature, methods, and limits of knowledge. Actual pedagogies, or teaching methods, can emerge from this theoretical foundation.

The epistemological position is important. As Brooks and Brooks (1993) indicated, a specific epistemology can have considerable impact on all aspects of teaching. The traditional approach has emphasized knowing as proceeding from mimetic activity (repeating what someone else tells you) and this has shaped teaching practice. Traditional epistemologies have also emphasized certain ways of knowing over other ways of knowing, resulting in marginalized positions for women and other minorities (Belenky, Clinchy, Goldberger, & Tarule, 1986).

The constructivist approach is quite different from this. It is a philosophy and an epistemology. According to Bruner (1986), constructivism holds as its central tenet that there is no "real world" that is separate from human cognition and human symbolic language. Each world is the product of the individual mind which perceives it, thinks about it, and describes it. As a consequence, constructivism does not generally give a privileged position to any one description of the real world. In addition, the worlds that we construct through our own cognition and use of symbolic language are not primary. They are built upon the worlds constructed by others, which we use as starting points. There is no primary, orignal reality to be discerned. It is the mind that is the instrument of world construction and it is also the mind that determines upon the interpretation of the world so constructed. This interpretation of the world that is constructed and perceived is the meaning that we ascribe to it.

Fraser and Walberg (1991) note that the constructivist approach has emerged from new developments in philosophy, history, and sociology which emphasize the centrality of meaning-making as a human activity. They note that there are two aspects to this meaning-making that are relevant to the field of education.

The first aspect of the meaning-making process is individual. The individual explores his or her environment and attempts to make sense of it, or to create meaning. The second aspect of the meaning-making process, which is really interdependent with, rather than independent of, the first, is the social element. As the individual is exploring the environment, he or she also encounters other people and animals. Sense-making and meaning-making do not occur outside of relationships with these significant beings populating the individual's world.

Fraser and Walberg (1991) note that most classroom environment research has occurred using the old paradigm, or epistemology, in which education involves instructing children or adults in a set of facts, principles, laws, or other concrete contents of subjects. Constructivism, however, represents a new epistemology and requires a new way of thinking about the teaching process.

The constructivist model emphasizes the creation of a particular kind of classroom climate that enables intellectual, affective, social, and moral education. DeVries and Zan (1995) describe it as "a developmentally appropriate approach to early education, inspired by Piaget's theory that the child constructs knowledge, intelligence, personality, and social and moral values" (p. 5). The constructivist approach focuses on ensuring that the classroom environment, and assignments create a good fit for the child.

This Piagetian approach ensures that activities will be appropriate to the child's interests, as well as developmental level. There is a melding of cognitive and affective perspectives, in which children are encouraged to experiment in the physical world, while also learning how to engage in social activities and cooperate with their peers in developmentally appropriate ways (DeVries & Kohlberg, 1990).

The constructivist approach is an educational method that builds on the work of Piaget in observing children's natural developmental process and on Kohlberg's work in devising a development model that explores the child's and adult's moral development (DeVries & Kohlberg, 1990). It is essentially a model that focuses on how the individual makes sense of the world around him or her and creates meaning within it.

1.4.2 *Characteristics of a constructivist learning environment*

As a consequence, the constructivist environment emphasizes moral development, as well as cognitive development. DeVries and Zan (1995) discuss the constructivist classroom in terms of the creation of a sociomoral environment or atmosphere. They consider this the first principle of a constructivist education or classroom.

In the sociomoral environment, students and teachers are expected to evince respect for each other and treat each other with consideration. According to DeVries and Zan

(1995), the aspect of education research or policy that views schools as not the appropriate purveyor of moral education is misguided, since schools automatically take a moral perspective in their communication about rules and appropriate behavior. As a consequence, DeVries and Zan (1995) indicate that the more relevant approach is to ensure that classrooms provide a sociomoral environment which allows for optimal student development cognitively, affectively, and morally.

While one criticism of constructivism might be this moral emphasis, Brooks and Brooks (1993) note that the most common criticism of it is that constructivism subordinates the curriculum to the interests of the individual child. The focus on relevance to the child and allowing the child to experiment in the physical realm seems to allow for a whole classroom of individual curricula.

This is not, however, the case according to Brooks and Brooks (1993). Instead, as they note, it is at least partially the teacher's job to create the condition of relevance for students and help them to understand the importance of specific topics and tasks. The teacher, who serves as the mediator in this process, provides a larger perspective on the world and the student's place within it.

Brooks and Brooks (1993) establish several principles as fundamental for the constructivist classroom. They include:

1. posing problems of emerging relevance to students;
2. structuring learning around primary concepts: the quest for essence;
3. seeking and valuing students' points of view;
4. adapting curriculum to address students' suppositions; and,
5. assessing student learning in the context of teaching.

Although these principles are fairly self-explanatory, it might be helpful to look at the last statement. This principle represents a very different way of thinking about teaching and evaluating student learning. According to the authors, it is not particularly helpful for the teacher to ask narrow questions to which there are singular correct answers. Instead, what is helpful is for the teacher to get a clearer view of what is happening in the learner's mind by probing more deeply to understand the child's answer and giving nonjudgmental feedback.

Brooks and Brooks (1993) also note that the constructivist classroom requires innovative assessment procedures by its very nature. As they note, it is very conflicting for teachers to teach in a child-centered way that focuses on knowledge and meaning construction, while then assessing the child's learning through traditional tests. As a consequence, teachers and schools need to think carefully about designing assessment processes that are authentic to the constructivist model and which are contextually based. This, they believe, should be founded on the assessment through teaching model which provides an ongoing evaluation of the child's understanding and present skills.

Essentially, the assessment tools need to be congruent with the constructivist philosophy and fit in to the constructivist learning environment. Novak (1996) noted that teachers are increasingly frustrated with the limitations of traditional evaluation tools, but that there are not a lot of acceptable substitutes. One that he proposed was the idea of concept maps. These can be used both as evaluative tools to show what students know, and as the foundation for future teaching. Concept maps provide information about how the students understand relationships between specific facts, words, and concepts and provide a tool for identifying student misconceptions. This is one of the more valuable tools for the constructivist classroom and, if it does not replace standardized tests, can serve as a valuable adjunct to them.

1.4.3 *Student-teacher, student-student relationships*

The teacher-child relationship is quite important in constructivist classrooms, as are the relationships between the child and other students. These are expected to be characterized by increasing cooperation and respect, with an emphasis on the importance of the social bond and the consequences of acting in ways that hurt it.

As DeVries and Zan (1995) note, constructivist teachers respect children's opinions, decisions, and contributions, but that does not mean that children can get away with any behavior they feel like. Instead, the teacher works with children to help them understand moral dilemmas and ways to resolve them. The teacher also emphasizes a disciplinary approach which helps students to gradually learn how to have more and more mutually satisfying relationships by managing their sociomoral behavior. The focus, the authors indicate, is on finding alternatives to traditional discipline which "emphasize the natural and logical consequences of the misdeed and the resulting break in the social bond" (DeVries & Zan, 1995, p. 9). In a constructivist approach, students are confronted with the results of their actions and asked to take the necessary actions to restore trust and repair whatever has been damaged.

One of the obvious problems of this approach, which is alluded to by DeVries and Zan (1995) is that students must care about the social bond, and about their relationships, in order for this approach to work. It presupposes that children have been socialized at least to the degree that they are capable of forming attachments, valuing them, and working on improving them. This might not be the case. It could also be problematic for those children who do value social bonds and behave in a moral manner, if children who do not value social bonds or behave well are allowed too much leeway by the teacher in their growth process.

The model that Brooks and Brooks (1993), and DeVries and Zan (1995) are exploring has clear values in helping the child develop as a whole person in a natural, age-appropriate, and individualized way. This is the constructivist approach, which is clearly child-centered. Yet, there are a number of qualities that seem necessary for this approach to work.

As noted earlier, it seems to require children that are relatively healthy and well-socialized. It also demands teachers who are quite skilled in working with groups, group dynamics, and the individual learner. It requires a classroom environment that is free from the pressure of parents and administrators who demand a certain level of achievement on standardized tests. It requires enough time for children to develop naturally and at their own pace, rather than according to the requisites of grading periods and grade levels.

1.5 Purpose of the Study

Constructivist approaches are not designed simply to ensure that students obtain the appropriate cognitive contents. They are also designed to assist in children's social and moral development, while helping them learn how to conceptualized and continually create new knowledge for themselves.

The purpose of this study, then, is to determine the answers to two basic questions:

1. Does a constructivist environment contribute to improved learning of science concepts?

2. Does a constructivist environment contribute to a better classroom learning environment, with less conflict, more cooperation, and better relationships among students and between students and the teacher?

1.6 Context

The study was conducted in a Chicago public high school. The school is located on the far-west side of the city of Chicago and is surrounded by large low-income housing projects. This type of locale is commonly, and euphemistically, referred to as "inner city," which really means poor and non-white.

The school serves a mainly minority population. Only about two percent of the student population is white, a negligible number are of Asian descent, and the vast majority of the students are either African-American or Mexican-American. Drugs, crime, violence, and dysfunctional family situations are common situations for most students, which presents a challenge for educators. Consequently, included in the mission of the school is the provision of a safe haven from these influences in order to create a more stable and caring learning environment.

In contrast to the student population, the school staff is made up primarily of whites. Out of a staff of 50, there are 27 whites, 21 African-Americans, and two Mexican-Americans. The staff is very experienced, with 40 members having at least 20 years of teaching experience. Of these, five teachers are in their 26th year of teaching, while 25 teachers have taught 32 years or more. The staff members are committed to creating a positive learning environment. Included in that commitment is a requirement that every teacher be heavily involved in enforcing school rules and maintaining good classroom behavior. Also, the school has dedicated mission and vision statements, as well as a guiding philosophy.

The school's declared vision is

> to prepare students for the challenge of the year 2000 and beyond, who will be able to: Claim their rightful place in society as a result of their educational training; make positive contributions to the community; and to be sensitive to the needs and differences of those who make up our society.

Additionally, the school has made its mission

> to improve academic achievement, improve attendance, and to reduce the drop out rate within our student population; to provide a curriculum that has a career focus; and to emphasize a value driven approach to help our students become enriched, educated citizens.

Finally, the school has an overall philosophy, which states that the school accepts the responsibility to educate all students, regardless of background and ability. This education will impart to all the essential knowledge and skills needed to attain personal and career goals and to participate fully in a democratic society both in the present and in the future.

1.7 Scope and Limitations of the Study

The basic limitations in this study are the lack of randomization and the small sample size. Both of these mean that the results of the study are limited in their applicability and less meaningful than they could be with a larger sample size. For example, expanding the study to include multiple classrooms in each sample would allow for measuring differences in great detail. Besides the experimental group and the control group, there could be a group using a mixed-method, alternating traditional and constructivist approaches. This provides the researcher with a better opportunity to discover the factors that are most significant in any improvements during the experimental period. In addition, it would provide a richer measurement of changes in learning environment satisfaction if students had been exposed to both methods.

The small size of the sample means that results could simply be random, rather than an indication of a significant relationship between methodology and results. Lack of randomization means that the composition of the groups themselves, or some other factor that has not been controlled for, could have had a greater impact on test improvements than the experimental procedure.

1.8 Summary of the Chapter

Constructivism has become one of the most important influences on modern pedagogy. According to Phillips (1995), it has become like a secular religion, with a number of different sects and true believers. Constructivism is helpful in enabling theorists to understand the social nature of learning and in encouraging pedagogues to emphasize active participation in learning. It is problematic when it deteriorates into absolute relativism.

As an epistemology, constructivism lends itself to use as a theoretical framework for the development of specific teaching philosophies and methodologies. Constructivist methodologies emphasize classroom environment as one of the important aspects contributing to student learning. The contention is that open, dialogic, moral, and supportive classrooms contribute to good learning outcomes.

This study seeks to answer the questions of whether a constructivist classroom leads to better learning outcomes and greater students' satisfaction with the classroom environment than a more traditional classroom. This is a small-scale study, with the limitation of its size and lack of randomization. However, it should contribute to our understanding of the relationship between student satisfaction with classroom environments and learning outcomes in the constructivist classroom.

1.9 Organization of Thesis

Chapter Two presents the review of literature and theoretical framework. It argues that the constructivist classroom is both a teaching and a learning environment. It also maintains that constructivism is a philosophy from which epistemologies can be derived. Chapter Three describes the participants, procedures, and materials used in the research approach. Chapter Four begins with a series of classroom observations and teacher interviews, and concludes with the quantitative research results. Chapter Five presents an explanation of the results, and a discussion of the relationship to other studies as well as a reflection on the implications of the results on future studies.

CHAPTER TWO

REVIEW OF THE LITERATURE AND THEORETICAL FRAMEWORK

2.1 Introduction

This review of the literature is designed to provide background information about constructivism, science education, and classroom environment literature. Each section provides a brief overview of the subject matter, connecting theory and experimental studies to the research problem under consideration in this study. The sections of this chapter are: Constructivism; Constructivist Approach to Teaching, Learning, and Staff Development; A Model of a Constructivist Learning Environment; Science Education; The Constructivist Learning Environment Survey; and Summary of the Chapter.

2.2 Constructivism

Constructivism is fundamentally a philosophy, although one can also derive an epistemology from it. The philosophy of constructivism and its application to education has developed throughout this century, although it is in recent decades that it has gained the most support. Bruner (1986) indicated that it was during the 1950s, with the cognitive revolution, that scientific support for constructivism was found. The work of people like Herbert Simon (1995), George Miller (1987), and Noam Chomsky (1988) focused on the deep structures of human knowing and learning, trying to understand the processes by which individuals knew what they knew. One of the major questions under consideration was the means by which knowledge was represented in the mind and mind itself was defined as separate from the human brain.

Goodman (1984) provided a good overview discussion, and defence, of the constructivist philosophy. The constructivist philosophy starts from the premise that there is no "real" world, no absolute reality outside of the human being that can be perceived accurately and described through any set of facts and concepts. Instead, the world that exists is fundamentally the product of human thinking and the human manipulation of symbols.

This means that there are many worlds, or at least many "versions" of worlds, as Goodman (1984) put it. There are many mental representations of the world, each of which can have cogency and coherence, although not equivalent truth or goodness. According to Goodman, the test of truth and goodness is not in the relationship of our descriptions to some outside absolute reality, but in the characteristics of our versions of reality and the relationship of our version to other versions. This is a different way of testing, or defining, reality. It allows for multiple viewpoints, rather than one truth, or one reality, but it also creates conditions of great ambiguity. This is one of the reasons that there is considerable resistance to constructivist frameworks; they do not provide a comforting sense of objectivity or a grasp of the "truth."

According to Phillips (1995), it is actually inaccurate to talk of a constructivist approach as if there were only one. As there are many worlds within constructivism, there are many constructivisms, he noted. There are, for example, three general areas of cognitive structure, or content structures, that are considered in constructivist writing. Some constructivists consider the cognitive domains of individual learners, some the public cognitive domains, and others a mixture of the two. In addition, there are a number of theoretical approaches explored by important authors that can be labelled constructivist, such as those of Kant (1964), Kuhn (1970), Piaget (1932), Dewey (1927), and Habermas (1971) among others.

Although all constructivisms raise epistemological issues and take an epistemological stance, Phillips (1995) indicated that these are not all the same. He created a framework to compare constructivisms, noting that they vary on three different dimensions.

The first dimension is the continuum between focus on individual psychology versus public discipline. He noted that Piaget and Vygotsky, for example, would focus on the end of the continuum toward individual learning, and how the individual constructs knowledge in his or her own world. On the other hand, feminist epistemologists frequently are at the other end of the continuum, with most of their focus on how public knowledge is socially constructed and influences the whole society.

The second dimension Phillips explored is one focused on the nature of constructivism itself. At one end of this continuum are those thinkers who contend that it is the human being who is the creator of knowledge and that it does not preexist, while at the other end of the continuum are those who believe that human beings discover knowledge through observation of nature or the world around them. Thus, empiricists like Locke, who view nature as the instructor, are minimally constructivist, if at all, since they view knowledge as primarily external and existing independent of the learner. There is also a complication, since individuals at the "humans as creator" pole are divided between those who focus on the individual creation and those who emphasize the sociopolitical construction (Phillips, 1995).

Finally, the third dimension, which continues the complexity, provides a continuum of looking at the construction of knowledge as an active process that involves either physical or mental activity in the individual or social domains. Thus, the individual or society can either be actively involved in constructing knowledge, or passively so, basically prewired, which is a non-constructivist approach. Phillips (1995) noted that Piaget is a good example of a constructivist thinker who focuses on the individual construction of knowledge as both a physically and mentally active approach. On the other hand, theorists such as Longino and Nelson contend that knowledge is socially constructed through the interaction of social relations. As Longino puts it, knowledge is "constructed not by individuals but by an interactive dialogic community" (Longino, 1993, p. 112).

If one uses this model, it is clear how constructivism as an epistemology can be utilized as an educational pedagogy underpinning a specific form of teaching that focuses on dialogue and the construction of knowledge by individuals within the classroom setting. There are also other considerations, which can either be supported strongly by a specific program of reform or not. For many of the feminist or Marxist social constructionists, the epistemological stance of their work requires that a reform effort focus on social empowerment. The pedagogy becomes corrective, attempting to enter new voices in the dialogue, which are often seen as voices that should be treated preferentially, since they can provide a more critical inquiry.

In other words, those at the bottom of the ladder economically, or marginalized minorities, have more questions about the current socially accepted knowledge than do those in more privileged positions. They become the leaders of the dialogue, which can become transformative critical discourse (Longino, 1993). For her, this can only occur when the community allows dissent and lets dissent alter its beliefs over time, while providing for recognized standards of evaluation of theories and observations.

Again, this can be applied to the constructivist classroom situation, although not in allowing some voices to become privileged. Instead, it can be applied by providing avenues for discussion, critical questioning and equal intellectual authority. At this point, theories and observations need to be subjected to agreed-upon standards of evaluation for truthfulness or acceptability, while the community of the classroom must be malleable enough to allow these new understandings to change concepts, beliefs, and attitudes.

2.3 A Case Study on Using the Constructivist Teaching Approach

As is apparent from the preceding discussion of the constructivist teaching approach, the changeover from more traditional methods to constructivist methods is a radical one, requiring many alterations of technique, classroom environment, and procedures. Teachers are not always certain of how to institute a constructivist approach, and may not have sufficient support to do so.

Appleton and Asoko (1996) sought to provide a clear description of how one teacher worked toward creating a constructivist classroom for the teaching of elementary science. They used the interpretive case study method that had been described by Yin (1989), which focused on developing a clear picture of teacher implementation over a short period of time. The teacher under study had participated in in-service training designed to familiarize teachers with constructivist learning concepts and their application to the teaching of science. The teacher attempted to implement some of these ideas in his classroom, but that implementation was affected by his own background, habits, and understanding of constructivism.

According to Appleton and Asoko (1996), a teacher who implements a constructivist view of learning could be expected to have a classroom that exhibited certain characteristics, including clearly defined conceptual goals, teaching strategies which develop the learners' original ideas, creation of an open classroom atmosphere, prior awareness of student ideas and concepts, and provision of opportunities for the learners to utilize new ideas in a number of different ways.

The teacher under study had participated in a 20-day in-service training program that emphasized these ideas. He sought to use them in a classroom of 27 ten-year-old science students in a church school in a middle class urban area. Appleton acted as the participant observer in the study, helping with the students and providing suggestions and support to the teacher.

The observation showed that Robert, the teacher, was able to make use of many of the principles learned in the in-service, including identifying his students' early ideas about a topic, involving them in creating learning situations, and helping them in their concept development. However, one major problem was identified, and it is a problem that affects much of elementary science teaching in particular. Although Robert was science coordinator for the school, and was teaching science to the students, he was not an "expert" in science. As a consequence, he was unable to help students with their conceptual development at some points because he himself did not have sufficient substantive knowledge about science. The authors pointed out, however, that he had more substantive science knowledge than most elementary teachers. They suggested that for constructivism to work in elementary schools, teachers may need access to experts in the subjects in order to truly help students develop conceptually, rather than be limited to facts available through their textbooks.

Appleton and Asoko (1996) concluded that Robert had made progress toward instituting a constructivist approach in the classroom, and that was what could have been expected when applying constructivist theories to teacher learning and implementation of such an approach as well. They also concluded that there are some issues involved in using in-service training to teach the constructivist approach, since it is a top-down, externally imposed event. In addition, they noted that change is always incremental and progressive, rather than immediate, with the need for in-service providers to create conceptual goals for their teacher-students.

2.4 Constructivist Approach to Teaching, Learning & Staff Development

As Appleton and Asoko (1996) indicated, in order to be congruent, educators working on staff development need to use constructivist principles in working with teachers and other school staff, as well as with students. The constructivist approach assumes that all learners are in process and are influenced by their old ideas in learning new ideas. This applies to teachers and clearly impacts their ability to create constructivist classrooms based on constructivist principles and theories.

In many instances, there is a failure to think about this issue clearly when designing staff development programs for teachers. For example, Stein et al. (1994) discuss constructivist principles for use in the classroom and implications of adopting these principles for staff development. The focus is on providing teachers with information, research, and modeling regarding constructivist approaches, but there is little focus on identifying the teacher's early ideas, setting clear conceptual goals, and allowing the teacher to engage in critical, reflective thinking and acting in a wide range of situations. In other words, the literature includes many instances in which teachers are to be taught constructivist principles in traditional ways and then are expected to adopt constructivist principles for use in their classrooms to teach their students.

A more appropriate model of staff development is described by Glasson and Lalik (1993). Glasson and Lalik worked with six science teachers to plan, implement, and reflect upon instruction using the learning cycle framework. The assumption of the work was not that teachers would immediately adopt constructivist principles and techniques, but that their ideas would change slowly during the course of the year as they worked with the material and explored constructivist teaching. In other words, the teachers were also seen to be learners who started with certain ideas and concepts and were actively engaged in creating knowledge and developing their conceptualizations.

For example, one of the teachers, Martha, who was studied in the most detail, initially indicated that the goal of science instruction was to arrive at acceptable conclusions. She was uncomfortable with some of the constructivist philosophy about allowing students to explore their ideas and concepts, while gradually increasing their understanding. However, working with constructivist teaching methods, she began to change and see the advantages of using that method. As a consequence, she became dissatisfied with some of her old methods, including grading systems, and experienced a great deal of frustration during the transition period.

Glasson and Lalik (1993) noted that all six of the teachers involved experienced this frustration and tension between the old ways and the new ones. In general, the tension was between positivist views, which undergird traditional methods, and postpositivist views, which are the foundation of constructivist methods. All of them had some difficulty in encouraging the students to take more control of their own learning, and were hesitant about encouraging students to express their own understandings. Yet, all of them made progress during the course of the year in these areas.

The beliefs and attitudes of teachers are important for constructivist researchers to understand and work with because they shape the teaching/learning environment. According to Fraser, Tobin, and Kahle (1992), most teachers tend to teach for science content from the textbooks in order to prepare students for tests. They do not teach for science understanding.

In order to explore more fully how teacher attitudes impact the teaching/learning environment, Fraser, Tobin, and Kahle (1992) worked with two teachers at Southside High School who were involved in teaching science to Grade Ten. These teachers first taught a five-week course on vertebrates, then after a two-week interval, a five-week course on nuclear energy. The researchers used a research team of six people to conduct observations, do interviews, and interpret data phenomenologically.

The results indicated that the teachers saw themselves in terms of specific metaphorical roles that were either teacher-centered or student-centered. For example, one of the teachers described himself as both the 'Captain of the Ship' and the Entertainer. In other words, he was at the center of all activities and in charge of everything that happened. The other teacher, however, saw herself metaphorically as Resource, which meant to her that she was someone the students could draw upon, while having relative control over their own learning.

Both teachers tended to use the available materials, although for different reasons. Both of them also required students to perform well on tests of content. However, there were significant differences between the two teachers in terms of equity issues. Peter tended to use gendered discourse and teaching strategies which were disadvantageous to the girls. On the other hand, Sandra's classroom was less competitive and less oriented to stereotypes. She attempted to reduce stereotypes in her classroom and help all students to develop to their full potential. However, there were problems because a small number of dominant boys tended to take up more of the time and equipment time in the classroom. The researchers noted that her patience with the boy's behavior tended to reinforce sex-role stereotypes that predicted boys would be rambunctious (Fraser et al., 1992).

These are the kinds of factors that work against learning science, or any other topic, with true understanding. Teacher beliefs and attitudes - whether about the teacher's role or about gender characteristics - shape the teaching/learning environment.

An even clearer example of this is provided in a study reported by Yager (1995). This study worked with teachers from the Iowa Scope, Sequence, and Coordination Program, which was designed to assist schools with reform of their middle school programs to use more constructivist approaches. It focused on the science, technology and society instructional approach and works through in-service and other training programs to introduce teachers to the constructivist approach in implementing the reform.

Yager (1995) explored both teacher changes and learning results for students. In the first instance, he compared 133 teachers involved with the constructivist program with 48 teachers involved in another in-service training program, but not one using constructivist principles. Results indicated that teachers using constructivist principles had increases in teacher confidence, higher levels of using constructivist techniques, and more student-centered classrooms.

In terms of student achievement, there were significant differences between the students in the 133 constructivist classrooms and the students in the 105 more traditional classrooms. The students in constructivist classrooms had a significant advantage over students in traditional classrooms in the concept domain, process domain, application domain, creativity domain, attitude domain, and world view domain. In other words, they tested higher in all six of the domains that were tested. In addition, results showed significant advantage for female students and average and below average students.

Yager's (1995) work seems to show significant advantages for both teachers and students for use of a constructivist approach. Teachers exhibit more confidence, while students learn more and feel more positive about the whole experience of learning. This study is a helpful one, because it works with a larger population than most of the research available on constructivist approaches, and shows the results in quantitative fashion. This is helpful in working with more traditional educators and school districts, showing them in measurable fashion how constructivist approaches can improve both teaching and learning.

2.5 A Model of a Constructivist Learning Environment

The constructivist approach depends upon the creation of a teaching-learning environment in all situations which is based on cognitive principles. A triphasic model of such an environment was created by Anderson, Akins, Calderon, and Mapp (1996) in order to explore the major dimensions of a constructivist learning environment. The model included three dimensions:

1. Dimension One (Opportunity for Constructivist Activity) is the dimension that focuses on teaching-learning activity that involves reflection, cognitive representation, and integration.

2. Dimension Two (Affect) explores the amount of affective support provided by the teacher.

3. Dimension Three (Pace) focuses on the tempo of classroom activity (Anderson et al., 1996).

The authors indicated that they predict greater student satisfaction at the vertex of the three dimensions which represent the more constructivist approach. In order to test that, they worked with data from four classes with teachers who varied in approach from didactor to constructivist. They used three coders, working independently, to assess the three dimensions in each class. They also assessed student perceptions by using an instrument with a Likert scale to measure student satisfaction with the classroom teaching-learning environment. The results indicated that lessons scored closer to the constructivist vertex were more highly rated by the students on levels of satisfaction, including understanding and positive emotional tone.

2.6 Science Education

One of the first massive efforts devoted to improved science education developed in response to the Soviet Union's success with Sputnik I. This was seen as a challenge to American ingenuity, and it was competitiveness that propelled the revision and financing of new science education efforts.

This still is one of the motivating factors in efforts to improve science education. Sivertsen (1993) noted that it is a national educational goal to be first in the world in science achievement, which means that primary and high school education efforts must be addressed. She noted that the current reform builds on the post-Sputnik reforms, with a major emphasis on new curricular materials which use a discovery or inquiry approach. She also noted that new understandings in cognitive science have provided new perspectives on how children learn. This includes the new understanding that children do not learn by absorbing knowledge, but by constructing knowledge. As a consequence, methods that are hands-on, inquiry-based, and utilizing exploration and dialogue are most effective.

Prather (1993) noted that there have been problems with science and math education in the United States since at least the 1940s, and that education reformers have been trying to address those issues in many different ways. In the late 1950s and early 1960s, the focus was on hands-on science teaching methods, science process, and discovery learning, but this was only partially successful. The urgency with which educators attempted to redress the balance with the Soviet Union precluded good planning and evaluation efforts.

By the 1980s, Prather noted, science education was again reported to be in a state of crisis. Although many scientists and engineers had been produced by the earlier efforts, the population as a whole was less than literate scientifically and mathematically. In looking at many different studies, educators concluded that the reason science reform had failed was that it had never fully been attempted. Most educators still used more traditional teaching methods and more traditional, commercial textbooks. In addition, there had been little movement theoretically and insufficient focus on outcomes.

What has been the focus of the new reform effort has been constructivism, which Yeany (1991) and others indicated may provide the unifying framework for a revised science education with a focus on developing both curriculum and teachers able to support its principles. However, he noted that constructivism remains too ill-defined, vague, and short on documentation. What is required, he contended, is a constructivist approach that is clearly-defined, limited, and well-documented.

Yeany later noted that the Constructivist Learning Model (Yager, 1991) had the potential to serve as that unifying strand or theme for science education. Researchers at the National Center for Improving Science Education proposed a teaching model that uses the Constructivist Learning Model. It includes four aspects: invitation, exploration, proposed explanation, and solution, and taking action. Under exploration, many of the specific constructivist techniques are included, such as brainstorming, experimenting with materials, designing a model, conducting experiments, and analyzing data.

Yager (1991) also provided a scale, or checklist, for teachers to use to determine the degree to which they are using the Constructivist Learning Model. The checklist asks questions about who is identifying the issue, the relevancy of the issue, and who plans the investigation and activities. Each of these, and the several others on the list, contributes to a self-check on the use of the Constructivist Learning Model.

There are a number of different strands contributing to the development of a more constructivist approach in the science classroom. According to the American Association for the Advancement of Science (1989), instruction needs to focus on key concepts and ideas in science, and on making the connections between science, mathematics, and technology. The focus needs to be on scientific ways of thinking, rather than on sheer volume of facts covered and memorized.

Kober (1993) emphasized that what we know about teaching science has changed drastically during the last few decades, although it harks back to methods as old as those used by Socrates. The new focus is on dialogue and reflection, rather than on lecture and learning by intimidation or imposition. It is by this direct, question-and-answer method that students refine their understanding of concepts and relationships. Again, this is a constructivist approach in which students are continually in the process of constructing knowledge and greater understanding.

There are other specific methods prescribed for the new science learning. Adams and Hamm (1994) recommend not only hands-on experience, but the use of student teams in the learning process. They note that learning is enhanced by using many different kinds of formats, rather than just one, including formats that address the sense and the different learning styles.

Some of the techniques recommended for science learning are very specifically derived from constructivist philosophy. For example, Novak (1996) described a method that he termed "concept mapping," which is a tool for science teaching and learning. Concept mapping emphasizes relationships between concepts and helping students develop a greater understanding of how various science concepts are hierarchically organized and in relationship to each other. Concept mapping provides both a means to assess current student knowledge and a means to create appropriate teaching plans that address limitations and misconceptions.

Fensham, Gunstone, and White (1994) noted that the purpose of constructivist teaching is not to encourage students to think that their ideas or concepts are automatically equal to those of practiced scientists. Instead, the purpose of teaching students using constructivist techniques is to intervene after identifying student understandings in order to promote the development and change of concepts in the direction of greater validity. There are criteria, as they note, and students need to develop in relationship to some model of valid or credible knowledge. Yet, this is distinguished between simply asking students to memorize science content from a textbook.

Russell (1993) noted that this is always the science teacher's dilemma, whether to teach from the textbook and to the curriculum or to utilize methods that are more constructivist in orientation, with the latter leading to better understanding and student satisfaction with learning environments. In particular, new teachers tend to rely on what they already know, including the methods that their teachers used to teach them. New teachers have little support and may find the reality of school overwhelming their ideals about using principles they were taught in school. Yet, they, too, tend to learn constructively, learning from experience plus their reflection upon that experience, along with new information and old ideals.

One way to avoid the dilemma, of course, is for curriculum to change. If both curriculum and teacher education are brought into congruence around the unifying theme of the Constructivist Learning Model (or a constructivist learning model), then the focus can be on refining constructivist teaching philosophy and strategies, rather than on attempting to incorporate them in situations where they do not fit well.

Cheung and Taylor (1991) tried this approach in looking at science education curriculum in the United Kingdom. They noted that while the Education Reform Act of 1988 set forth requirements for a national curriculum, many of the key terms were vague and ill-defined. Cheung and Taylor sought to utilize Piaget's Spiral of Knowing as a means to think about the national curriculum and develop it in constructivist ways.

They contend that the Spiral of Knowing allows for an understanding of science learning, and science knowledge, as both personally and socially constructed. For them, a constructivist pedagogy in science learning then requires that the personal be related to the socially constructed, or publicly mediated knowledge. In other words, like Fensham, Gunstone, and White (1994), they do not see constructivism as relativism, but as a means in which the student's developing knowledge is supported by teacher interventions designed to promote student concepts which are evaluated against socially constructed criteria.

There has to be a reason for the student's knowledge to even begin to develop, however. Constructivist approaches recognize that curricula, and problems, that are imposed from the outside may not be relevant to students and may not engage their problem-solving capacities. Wheatley (1991) noted that the first step in a constructivist approach is to identify those problems or issues that are perturbing to the students, or potentially perturbing, because it is those perturbations that push students, or anyone, to learn. Their learning involves gathering information, developing concepts, testing hypotheses, and taking action in order to reduce those perturbations. In a problem-centered learning model, as proposed by Wheatley (1991), they identify tasks, work together in groups to construct potential answers to problems, and come together to share those responses. The collaborative effort represents one step in bringing together personal knowledge construction and socially acceptable, or publicly mediated knowledge. This is further tested against science expert knowledge.

Roth (1993) contended that problem-centered learning can also integrate aspects of the curriculum, and that science and math, for example, do not have to be taught as totally separate bodies of knowledge, but as related concepts. In his case study, integration of math and science in a constructivist laboratory was quite effective, allowing students to frame their own questions, work with different kinds of materials and equipment, and reach high-level standards in both science and math. In reporting on the example of one student, Roth noted that the student was actually given credit only in physics, despite his high-level work in mathematics, too, because of the school's separation of the subject matter. This is another example of the problems resulting when constructivist teaching is attempted within a non-constructivist curricular framework. It would clearly be more useful to work on curriculum development, teacher education, and specific strategies, all at the same time.

However, there is also potential to work with the incongruity. As Saunders (1992), Wheatley (1991) and others have noted, learning takes place when the individual is perturbed, or placed in a state of disequilibrium. Thus, the science learner may equally learn social knowledge when faced with the incongruity between a constructivist classroom and a non-constructivist curriculum or school environment.

2.7 The Constructivist Learning Environment Survey

As researchers became more interested in classroom learning environments, they sought to find, or develop, assessment tools that would help them evaluate the learning environments and discover how they contributed to student learning and students perceptions.

Fraser, one of the foremost theorists and researchers working with constructivist concepts, was involved in developing both the original and the redesigned Constructivist Learning Environment Survey (CLES). The original CLES was designed in the early 1990s and utilized psychosocial principles to assess several aspects of the classroom environment.

However, there is a redesign of this instrument presented in the International Journal of Educational Research (Taylor, Fraser, & Fisher, 1997). This redesign is, in the authors' words, intended "to incorporate a critical theory perspective on the cultural framing of the classroom learning environment" (p. 1). The authors thought that the initial CLES had a theoretical framework that was insufficient to support a strong program of constructivist reform. The redesign was created to address that problem.

This redesign emphasizes different factors than the initial CLES, but seems to have even greater credibility based on both qualitative and statistical studies. The major factors under consideration are student and teacher perceptions of Personal Relevance, Uncertainty, Student Negotiation, Shared Control, and Critical Voice. Each scale was designed to include six items which had the response alternatives of Almost Always, Often, Sometimes, Seldom, and Almost Never.

In looking at the development and validation of this instrument, it is apparent that the researchers followed good practice. They started with two small-scale qualitative studies to refine the instrument and determine final wording. They then used the instrument in large-scale trials in both the United States and Australia, using quantitative methodologies. They were looking specifically for internal consistency, factorial validity, and cross-cultural integrity and obtained good results for all measures (Dryden & Fraser, 1996; Taylor, Fraser, & Fisher, 1997).

The first qualitative study involved collaboration with a mathematics teacher working with a mixed-sex 8th grade class in Australia. The researchers worked with the teacher in the early part of his teaching a five-week mathematics activity to his class. The researchers participated as participant-observers and also analyzed curriculum documentation and interviewed teachers and students. They were particularly interested in student input from those who had unfavorable attitudes toward the classroom environment and they sought to learn more about student attitudes toward the CLES itself (Taylor, Fraser, & White, 1994).

In the second collaborative study, they worked with a grade 10 science class in Perth, with an all-girl class in an all-girl school. They collaborated with a teacher conducting a biotechnology course that was designed to help students articulate their ethics and beliefs and engage in critical and reflective thinking. Again, the intention of the researchers was to determine the usability of the CLES for students, and its ability to help the researchers make sense of their observations regarding the classroom environment (Taylor, Dawson, & Fraser, 1995).

This series of studies, along with the earlier work on the original CLES, provides a good background for understanding the development and use of the instrument. The research is well-designed to serve the purposes of the researchers, and it seems as though the new CLES is plausible and valid.

The new CLES is clearly designed to test for a certain perspective. The test items are intended to measure if the students feel that the information is personally relevant to them, for example, and if students are taught to believe that science is imperfect. The assumption behind this instrument is that the constructivist approach is desirable, and that certain principles underpin that approach. Among those principles are an understanding of knowledge as socially constructed, constantly changing, and designed to deal with real-life problems. These are measured through the use of the CLES.

2.0 Summary of the Chapter

The constructivist classroom is both a teaching and a learning environment. Constructivism is a philosophy from which epistemologies can be derived. These epistemologies undergird philosophies of teaching that depend upon certain specific principles. These principles include the basic assumption that knowledge is always in the process of being created by the individual and that the individual tests that knowledge in a wide range of situations in the world in order to refine it. Phillips (1995) indicated that there are different kinds of constructivism that vary in how they see the role of the individual and society, and the role of humans as creators or humans as learner/observers of nature as the instructor.

In terms of teaching/learning environments, constructivism of all sorts focuses on engaging the individual student in an active process of constructing his or her knowledge. Constructivisms that are more oriented to sociopolitical approaches emphasize the collectivity of knowledge creation and focus on social empowerment. All forms of constructivism emphasize process over revealed truth, and require teachers to alter their strategies.

Teachers, too, are learners. Many teacher training programs still attempt to impose top-down training of revealed truths, even from constructivism. However, studies by Fraser, Tobin, and Kahle (1992) and Yager (1995), among others, show that teachers change their ideas over time and that they only move gradually toward a constructivist approach. The results of using such an approach seem to be positive for both teachers and learners.

This review of literature has revealed an absence of this theoretical and empirical approach in an inner city environment, such as science classes in Chicago. Therefore, it is intended that this study expands the literature in this area and makes an important contribution to students' learning of science in such classrooms. The following chapter contains an account of the methodology of the study used for an attempt to achieve this.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter describes the participants, procedures, and materials used in this research project. A multi-method approach using both quantitative and qualitative research methods was used, affording both detailed analysis of the teaching methods as well as rich descriptions of the classroom environments. All materials used in the quantitative portion of the research were previously developed and tested, while the interview protocols used in the qualitative approach were developed following the tradition of the research literature about this approach.

3.2 Research Design

The methodology used to answer the research questions was a multi-method approach utilizing both quantitative and qualitative approaches. The quasi-experimental approach of the OXO (Observe, Experiment, Observe) model was determined to be the appropriate approach for the quantitative side of the research. By using this approach, the study moved from general research questions to testable hypotheses. Since the research questions concerned comparisons, there was need for a control, or comparison group. The specific hypotheses were:

H1: Students in a classroom where a constructivist approach to learning is used will exhibit greater personal relevance in their learning environment than students in traditional classes.

H2: Students in a classroom where a constructivist approach to learning is used will exhibit a greater recognition of the uncertainty of scientific knowledge than students in traditional classes.

H3: Students in a classroom where a constructivist approach to learning is used will exhibit greater critical voice in their learning environment than students in traditional classes.

H4: Students in a classroom where a constructivist approach to learning is used will exhibit greater shared control in their learning environment than students in traditional classes.

H5: Students in a classroom where a constructivist approach to learning is used will exhibit greater student negotiation in their learning environment than students in traditional classes.

H6: Students in a classroom where a constructivist approach to learning is used will exhibit greater improvement in their learning of science concepts than students in traditional classes.

The primary objective of this study is encompassed in Hypothesis 6, that is, whether students in a classroom utilizing constructivist teaching techniques are better served pedagogically than students in a classroom utilizing traditional teaching techniques. Hypotheses 1 through 5 were intended to show that there were significant differences between the two classrooms in such a way that one could be accurately designated the constructivist classroom and the other designated the traditional classroom. Therefore, the research took place in two stages. First, a series of interviews with students and teachers was conducted and a survey instrument was applied in order to test the assumptions embodied by Hypotheses 1 through 5. Once it was determined that two classrooms differing significantly in pedagogical terms had been identified, then stage two of the research took place, wherein the performance of the students in each classroom was measured to test Hypothesis 6.

There were several primary limitations to this study, including lack of randomization and the small sample size. The classes used for assessment were, of necessity, a convenience sample. As a consequence, there is no assurance that the teachers leading the classes were proficient or comfortable with their assigned teaching environment. This particular problem was overcome to a certain extent by choosing teachers with ongoing experience in traditional methods to lead the control group and teachers with ongoing experience in constructivist methods to lead the experimental group. Additionally, qualitative data which detail the classroom environment, the teachers, and the students, provide a rich description which can be used to assess the appropriateness of the control group/experimental group comparisons.

3.3 Data Sources

The study was conducted in a Chicago public high school. The school is located on the far-west side of the city of Chicago and is surrounded by large low-income housing projects. This type of locale is commonly, and euphemistically, referred to as "inner city," which really means poor and non-white.

The school serves a mainly minority population. Only about two percent of the student population is white, a negligible number are of Asian descent, and the vast majority of the students are either African-American or Mexican-American. Drugs, crime, violence, and dysfunctional family situations are common situations for most students, which presents a challenge for educators.

The target population was students in 10th grade science classes. Two separate classrooms of students in a 10th grade general science program were selected to serve as the experimental and control groups. One group was taught the material using traditional teaching methods in a traditional learning environment, functioning as the control group. The second group was taught the same basic material using constructivist methods in a constructivist learning environment.

The two classes chosen for the study contained 25 students each. In order to be considered a valid participant, it was required that a student take part in the survey, as well as both the pre-test and post-test of science knowledge. A total of five students, two in the control group and three in the experimental group, failed to complete all three instruments. This left a final sample of 45 students, for a 90% completion rate. The final total of 45 students who participated in the research included 22 in the Experimental Group (which represented the constructivist-based classroom) and 23 in the Control Group (which represented the traditional classroom). The sample contained 26 females and 19 males. The Experimental Group contained 13 females and 9 males, while the Control Group contained 13 females and 10 males. No data were collected on ethnicity of the students.

The traditional learning environment can be characterized as a classroom situation in which students work alone and rely heavily on textbooks, workbooks, and lectures. They are not particularly encouraged to engage in writing activities. Students do not participate in establishing class rules and they are viewed as blank slates onto which information is etched by the teacher. Student answers are solicited by the teacher primarily to validate that students have learned what the teacher wants them to learn. Assessment of learning is separated from the teaching process and occurs almost entirely through weekly tests.

On the other hand, the constructivist classroom has a learning environment which looks quite different. Students work in small groups, emphasize creative writing assignments, and rely heavily on cooperative activities and manipulation of materials during the learning process. They participate in establishing rules for the classroom and they are viewed as participants in knowledge creation, rather than empty vessels or blank slates. They are seen as valuable thinkers who contribute to the creation of new theories about the world. Teachers seek out student viewpoints in order to understand students' present concepts for use in the ongoing creation of learning and meaning. Students' current learning is used as the basis of future lesson plans. Specific techniques are used that are described in constructivist research, including such things as concept mapping, interviewing, teaching experiments, contrastive teaching, and concept substitution. Finally, the assessment of student learning is an ongoing process based on the observation of student work, student creation of portfolios, and group presentations, among other things.

3.4 Data Collection

3.4.1 *Basic Set-up*

The same textbook was used by both groups. This textbook was the General Science text published by Holt, Rinehart and Winston, with the latest revision date of 1988. This is a basic text used in the Chicago Public School District. It is divided into four units and 23 chapters. The main units are "What Makes up our World," which includes chapters on atoms and chemical activity; "How Does Energy Affect Matter," which includes chapters on energy, waves and sound, and light; "How is the Earth Changing," which includes chapters on changes in the rocks, the oceans, and the earth in space; and, "What Makes up our Living World," which includes chapters on life on earth, the human organism, and the biosphere. In other words, this text provides an overview of much of the basic material of the physical, chemical, geological, and biological sciences.

The classroom learning environments were established from the beginning through the use of two different approaches. In the traditional learning environment the emphasis was on covering as much content knowledge as the time allowed. The teacher worked strictly in accordance with the syllabus and in the order suggested. Traditional teaching methods were used, focusing on lectures, skill books, work sheets, and tests centered around textbook subject matter.

On the other hand, the constructivist learning environment in the other classroom was established by starting with an initial exploration of student ideas, and then a variety of approaches was used. This included "Creative Writing" in which individuals wrote all their ideas about the particular topic, then formed into groups of four to further compare, discuss, and explore these concepts. Other methods that were used were suggested in the literature on constructivism and included independent student projects, journals, posters, and group videotaped sessions.

3.4.2 *Procedures*

The instrument chosen to address the first five hypotheses was the Constructivist Learning Environment Survey (CLES). The CLES was administered to students in each class after one full week of science instruction. It was administered to all students for a second time at the end of the school term.

The CLES was developed initially to help researchers determine how well a specific classroom environment fits with the constructivist approach (Fraser & Walberg, 1991). It was designed to assess four different dimensions and to be used by teachers themselves to think about how their teaching approach might be reshaped to be more congruent with a constructivist epistemology.

The original CLES included four separate scales, which were designed to assess the constructivist dimensions of (1) Autonomy, (2) Prior Knowledge, (3) Collaboration, and (4) Student-Centeredness or Reflection (Taylor & Fraser, 1991). The original version of the VLES was based largely on a psychosocial view of constructivist reform that focused on students as co-constructors of knowledge but did not take into account the cultural context framing the classroom environment. Because of the importance of teachers and students becoming critically aware of how their teaching and learning roles are being restrained by such forces, a decision was made to re-design the CLES to incorporate a critical theory perspective on the cultural framing of the classroom environment (Taylor, Fraser, & Fisher, 1997). The new version of the CLES, which was used in this study, included and reformulated these four characteristics in a new format that measured five related characteristics. These characteristics were (1) Personal Relevance, (2) Uncertainty, (3) Critical Voice, (4) Shared Control, and (5) Student Negotiation (Taylor, Fraser, & Fisher, 1997). Although the new CLES form is relatively new, it should prove to be as useful a tool in conducting research that emphasizes the constructivist epistemology as was the old form. Table 3.1 contains a description of each of the scales in the CLES together with a sample item from each scale.

Table 3.1

Description of Scales and Sample Items for the CLES

Scale Name	Description	Sample Item
Personal Relevance	Relevance of learning to students' lives	In this science class, I learn about the world outside the school.
Uncertainty	Provisional status of scientific knowledge	In this science class, I learn that the views of science have changed over time.
Critical Voice	Legitimacy of expressing a critical opinion	In this science class, it's OK to ask the teacher, "Why do we have to do this?"
Shared Control	Participation in planning, conducting and assessing of learning	In this science class, I help the teacher to plan what I'm going to learn.
Student Negotiation	Involvement with other students in assessing viability of new ideas	In this science class, I ask other students to explain their ideas.

Data addressing the sixth hypothesis were collected using the Illinois Goal Assessment Program tests. Students were administered an assessment test at the beginning of the school year and reassessed at the end of the school term.

These tests are designed to address the four major goals established by the Illinois State Board of Education for science. The four goals include working knowledge of:

1. The concepts and basic vocabulary of biological, physical, and environmental sciences and their application to life and work in contemporary technological society.
2. The social and environmental implications and limitations of technological development.
3. The principles of scientific research and their application in simple research projects.
4. The processes, techniques, methods, equipment, and available technology of science.

The goals, and the tests, were designed to provide school districts with the means of tracking the accumulated learning of their students at several different times during the school career. The state regularly assesses student science learning in grades 4, 7, and 11. However, local districts, and schools are given the option to administer their local science assessment at any time. They must assess science at least twice before grade 9 and at least once during the high school years. The tests are provided by the state and are geared toward the grade level assessed, providing benchmarks regarding the elements of science that students should know by a specific time during their schooling. For example, in looking specifically at biology, Goal 1 elements, students at the Grade 7 level are expected to be able to compare the structures common to all living cells, know the major structures and parts of cells, and know specific cell functions within biological systems. By Grade 11, they should be able to identify the structure and components of chromosomes, genes, and DNA and know the rules of genetic inheritance (Sample tests of Illinois goals in science, 1993).

These tests were designed by the Illinois State Board of Education (ISBE) with the criticism and assistance of the Science Assessment Advisory Committee, which included 25 members from both public school and university environments. The tests are designed to measure both performance literacy and performance skills. The criteria to select specific test items were content validity, importance, difficulty, classification according to a Productive Thinking Scale, power to discriminate among student abilities, freedom from bias, and subject-area distribution. ISBE staff, Illinois educators, advisory board members select, edit and choose the items, which are reviewed by groups, including classroom teachers, who screen each item for grade-level appropriateness, content validity, importance, accuracy of the answers, readability, and clarity of graphics and vocabulary. In addition, ISBE pilot-tests all items used in the science assessment, creating a statistical profile for each item and omitting those which are too easy or too difficult (Sample tests of Illinois goals, 1993).

Both before the beginning and during the term of the study, the researcher visited eac class on five occasions. On these visits, detailed notes were taken about the classroom environments. The notes from the early visits were used to confirm that the environments were substantially different, and that each classroom conformed to the theoretical descriptions of traditional and constructivist classrooms. Later visits confirmed that these distinctions held up throughout the course of the study. A checklist used to observe the classroom environments is included in Appendix 1.

During each classroom visit, the researcher would interview a student about their learning activity, both in and out of class. A different student was chosen each time, and the data collected from these interviews served as an additional source of data to enrich the description of what was occurring in the classroom. Additionally, the teachers for each classroom were interviewed separately before, during, and after the study, adding further detail to the classroom environment descriptions. The interview protocols for both the student and teacher interviews are included in Appendix 2.

3.5 Data Analysis and Interpretation

For Hypotheses 1 through 5, t-tests assessing the differences between group means were used. Group 1 (control, traditional environment) was hypothesized to exhibit lower scores than Group 2 (experimental, constructivist environment).

For H6, it could not be assumed that each group would start from the same base of knowledge; thus, analysis of this hypothesis proceeded in stages. First, the pre-tests of proficiency were assessed by t-test. If no significant differences in prior knowledge were found, then differences in the final proficiency scores were also assessed using a t-test. It was hypothesized that Group 1 would have lower final scores than Group 2.

The qualitative data (classroom descriptions, interviews with students and teachers) were compiled by the researcher and written into a narrative of the differences between the two classroom environments thus adding understanding to the overall findings.

3.6 Ethics

The basic ethical issue in working with two groups of people is well-illustrated by the infamous Tuskegee Syphilis Study. Research becomes unethical when the control group is denied treatments that give advantage to the experimental group, or that prevent the control group from suffering additional harm.

In terms of school children and educational methods, this is more relevant over the long-term than the short amount of time that this study covers. If, for example, constructivist methods were shown to provide students with a clear and significant advantage in learning science, then to continue to teach students with traditional methods would be to participate in their harm, or disadvantage. This is a complex situation, however, since the researcher has neither the authority nor the power to require that all classroom teachers immediately adopt constructivist methods in the classroom if that is the result of the research. In addition, one piece of research is not sufficient to determine that constructivism, or traditional methods, have the advantage in learning science. Nonetheless, the ethics of the situation require disseminating results of such research so that teachers and education researchers can work with the best information in designing appropriate and effective programs for children.

3.7 Summary

This chapter described the research methods employed in this study. A multi-method approach, combining rich descriptions and interviews in the qualitative tradition with the precise experimental conditions of the quantitative tradition, was selected. The procedures, participants, and materials to be used were described. In the following chapter, the general results of these methods will be presented. The qualitative results are described and the quantitative results are statistically analyzed.

CHAPTER FOUR

RESULTS

The research was carried out over the course of the fall semester of 1997 at a public high school in the Chicago, Illinois School District. Students in two classrooms, one taught from a traditional perspective, the other taught from a constructivist perspective, were tested on basic science knowledge twice, near the beginning and near the end of the term. Students were also surveyed about their respective classroom environments near the end of the term. Additionally, the researcher visited each class several times, taking notes, interviewing teachers, and speaking to students. The results of these tests, surveys, and observations are detailed in this chapter.

4.1 Quantitative Research

The sample of 45 students who participated in the research included 22 in the Experimental Group (which represented the constructivist-based classroom) and 23 in the Control Group (which represented the traditional classroom). The Experimental Group contained 13 females and 9 males, while the Control Group contained 13 females and 10 males. No data were collected on ethnicity of the students.

Hypothesis 1, which proposed that students in a classroom where a constructivist approach to learning is used will exhibit greater personal relevance in their learning environment than students in traditional classes, was assessed for significance with a t-test. The dependent variable, personal relevance in the learning environment, was measured by means of the CLES instrument.

The results for group differences on Personal Relevance are found in Table 4.1. Students in the Experimental Group had a mean score of 3.33 with a standard deviation of .01, while students in the control group had a mean score of 2.17 with a standard deviation of .30. The t-test yielded a t-value of 18.16 with 43 degrees of freedom, which is significant at $p<.001$. Thus, support for H1 was found.

Table 4.1
T-test for Independent Samples on Variable Personal Relevance

Variable	Number of Cases	Mean	SD	SE of Mean
Experimental	22	3.33	.01	.01
Control	23	2.17	.30	.06

Mean Difference: 1.16
Levene's Test for Equality of variances: F=70.89, p=.00

Variances	t-value	df	2-tail sig.	SE of Diff.	95% CI for Diff
Equal	18.16	43	.000	.064	(1.031, 1.288)
Unequal	18.58	22.00	.000	.062	(1.030, 1.289)

The results for Hypothesis 2, which stated that students in a classroom where a constructivist approach to learning is used will exhibit greater recognition of the uncertainty of science than students in traditional classes, are found in Table 4.2. Students in the Experimental Group had a mean score of 3.09 with a standard deviation of .05, while students in the control group had a mean score of 2.00 with a standard deviation of .01. The t-test yielded a t-value of 34.45 with 43 degrees of freedom, significant at $p<.001$. Thus, support for H2 was found.

Table 4.2
T-test for Independent Samples on Variable Uncertainty of Science

Variable	Number of Cases	Mean	SD	SE of Mean
Experimental	22	3.09	.15	.03
Control	23	2.00	.01	.00

Mean Difference: 1.09
Levene's Test for Equality of variances: F=84.40, p=.000

Variances	t-value	df	2-tail sig.	SE of Diff.	95% CI for Diff
Equal	34.45	43	.000	.032	(1.027, 1.155)
Unequal	33.67	21.00	.000	.032	(1.024, 1.158)

The results for Hypothesis 3, that students in a classroom where a constructivist approach to learning is used will exhibit greater critical voice in their learning environment than students in traditional classes, are found in Table 4.3. Students in the Experimental Group had a mean score of 3.50 with a standard deviation of .002, while students in the control group had a mean score of 2.24 with a standard deviation of .45. The t-test yielded a t-value of 13.17 with 43 degrees of freedom, significant at $p<.001$. Thus, support for H3 was found.

Table 4.3
T-test for Independent Samples on Variable Critical Voice

Variable	Number of Cases	Mean	SD	SE of Mean
Experimental	22	3.50	.002	.002
Control	23	2.24	.45	.01

Mean Difference: 1.26
Levene's Test for Equality of variances: F=70.89, p=.000

Variances	t-value	df	2-tail sig.	SE of Diff.	95% CI for Diff
Equal	13.17	43	.000	.096	(1.068, 1.454)
Unequal	13.47	22.00	.000	.094	(1.067, 1.455)

The results for Hypothesis 4, that students in a classroom where a constructivist approach to learning is used will exhibit greater shared control in their learning environment than students in traditional classes, are found in Table 4.4 Students in the Experimental Group had a mean score of 3.27 with a standard deviation of .46, while students in the control group had a mean score of 1.74 with a standard deviation of .45. Levene's test for equality of variances yielded an F score of .031, which is not significant, meaning that the t-test for unequal variances must be used. This t-test yielded a t-value of 11.36 with 42.84 degrees of freedom, significant for $p<.001$, support H4.

Table 4.4
T-test for Independent Samples on Variable Shared Control

Variable	Number of Cases	Mean	SD	SE of Mean
Experimental	22	3.27	.46	.097
Control	23	1.74	.45	.094

Mean Difference: 1.53
Levene's Test for Equality of variances: F=.03, p=.861

Variances	t-value	df	2-tail sig	SE of Diff.	95% CI for Diff
Equal	11.37	43	.000	.135	(1.261, 1.806)
Unequal	11.36	42.84	.000	.135	(1.261, 1.806)

The results for Hypothesis 5, which held that students in a classroom where a constructivist approach to learning is used will exhibit greater student negotiation in their learning environment than students in traditional classes, are found in Table 4.5. Students in the Experimental Group had a mean score of 4.08 with a standard deviation of .15, while students in the control group had a mean score of 2.74 with a standard deviation of .45. The t-test yielded a t-value of 13.25 with 43 degrees of freedom, significant at $p<.001$, supporting the fifth hypothesis.

Table 4.5
T-test for Independent Samples on Variable Student Negotiation

Variable	Number of Cases	Mean	SD	SE of Mean
Experimental	22	4.08	.15	.032
Control	23	2.74	.45	.094

Mean Difference: 1.34
Levene's Test for Equality of variances: F=27.86, p=.000

Variances	t-value	df	2-tail sig.	SE of Diff.	95% CI for Diff
Equal	13.25	43	.000	.101	(1.133, 1.540)
Unequal	13.49	27.18	.000	.099	(1.133, 1.540)

In summation, all five factors of the CLES instrument were found to be significantly significant. Students in the Experimental group scored higher on all levels of the survey than did students in the Control group. Therefore, Hypotheses 1 through 5 are all supported by these findings.

Hypothesis 6, which held that students in constructivist-based classrooms would exhibit greater improvement in their learning of science concepts, was assessed by measuring scores on the Illinois Goal Assessment Program tests. Students were given the tests before the beginning of the research in order to determine what differences existed between the two groups before the experiment began. This test score served as a pre-test. Students in the Experimental Group had a mean score of 77.09 with a standard deviation of 8.42. Students in the control group had a mean score of 76.91 with a standard deviation of 8.43. The Levene's test for equality of variances yielded an F score of .011, which was not statistically significant, requiring that the t-test for unequal variances was used. The t-test yielded a t-value of .07 with 42.92 degrees of freedom, and the differences were not statistically significant. The results of the t-test on the pre-test are displayed in Table 4.6.

Table 4.6
T-test for Independent Samples on Variable Pre-test

Variable	Number of Cases	Mean	SD	SE of Mean
Experimental	22	77.09	8.42	1.795
Control	23	76.91	8.43	1.757

Mean Difference: .18
Levene's Test for Equality of variances: F=.011, p=.918

Variances	t-value	df	2-tail sig.	SE of Diff.	95% CI for Diff
Equal	.07	43	.944	2.511	(-4.888, 5.244)
Unequal	.07	42.92	.944	2.511	(-4.888, 5.244)

Because there was no significant difference between the groups on the pre-test scores, it was possible to assess the differences between groups on the post-test by means of a t-test. On the second application of the test, students in the Experimental Group had a mean score of 85.91 with a standard deviation of 5.93. Students in the Control Group had a mean score of 81.70 with a standard deviation of 5.90. The Levene's test for equality of variances yielded an F score of .022, not significant, so the unequal variances t-test was utilized. A t-value of 2.39 with 42.89 degrees of freedom had a 2-tailed significance of p=.021. Because the hypothesis predicted that the Experimental Group would score higher, a one-tailed significance is required. This is computed by simply halving the two-tailed number. Therefore, the differences between group scores on the post-test were found to be significant at p=.01. These results are displayed in Table 4.7.

Table 4.7
T-test for Independent Samples on Variable Post-test

Variable	Number of Cases	Mean	SD	SE of Mean
Experimental	22	85.91	5.93	1.264
Control	23	81.70	5.90	1.229

Mean Difference: 4.21
Levene's Test for Equality of variances: F=.022, p=.884

Variances	t-value	df	2-tail sig	SE of Diff.	95% CI for Diff
Equal	2.39	43	.021	1.763	(-.657, 7.770)
Unequal	2.39	42.89	.021	1.763	(-.657, 7.770)

There were no significant differences in performance before the research period started. Both groups increased their scores between the time of the first test and the second. At the time of the second test, however, the Experimental group showed a statistically significant better performance than the Control group. Therefore, support for Hypothesis 6 is confirmed.

4.2 Qualitative Research

The qualitative research began with a series of classroom observations and teacher interviews. This was done in order to provide a better description of the classroom environments. Additionally, this allowed the researcher to ensure that the two groups were equivalent in important ways, lending increased validity to the quantitative comparisons.

4.2.1 *Classroom Descriptions*

The following section is a summary of the classroom observations. The actual recorded observations are presented in Appendix 3.Both classrooms were of roughly the same size, the Experimental room measuring 30 feet by 45 feet, while the Control room measured 30 feet by 46 feet. Each class was composed of 25 students. The students in the Experimental group appeared to have more room in which to move around, however, because of the difference in classroom configuration. In the constructivist (experimental) room, desks were set up in circular groups of four or five, while in the traditional (control) room, desks were arranged in straight rows, with students sitting behind one another. Both classrooms used a similar mixture of overhead and window lighting. Both rooms depended on steam heating, and both tended to be either a little too warm or a little too cold.

The constructivist classroom contained a large number of visual displays. There were four large posters used to identify the parts of the human body and a large periodic table of the elements. There were 26 plants and four boxes of insect samples around the room that students used to conduct research projects. The room also had two large cabinets containing audio-visual equipment, encyclopedia, dictionaries, and journals. In contrast, the traditional classroom had no displays other than a periodic table. There was a bookshelf with a similar collection of books and journals, but no audio-visual equipment. Both classrooms had 10 computers for student use.

The constructivist classroom was a highly animated one. Students seldom remained at their desks, constantly moving about the classroom observing various projects. There was an almost constant underlying buzz in the room as the students were always discussing their projects with one another and their teacher. Students tended to be highly engaged in their work. Animated discussions between and among students and with the teacher dominated the classroom as the students actively partook in their educational experience

The traditional classroom was much more muted. A large degree of the students class time was devoted to teacher lectures and text book assignments. There was little movement about the room and, except for the first few minutes of class, little interaction between students.

The observed differences in the classrooms relate to hypotheses 3 (critical voice), 4 (shared control), and 5 (student negotiation). "Critical voice" refers to whether a social climate has been created in which students feel comfortable in questioning the teacher's study plan and methods. "Shared control" concerns whether students are invited to share with the teacher the control of the learning environment. "Student negotiation" assesses the ability of students to share with one another and to listen attentively. Each of these factors requires an environment open to sharing and negotiation in order to thrive. The more open and inviting physical environment displayed in the constructivist classroom creates such a space, and the difference is stark when compared to the rigid and regimented space of the traditional classroom.

4.2.2 *Teacher Interviews*

The following reports present the results of the two teacher interviews.

Traditional Teacher's Interview Protocol

Interviewer:
1. How many years have you been teaching?

Teacher: 20 years

2. How many at this level?

Teacher: 10 years

3. How many at this subject?

Teacher: 9 years

4. How long at this school?

Teacher: 10 years

5. Briefly describe your training and background in education.

Teacher: BS Degree in Education
MS Degree in Special Education

6. Have you found that your teaching style has evolved over the years?

Teacher: My teaching style has some what remained traditional

7. What do you feel have been the major influences on your teaching style?

Teacher: The major influences on my teaching have been the students. The majority of the students are very slow learners with serious behavior problems. Therefore, it is difficult for me to develop new teaching styles.

8. Are you aware of the theories surrounding a constructivist learning environment?

Teacher: No

9. If you had the ability to run your classroom whatever way you saw fit, without any outside interference or input, would you make any changes to what you currently do?

Teacher: Yes, I would purchase materials in order to conduct hand-on experiments and have students work in small groups. I would have parents volunteer to work in labs with students in order to eliminate behavior problems. Purchase computers for students to do research projects, and have students keep journals on activities that take place in the classroom.

10. Climate

The Traditional classroom appears to be cold. The students seldom get out of assigned desks. They appear to be very bored.

11. Miscellaneous

Traditional classroom learning, the students work individually. Teacher is involved in lectures, textbooks and very peer hand-on experiments. Classroom teacher appear to set the tone for learning. The students have very little input in their learning environment.

Constructivist Teacher's Interview Protocol

Interviewer:

1. How many years have you been teaching?

Teacher: 21 years

2. How many at this level?

Teacher: 8 years

3. How many at this subject?

Teacher: 6 years

4. How long at this school?

Teacher: 8 years

5. Briefly describe your training and background in education.

> Teacher: I have a BS degree in Education from Chicago State University. A MS degree in Science Education from Northern Illinois University.

6. Have you found that your teaching style has evolved over the years? (If yes, prompt for elaboration).

> Teacher: Yes, I have changed my teaching style. During my graduate work, I took a course on Constructivist teaching. For Constructivists, knowledge refers to the internal mental constructions of the individual. According to von Glasersfeld, one can never know what is in the mind of another and, therefore, can never place knowledge in books or human artefacts. Constructivist learning is an instructional strategy in which students work in small learning groups. These groups usually have three to five members who work together to accomplish an academic goal.

7. What do you feel have been the major influences on your teaching style?

> Teacher: The major influence on my teaching styles has been the recent training in Constructivist teaching and learning.

8. Do you have a personal or guiding philosophy on how a classroom should run? (If yes, elaborate: prompt for views on classroom environment, student participation, lecturing style or preference, reliance on textbooks).

> Teacher: Yes, my philosophy on how a classroom should be run is based on constructivism. Therefore, constructivism is the center of my training in Science Education. It can be translated to practical application at the classroom level, and that it engenders. An atmosphere for positive social interaction and free exchange of ideas amongst students and with the teacher. Students should take an <u>active</u> part in class participation. Teachers should limit the time spent on lectures. Textbooks should be used as a supplement to other resources used in a classroom.

9. Are you aware of the theories surrounding a constructivist learning environment? (If yes, as for their description of the theory.)

> Teacher: Yes, the Constructivist Theory implies a teaching style that promote group learning, where two or three students discuss approaches to a given problem with little or no interference from the teacher. The Constructivist teacher would rather explore how students see the problems and why their paths toward a solution seem promising to them. The Constructivist teacher create a learning environment, whereas, the student's thinking experiences, and interests create lessons which frequently mean altering teachers' plans.

10. If you had the ability to run your classroom whatever way you saw fit, without any outside interference or input, would you make any changes to what you currently do? (If yes, prompt to elaborate)

> Teacher. No, I would not change my classroom learning environment.

Each teacher was initially interviewed about their education and experience. The teacher of the constructivist classroom had 21 years teaching experience, while the traditionalist teacher had 20 years. However, the traditional teacher had ten years experience at her current level and nine years in science, compared with eight at this level and six in science for the constructivist teacher.

Both teachers had both a Bachelor of Science degree and a Master of Science degree in Education. While the traditional teacher reported that her style had remained somewhat the same over the course of her career, the constructivist teacher noted that, after exposure to constructivist theory during her Master's degree studies, she has attempted to modify her style. The traditional teacher identified the students, and especially their behavior problems, as the primary influence on her teaching style. The constructivist teacher pointed, again, to her training in constructivist methods as the major influence.

Finally, each teacher was asked what they would change about teaching if they had a free hand. The constructivist teacher felt that her current style was good and would change nothing. The traditionalist teacher, although previously stating that she was unaware of constructivist theories and methods described changes that would create the essentials of a constructivist environment.

After the completion of the study, follow-up interviews with each teacher were conducted. These interviews were designed to specifically examine the hypotheses tested in this research project. The teachers were read a description of each of the five concepts under consideration (personal relevance, uncertainty of science, critical voice, shared control, and student negotiation). They were then asked, first, to assess the importance of the item to pedagogical development and, second, to describe in what ways - if any - their teaching style helped to foster it. In the following summaries of the teachers' comments, the teacher who uses constructivist techniques will be identified as Teacher C, while the teacher who uses primarily traditional methods will be identified as Teacher T.

Personal Relevance

Personal relevance relates to "the connection of school science to students' out-of-school experiences as a meaningful context for the development of students' scientific and mathematical knowledge" (Taylor, Fraser, & Fisher, 1997, p. 296). Both teachers acknowledged that making lessons relevant to students' every-day experience was both a valuable teaching method as well as a necessary foundation of pedagogy. However, they reported substantially different approaches to addressing personal relevance. Teacher C reported that she tries to work relevance into every aspect of her lesson plan. She uses every day examples in her lectures and projects, uses common materials for demonstrations, and grants extra credit for students who make special efforts to relate their schoolwork and projects to their every day lives. Teacher T reported that she tries to include examples from every day life in her lectures, but all other class work is limited to textbook projects and exercises.

Uncertainty of Science

Uncertainty of science relates to "the extent to which opportunities are provided for students to experience scientific knowledge as arising from theory-dependent inquiry involving human experience and values, and as evolving, non-foundational, and culturally and socially determined" (Taylor, Fraser, & Fisher, 1997, p. 296). Teacher C fully endorsed this position, extending it by saying that "there is no such thing as 'truth,' because what we call truth changes depending on time, history, and culture." Teacher T, on the other hand, rejected the entire notion of "uncertainty of science." The goal of science, she stated, was to discover immutable truths that hold across cultures and ages. Several times, she referred to the Law of Gravity which, she said, "remains as true for a tribesman in New Guinea today as it was for Isaac Newton in the 14th century (sic)."

Given these differences in the two teachers' beliefs about the uncertainty of science, it is not surprising that there were significant differences in their classroom approaches to the issue. For Teacher T, in fact, the issue does not even come up. "Scientific fact is scientific fact," she said, "and it would be disservice to the students to suggest that those facts could change depending on where and when you live." Teacher C, on the other hand, likes to point out to her charges that at various times in history it was considered scientific "fact" that the earth was flat and that the universe orbited around the earth. She states that her students are told that "while facts are knowable, but we can never be sure that we know all the facts right now."

Critical Voice

Critical voice refers to "the extent to which a social climate has been established in which students feel that it is legitimate and beneficial to question the teacher's pedagogical plans and methods and to express concerns about any impediments to their learning" (Taylor, Fraser, & Fisher, 1997, p. 296). Once again, Teacher T rejected this notion out of hand, stating that "allowing such license to the students is an invitation to chaos." Teacher C, however, fully endorsed the notion and described how such a climate is fostered in her classroom. This included setting up grade contracts by which students were able to agree to precisely the activities they must engage in to receive a given grade.

Shared Control

Shared control refers to whether students are "being invited to share with the teacher control of learning activities, and the determination and application of assessment criteria" (Taylor, Fraser, & Fisher, 1997, p. 296). Teacher T here repeated the same objections that she had expressed about the concept of critical voice. In fact, at this point she became visibly flustered and nearly refused to continue the interview. "I've heard of this kind of teaching system before," she said, "and I know for a fact that it doesn't work." When asked how she would explain the numerous studies that support the effectiveness of such methods, she responded that they "must be phony studies with cooked up results."

Teacher C responded that while she fully endorsed the notion of shared control, she found it difficult to separate it in practice from the concept of critical voice. "In classroom practice," she said, "they are bound up together, and the same techniques I described for (critical voice) are the ones I use to instill (shared control)."

Student Negotiation

Student negotiation refers to "the extent to which opportunities exist for students to explain and justify to other students their newly developing ideas, to listen attentively and reflect on the viability of other students' ideas and, subsequently, to reflect self-critically on the viability of their own ideas" (Taylor, Fraser, & Fisher, 1997, p. 296). Teacher C responded that "this is probably the most important part of my teaching technique." The students in her classroom sit in small clusters of four and five desks and, except for periods of lecturing or testing, are encouraged to work together and to discuss their ideas with one another. Teacher C felt that this time allows the students to not only develop ideas better, but also to gain more confidence in expressing them.

Teacher T repeated the belief that student negotiation was an important element of learning. However, she did not describe such an environment in her classroom, other than allowing five to ten minutes of each class period for a question and answer session. The primary means of students' exploring their own and each other's ideas came in the independent study group that Teacher T helped to set up. Only five of her 23 students belong to the study group.

4.2.3 *Student Interviews*

Four students from each classroom were interviewed during the course of the study. Due to scheduling difficulties, each group of four students were interviewed together rather than separately. Unfortunately, this led to certain regularity of responses among the students. Typically, after the first student had responded, the other three would simply mimic the original response. For this reason, only summaries of the interviews will be discussed rather than particular responses. A total of 20 questions were asked of the students, covering each of the five factors of a constructivist classroom. For each factor, the students were asked questions that assessed their exposure to and affinity for a constructivist position generally and within their science classroom in particular. The students from the classroom using constructivist learning techniques will be identified as Classroom C, the students from the traditional classroom will be identified as Classroom T.

The following pages present the details of what occurred in each of the student interviews and provide an indication of the types of responses given by the students.

Traditional Classroom Students Interview Protocol

Student I:

1. First, do you like to ask questions in class?

Answer: Yes

2. In other classes, too, or just this one?

Answer: Yes, in all my classes.

3. Does your teacher encourage you to ask questions?

Answer: No

4. Do your other teachers encourage you to ask questions?

Answer: Yes, some teachers.

5. Do you get to interact with other students in class?

Answer: No, it is not permitted.

6. In other classes, too, or just this one?

Answer: In some classes.

7. Does your teacher encourage you to interest with one another?

Answer: No, she doesn't encourage us to interact with each other.

8. Do your other teachers encourage you to interact with one another?

Answer: Yes, it depends on the project.

9. Do you like to interact with other students in class, or would you rather study and learn on your own?

Answer: Yes, all students enjoy talking and working on projects, I enjoy working with other students.

10. Do you think that its important for teachers to relate your classroom studies to the outside world?

> Answer: Yes, teachers should relate classroom studies to the outside world.

11. In every class, or just in science?

> Answer: None of my classes.

12. Does your science teacher do this?

> Answer: No

13. How about other teachers?

> Answer: No

14. In science class, what do you think is the best way to learn; is it through lectures, textbooks, in-class experiments, homework, or something else? And what is the worst way?

> Answer: The best way to learn science, is through in-class experiments and homework. The worst way of learning is reading out of a textbook.

15. In other classes, what do you think is the best way to learn, is it through lectures, textbooks, in-class examples, homework, or something else? And what is the worst way?

> Answer: In other classes, learning is fun if it is done by in-class example, homework, and working on computers. The worst way is reading from a textbook and completing questions from a textbook.

16. Do you feel that you have learned a lot about science in this class?

> Answer: No, we have not learned a lot about science.

17. Do you think that you could have learned more if it had been taught differently?

> Answer: Yes, we could have learned more if we had been given hand-on experiments, homework and special projects.

Student II: Answers

1. Yes, because learning takes place when you ask questions.

2. Yes, sometimes.

3. Yes, sometimes.

4. No

5. We do not interact with other students in class.

6. No, most classes encourage independent activities.

7. No, he/she does not encourage us to interact with one another.

8. No.

9 Yes, interacting with other students enable us to exchange ideas.

10. Yes, teachers should relate information to the outside world.

11. None of my classes.

12. No, they do not relate information to the outside world.

13. In science, the best way to learn is through hand-on science. The worst way is reading out of the textbook.

14. No, we could have learned more had we been given labs.

15. Yes, change teaching from textbooks and have students work on computers.

Student III Answers:

1. Yes, I enjoy asking questions in class. I have a great interest in learning.

2. No, not in this class. We must work quietly and alone.

3. No, he wants us to work quietly.

4. No, we work alone.

5. No, not in this class.

6. No, we aren't encourage to interact with classmates.

7. Some teachers encourage us to interact with classmates.

8. Yes, my Science teacher encourage me to interact with my classmates.

9. Yes, I enjoy interacting with classmates. I do not enjoy working alone.

10. Yes, teachers should relate materials to the outside world in order to enhance our knowledge.

11. Some classes.

12. No, my science teacher doesn't relate information to the outside world.

13. No.

14. In science class, we would learn science better if we had computers.

15. The worst way of learning science is reading the textbooks and answering questions at the end.

16. No.

17. In other classes, the best way to learn is through in-class projects and working on computers.

Student IV Answers:

1. Yes, to be informed and have a clear understanding.

2. No, not in this class.

3. No, must remain quiet.

4. No, teacher doesn't encourage us to ask questions.

5. No, we work individually and quietly alone.

6. No, most of my other classes.

7. No, teacher doesn't want us working together.

8. Yes, Art teacher.

9. Yes, interacting with other students learning takes place. It's fun.

10. Yes, teachers should relate learning to the outside world, it makes learning fun.

11. No, my teacher doesn't relate information to the outside world.

12. No.

13. Some teachers.

14. In science, learning is fun if we were permitted to do hand-on science. We read page by page. We then answer questions from the textbooks. The worst way is the way we are learning presently.

15. In other classes, the best way of learning is through research projects and some homework. The worst way is reading out of textbooks.

16. No, I don't enjoy learning science.

17. Yes, if we had in-class experiments and research projects.

Constructivist Classroom Students Interview Protocol

Student I:

1. First, do you like to ask questions in class?

Answer: Yes, in other classes we are not encouraged to ask questions.

2. Does your teacher encourage you to ask questions?

Answer: Yes, in Science we work in small groups. We must ask questions.

3. Does your teacher encourage you to ask questions?

Answer: No, we are supposed to work quietly.

4. Do you get to interact with other students in class?

Answer: Yes, we interact with each other by working in small cooperative groups.

5. In other classes, too, or just this one.

Answer: No, we work quietly alone.

6. Does your teacher encourage you to interact with one another?

Answer: Yes, in Science we are encouraged to work in small groups and exchange ideas, or discuss the issue.

7. Do your other teachers encourage you to interact with one another?

Answer: No, the teachers are in control and do all the talking.

8. Do you like to interact with other students in class, or would you rather study and learn on your own?

Answer: Yes, all students enjoy interacting or talking with each other. It makes learning fun.

9. Do you think that it's important for teachers to relate your classroom studies to the outside world?

Answer: Yes, Science is not a local issue, it is a global issue, therefore, one needs to be exposed to both local and global views.

10. In ever class, or just in Science?

Answer: Mainly in Science class.

11. Does your Science teacher do this?

Answer: Yes, she makes comparison of science issues to other parts of the world. The teacher have students do research projects on different issues showing a global views, then we must explain the different views.

12. How about other teachers?

Answer: No.

13. In Science class, what do you think is the best way to learn; is it through lecturers, textbooks, in-class experiments, homework, or something else? What is the worst way?

Answer: In Science, it is best to give in-class experiment group work and research projects. The worst way to learn is having a teacher lecture for 40 minutes and complete lots of work sheets.

14. Do you feel that you have learned a lot about Science in this class?

Answer: Yes, we have fun in Science class.

15. Do you think that you could have learned more if it had been taught differently? What would you change?

Answer: Yes, I would not change my Science class. It is fun.

Student II Answers:

1. Yes, when asking questions in class, one gains a better understanding of the subject matter.

2 No, just this class

3. Yes, my Science teacher encourages me to ask questions.

4. No, my other teachers do not encourage class participation.

5. Yes, we get to work in small groups.

6. No, in other classes, we do not interact with other students.

7. Yes, my Science teacher encourages group work.

8. Yes, we are encouraged to interact with one another.

9. Yes, I enjoy interacting with other students, it makes learning fun. Working alone makes learning boring.

10. Yes, teachers should relate learning to the outside world. It gives learning a global view.

11. No, not in every case, just Science.

12. Yes, in Science we study local views and outside views. It gives the students an extended view of learning Science.

13. Science teachers always gives two different views. We research the various types of animals in Australia.

14. The best way of learning Science involves the students in hand-on Science. There is much more to work with. I never liked Science from the beginning of school, but this is better. We feel like real scientist. The worst way is having students learn Science from reading textbooks.

15. Yes, we have learned a lot in Science class this year. I have always believed in hands-on Science. The Science teacher who was here before didn't do many labs. He was a textbook kind of teacher. I would not change my science class. It is fun when we do our presentations.

Student III Answers:

1. Yes, asking questions give me a better understanding of the material.

2. No, just this class.

3. Yes, we have oral discussions.

4. No, my other teachers do not encourage oral discussions.

5. Yes, we interact when we do cooperative activities.

6. No just this class.

7. Yes, my science teacher encourages us to ask questions.

8. No, my other teachers do not encourage us to ask questions in class.

9. Yes, interacting with other students is fun. It makes learning very exciting.

10. Yes, teachers should relate information to the outside world. It explains our knowledge.

11. No, just in Science class.

12. Yes, my Science teacher always relate information to the outside work. She wants us to be exposed to global knowledge.

13. No, my other teachers do not relate information to the outside world.

14. The best way to learn Science, is through in-class experiments and homework. The worst way, is through reading out of textbooks.

15. Yes, we have learned a lot in Science.

16. No, I would let my Science class remain the same.

Student IV Answers:

1. Yes, not in all classes. I do ask questions in Art, because learning about different artists interest me.

2. Yes, in other classes.

3. Yes, my Science teacher.

4. Yes, my Science teacher has us working in small groups. Therefore, we are expected to ask questions.

5. No, we are expected to work quietly.

6. Yes, we interact when we do Science experiments. Also investigating various behaviors.

7. No, just in Science, she expects us to work as a team.

8. No, my other teachers do not encourage us to work together.

9. Yes, I personally would rather work in a group. It makes learning exciting.

10. Yes, teachers should relate materials to the outside world in order to expand our knowledge.

11. No, not in every case, but in Science we discuss animals in Africa and Asia. She enjoys talking about things in Africa.

12. In Science, the best way of learning is through hands-on lab and homework. The worst way is when the teacher talks for 45 minutes and never permits students to have an input.

13. In other classes, the students should have an input in what is being taught. The worst way is through lecture-teacher talking and worksheets.

14. Yes, we have learned a lot in Science. I really enjoyed the guest speaker Dr Pinto spoke to us about the human brain. He was very, very exciting.

15. No.

Personal Relevance

All eight students, regardless of the classroom from which they came, expressed support for the need for personal relevance in their learning environment. Further, they also said that very few of their teachers attempt to create personal relevance. The students from Classroom C stated that their science teacher goes out of her way to include personal relevance, while the students from Classroom T said that their teacher almost never does so.

Uncertainty of Science

The students from Classroom T seemed confused by the notion of the uncertainty of science, and stated that neither their science teacher nor any of their other teacher had suggested such a thing. They did not express support for the notion. The students from Classroom C reported that their science teacher did express the ideas of the uncertainty of science, but none of their other teachers did. They expressed only moderate support for the notion.

Critical Voice and Shared Control

The students from Classroom C stated that their teacher makes an effort to get their ideas about how the class is being taught. They also stated that she is open to comments and suggestions about various things. She is the only teacher they have who is open in such a way. All four stated that they found this classroom environment to be valuable and empowering. The students from Classroom T said that none of their teachers, including their science teacher, maintained such a classroom atmosphere. In one of the few unsolicited responses from this group, one student said that "I probably couldn't respect a teacher who tried something like that, and most kids that I know would try to take advantage of the situation."

Student Negotiation

The students from Classroom C stated that science is "one of (our) favorite classes" because of the opportunity to share their ideas and to work out problems together. Only in their science class, they reported, are they encouraged and allowed to do this on a regular basis, although they occasionally do so in some of their other classes (especially their civics class). The students from Classroom T similarly stated that in many of their classes they are allowed to share and interact on occasions and that they find it to be a valuable and enjoyable experience. In the science classroom, such an opportunity is rare, but no more so than in other classes, but they believed that it would probably be even more useful to them there than elsewhere.

CHAPTER FIVE

DISCUSSION

5.1 Explanation of Results

It was hypothesized that students in a constructivist classroom would perform better academically than students in a traditionalist counterpart. This hypothesis was dependent on assuring that the two classrooms tested were indeed practising different pedagogical methods. Therefore, five preliminary hypotheses were proposed to be used to investigate the classrooms on five factors of constructivism. The five factors were assessed using the Constructivist Learning Environment Survey (CLES), while a sixth hypothesis relating to student academic achievement was investigated by using a test based on the Illinois Goals Assessment Program (IGAP). The IGAP test is a traditional skills test in which answers on individual items are summed into a single score, with 100 representing a perfect score.

The CLES measures five aspects of the classroom learning environment. The first factor, Personal Relevance, deals with the degree to which the students feel that class and course work relates to the world at large. The second, Uncertainty of Science, examines the students' learning about science. The third, Critical Voice, deals with how students' learn to speak out about their learning. The fourth, Shared Control, measures the students' developing a method for learning how to learn and the fifth factor, Student Negotiation, examines how the student is learning how to communicate. Differences in students' perceptions of these factors in the two classes, one constructivist and the other using a more traditional approach, were investigated. Statistical differences between the class means were estimated using the t-test. The t-test is a statistic that takes the form of a ratio consisting of mean differences in the numerator and an estimate of sampling error in the denominator (Smith, 1998, p. 127). Typically, the t-test is used when at least one of the samples is small.

The use of a validated survey instrument and a recognized statistical test made the results from the study easier to interpret. For each of the five factors, the differences between the Control and Experimental Groups were found to be significant ($p<0.01$). This indicated that there were in fact significant differences in the pedagogical approach used in the two classrooms. Interviews with the teacher and a sample of students from each classroom confirmed these differences.

One approach to comparing the test scores of the constructivist to the traditional classroom would not have been methodologically valid as any differences between the groups might have been the result of history; that is, a group with a higher mean score might have been ahead academically at the beginning. Indeed, in such a situation, the group that scored lower might have shown greater real improvement due to their environment. To protect against this threat, the students were first tested at the beginning of the Spring semester in order to obtain a baseline measure. When compared with one another, the experimental group (constructivist classroom) did in fact score slightly higher on average (77.1 to 76.9), but this difference was found to be statistically insignificant.

The students were then tested again at the end of the semester. Both groups of students improved their scores dramatically over the intervening weeks, the constructivists almost nine full points to 85.9 and the traditionalists over five and a half points to 81.7. The more than four point difference between the two groups, however, was as dramatic as the improvements. This is strong evidence of the superiority of the constructivist technique. Hypothesis 6 (students in a classroom where a constructivist approach to learning is used will exhibit greater improvement in their learning of science concepts than students in traditional classes) and the study as a whole, was strongly supported by this research.

5.2 Relationship to Other Studies

There are several issues that are of interest in thinking about the results of this study. They include: (1) characteristics of a constructivist learning environment; (2) contribution of constructivist learning environment to achievement; and, (3) student-student and teacher-student relationships.

5.2.1 *Characteristics of a Constructivist Learning Environment*

There have been a number of discussions about the characteristics or qualities that comprise a constructivist learning environment. Some of these were reviewed in the literature section of this study. In general, the focus has been on creating a classroom with personal relevance to the student in which cognitive, affective, and moral development can all occur.

For example, DeVries and Zan (1995) emphasized the importance of creating a sociomoral environment or atmosphere in the classroom in which students and teachers can work easily together with respect and trust. In looking at the instrument used in this study, Critical Voice, Shared Control, and Student Negotiation seem most pertinent to this emphasis.

Brooks and Brooks (1993) emphasized the importance of developing an atmosphere of personal relevance in the constructivist classroom. This characteristic was addressed in the CLES in the first scale, Personal Relevance. Brooks and Brooks also noted the importance of developing good assessment tools that helped discover what children knew and how they conceptualized ideas. The Uncertainty of Science in the CLES addressed that issue.

Observations of the classrooms also showed differences between the constructivist and the traditional classroom. The constructivist classroom had a much more open atmosphere than the traditional classroom. It was more open spatially, interpersonally, and intellectually. This is congruent with the description of a constructivist classroom in Appleton and Asoko (1996), in which an open classroom atmosphere is one of the most significant characteristics.

Furthermore, both classroom observations and the CLES results indicated that the characteristics that Anderson, Akins, Calderon, and Mapp (1996) described in their three-part model were characteristics of the experimental classroom. The classroom had high opportunity for constructivist activity, good affective support provided by the teacher, and a high pace, or vital classroom environment. In the study by Anderson, Akins, Calderon, and Mapp, high scores on these dimensions were postulated to lead to high student satisfaction. This was supported by the data in this current study.

Although there are other qualities and characteristics associated with the constructivist classroom, clearly the CLES addressed several of those considered important by researchers and theorists. Thus the current study can be seen to directly tie together theory and research in the real world. The theory is the foundation of the instrument. Use of the instrument in the current study indicates that the teacher had indeed been able to create a constructivist-style classroom.

5.2.2 *Constructivism and Academic Achievement*

In looking at the literature on constructivism and achievement, there is less emphasis on achievement tests and more emphasis on alternative evaluative methods. For example, Novak (1996) indicated that teachers are increasingly frustrated with the limitations of traditional kinds of assessment tools and that there are a number of substitutes that provide better information.

Brooks and Brooks (1993) specifically noted that the constructivist classroom required innovative assessment procedures. They believed that it was inappropriate, and a conflict for teachers and students, if students were taught in a constructivist way, but then assessed using traditional testing procedures. However, that is exactly what happened in this study. In the constructivist classroom, the focus was on knowledge and meaning-construction. However, the standard tests measure what information the student has learned and, how the student is able to apply that learning. Optimally, students would be assessed in ways authentic to constructivist methodology. However, this would make it difficult to compare them with a control group on measures that school districts still use as benchmarks for their own judgements on achievement.

In other words, constructivism has to prove itself in the current situation, because school districts still use these other measures in order to gain support for school funding, among other things. School districts use test scores to prove to parents that they are doing their job. Until that changes, constructivism will probably have to prove itself on the same measures.

Interestingly enough, this current study indicated that constructivist methods were successful in teaching students information, as well as meaning-construction. The students performed significantly better than their peers, even on a standardized test, which is not the optimum assessment instrument for a constructivist classroom. Even so, as discussed in the second chapter, there have been studies previously that indicated this type of relationship between constructivist classrooms and improved performance on traditional academic achievement tests.

5.2.3 *Student-Student, Student-Teacher Relationships*

In the current study, both observation and results from the CLES indicated that the relationships between individuals in the classroom were much more vital. The students in the constructivist classroom were constantly engaging with each other and the teacher. In the other classroom, the primary engagement was in the form of teacher lecture and student responses to questions. Students in the constructivist classroom had significantly different scores from their counterparts in the traditional classroom on Critical Voice, Shared Control, and Student Negotiation, all characteristics dealing with interpersonal relationships at the classroom level.

DeVries and Zan (1995) noted that constructivist teachers treated their students with respect, but also required students to behave respectfully and learn how to communicate appropriately with each other. The current study seems to indicate that these students were able to learn how to negotiate with each other and find their own voices within a respectful environment.

As DeVries and Zan (1995) also indicated, this approach works best if students care about the social bond and their relationship. In this school, in this classroom, the students did care about social relationships. It was also apparent that they had good interpersonal skills with which to begin. The teacher, too, had good interpersonal skills and appeared to care about relationships with the students. Results might be different in a classroom in which students had behavioral problems that resulted in extremely anti-social behavior, or in classrooms in which students were extremely distrustful or wary of each other and the teacher.

5.3 Implications of the Results

Although no definitive conclusions can be drawn from a study of this type, with its limitations, there are implications that can be explored. The results of this study, in tandem with results reported in the literature previously and reviewed in this study, suggest certain relationships.

Perhaps the most significant finding of the study is that students in the experimental classroom scored higher on the achievement test than students in the more traditional classroom, even though constructivist approaches tend to focus on different assessment tools. In other words, even while using non-traditional methods, students acquired the information and skills available to students in a more traditional classroom at a faster rate.

In looking at the literature, there currently appears to be no advantage to continuing to use traditional methods. There are problems associated with making the change to constructivist methods, but they consistently have been shown to produce better results in terms of both achievement and student satisfaction. There are however, some problems in making the changeover.

5.3.1 *Teacher Training Issues*

Most teachers have been trained to use traditional methods, rather than constructivist methods. School districts probably cannot afford to engage in the intensive retraining necessary in order to help all their teachers develop the necessary skills to create constructivist classrooms. In addition, some teachers may not be able to make the change after years of teaching in one way and some may not want to make the change.

5.3.2 *Public Relations*

It cannot be emphasized enough that school districts must sell their methods to the public in order to obtain public support in terms of adequate funding for their programs. If the public does not believe that schools are doing a good job, or if the public believes that schools are using "newfangled" but unsuccessful methods to teach students, the public will rebel and will not provide sufficient support for the schools. The general population seems to be best convinced by being shown quantitative results in terms of graduation rates and student grades and test scores.

Thus, the fact that constructivist teaching methods increased student test scores beyond those of students in more traditional classrooms is highly significant for the schools. Even though it represents a compromise with constructivist philosophy, it would be helpful to continue to assess students in traditional ways, if test scores improve, in order to show the general public the kind of positive quantitative results that are viewed as credible.

5.3.3 *Student Social Skills*

As noted in the introduction and the review of the literature, student capacity for forming social bonds is extremely important to the successful use of constructivist methodologies. Still, the optimum is for students and teachers to have good interpersonal skills and for them to value the social bond. Since constructivist classroom are so much more interactive than traditional classrooms, a new set of skills could be considered as prerequisites, or precursors. Again, this might be a public relations problem for schools, since in some areas there has been considerable controversy about teaching students interpersonal skills or such characteristics as self-esteem.

5.3.4 *Other Issues*

There are other issues that are more peripheral, but still important. For example, both classroom design and textbook purchasing would probably change with constructivist methods. This could be a long-term shift, however, with current classrooms and textbooks adapted for use in constructivist environments.

Despite the above-discussed problems, there is enough weight to the literature at this point for schools to give serious consideration to a shift toward the constructivist approach to learning. Although school districts and publics may not be as concerned with student satisfaction levels as they are with measurable results on achievement tests, the combination of the two should be a powerful inducement to real change.

5.4 Limitations of the Study

Although the study lends support to the hypotheses, it should be noted that further research must be conducted in this area. More and larger samples would strengthen the findings of this study. Typically, samples of larger than 23 would ideally be chosen. Also, more classes in multiple schools should be used.

The study suffered from other sampling problems as well. No attempt was made at randomization, as two equal-size groups were readily available for research. Also, the school at which the study took place cannot be said to be representative of the population of schools as a whole (further argument for extending the study to more classes and schools). The use of a convenience sample such as was done here tends to limit the implication of the results, because the findings can only strictly be said to be true for classes at this particular school.

Also, the CLES was only administered once during the year as previous research (Fraser, 1998) has indicated the stability of classroom learning environments. The use of the CLES on different occasions would have indicated whether this was in fact true.

5.5 Significance for the Chicago School

The findings of this study hold special interest for the students and staff of the Chicago school, where the study was conducted. The student population includes many students who are hindered in their education by various environmental factors. The constructivist approach serves to unite students, allowing them to participate together in pursuit of common classroom goals. This cooperative, nurturing classroom environment serves as a haven from the pressures and problems of many students' day-to-day lives. This is important because it makes school a pleasant destination, rather than an onerous task. It is expected, then, that in addition to its demonstrated effectiveness in boosting the classroom performance of students, a constructivist classroom environment will encourage more students to attend school. At a school where attention to reducing the drop out rate is one of the stated goals, this is not an insignificant contribution.

REFERENCES

Adams, D., & Hamm, M. (1994). *New design for teaching and learning in mathematics and science.* San Francisco, CA: Jossey-Bass Publishers.

American Association for the Advancement of Science (1989). *Science for all Americans.* Washington, DC: American Association for the Advancement of Science.

Anderson, G.J. (1970). Effects of classroom social climate on individual learning. *American Educational Research Journal, 7*(2), 135-151.

Anderson, R., Akins, S., Calderon, I., & Mapp, P. (1996). *A triphasic model of the teaching-learning environment based on constructivist principles.* Columbia University Teachers College, Eric Document, #ED 347 056.

Anderson, R.D., & Pratt, H. (1995). *Local leadership for science education reform.* Dubuque, IA: Kendall/Hunt Publishing Company.

Anderson, G.J., Walberg, H.J., & Welch, W.W. (1969). Curriculum effects on the social climate of learning: A new representation of discriminant functions. *American Educational Research Journal, 6*(3), 315-327.

Appleton, K., & Asoko, H. (1996). A case study of a teacher's progress toward using a constructivist view of learning to inform teaching in elementary science. *Science Education, 80*(2), 165-180.

Belenky, M.F., Clinchy, B.M., Goldberger, N.R., & Tarule, J.M. (1986). *Women's ways of knowing.* New York: BasicBooks.

Brooks, J.G., & Brooks, M.G. (1993). *In search of understanding - The case for constructivist classrooms.*

Bruner, J. (1986). *Actual minds, possible worlds.* Cambridge, MA: Harvard University Press.

Cheung, K.C., & Taylor, R. (1991). Towards a humanistic constructivist model of science learning: Changing perspectives and research implications. *Journal of Curriculum Studies, 23*(1), 21-40.

Chomsky, N. (1988). *Language and problems of knowledge: The Managua letters.* Cambridge, MA: MIT Press.

DeVries, R., & Kohlberg, L. (1990). *Constructivist early education: Overview and comparison with other programs.* White Plains, NY: Longman.

DeVries, R., & Zan, B. (1995). Creating a constructivist classroom atmosphere. *Young Children, November,* 4-13.

Dewey, J. (1927). *The public and its problems.* New York: Harper-Row.

Dryden, M., & Fraser, B.J. (1996, April). *Use of classroom environment instruments in monitoring urban systemic reform.* Paper presented at the annual meeting of the National Association for Research in Science Teaching, St. Louis, MO.

Fensham, P.J., Gunstone, R.F., & White, R.T. (1994). Science content and constructivist views of learning and teaching. In P. Fensham, R. Gunstone, & R. White

(Eds.). *The content of science: A constructivist approach to its teaching and learning.* London: The Falmer Press.

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

Fraser, B.J. (1989). *Assessing and improving classroom environment.* Perth, Western Australia: Curtin University of Technology.

Fraser, B.J. (1986). *Classroom environment.* London: Croom Helm.

Fraser, B.J. (1984). Differences between preferred and actual classroom environment as perceived by primary students and teachers. *British Journal of Educational Psychology, 54,* 336-339.

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., & Fisher, D.L. (1983). Student achievement as a function of person-environment fit: A regression surface analysis. *British Journal of Educational Psychology, 53,* 89-99.

Fraser, B.J., & O'Brien, P. (1985). Student and teacher perceptions of the environment of elementary school classrooms. *The elementary School Journal, 85*(5), 567-580.

Fraser, B.J., Tobin, K., & Kahle, J.B. (1992). Factors which militate against learning science with understanding. *The Australian Science Teachers Journal, 38*(3), 63-66.

Fraser, B.J., & Walberg, H.J. (1991). *Educational environments*. Oxford, England: Pergamon Press.

Glasson, G.E., & Lalik, R.V. (1993). Reinterpreting the learning cycle from a social constructivist perspective: A qualitative study of teachers' beliefs and practices. *Journal of Research in Science Teaching, 30*(2), 187-207.

Goodman, N. (1984). *Of mind and other matters*. Cambridge, MA: Harvard University Press.

Habermas, J. (1971). *Knowledge and human interests*. Boston: Beacon Press.

Kant, I. (1964). *Groundwork of the metaphysic of morals*. New York: Harper Row.

Kober, N. (1993). What we know about science teaching and learning. *EDTalk series*. Washington, DC: Council for Education Development and Research.

Khun, T.S. (1970). *The structure of scientific revolutions*. Chicago: University of Chicago Press.

Larsen, S. (1988). Information can be transmitted but knowledge must be induced. *PLET, 23*(4), 331-335.

Longino, H. (1993). Subjects, power and knowledge: Description and prescription in feminist philosophies of science. In L. Alcoff & E. Potter (Eds.), *Feminist epistemologies*. New York: Routledge.

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

Miller, G. (1987). How children learn words. *Scientific American, September*.

Moos, R.H. (1986). *Work environment scale manual.* Palo Alto, CA: Consulting Psychologists Press.

Moos, R.H., & Trickett, E.J. (1974). *Classroom Environment Scale manual.* (1st ed.). Palo Alto, CA: Consulting Psychologists Press.

Northfield, J., Gunstone, R., & Erickson, G. (1996). A constructivist perspective on science teacher education. In D.F. Treagust, R. Duit, & B.J. Fraser (Eds.), *Improving teaching and learning in science and mathematics.* New York: Teachers College Press.

Novak, J.D. (1996). Concept mapping: A tool for improving science teaching and learning. In D.F. Treagust, R. Duit, & B.J. Fraser (Eds.). *Improving teaching and learning in science and mathematics.* New York: Teachers College Press.

Perry, W.G. (1970). *Forms of intellectual and ethical development in the college years.* New York: Holt, Rinehart & Winston.

Phillips, D.C. (1995). The good, the bad, and the ugly: the many faces of constructivism. *Educational Researcher, 24*(7), 5-12.

Piaget, J. (1932). *The moral judgement of the child.* New York: Harcourt Brace.

Pierce, C. (1994). Importance of classroom climate for at-risk learners. *Journal of Educational Research, 88*(1), 37-42.

Prather, J.P. (1993). Reform revisited: The trend toward constructivist learning. *Journal of Elementary Science Education, 5*(2), 52-70.

Roth, W.-M. (1993). Problem-centered learning for the integration of mathematics and science in a constructivist laboratory: A case study. *School Science and Mathematics, 93*(3), 113-122.

Russell, T. (1993). Learning to teach science: constructivism, reflection, and learning from experience. In K. Tobin (Ed.) *The practice of constructivism in science education.* Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Sample tests of Illinois goals in Science. (1993). Illinois Goal Assessment Program: Illinois State Board of Education.

Saunders, W.L. (1992). The constructivist perspective: Implications and teaching strategies for science. *School Science and Mathematics, 92*(3), 136-140.

Sivertsen, M.L. (1993). *Transforming ideas for teaching and learning science.* Washington, DC: U.S. Department of Education.

Simon, H. (1995). Behavioral sciences -- The psychology of proof. *American Scientist.*

Smith, M.J. (1988). *Contemporary communication research methods.* Belmont, CA: Wadsworth Publishing Co.

Stein, M., Edwards, T., Norman, J., Roberts, S., Sales, J., Alec, R., & Chambers, J.C. (1994). *A constructivist vision for teaching, learning, and staff development.* Detroit School District Publication, Eric Document, #ED 383 557.

Taylor, P.C., Dawson, V., & Fraser, B.J. (1995, April). *A constructivist perspective on monitoring classroom learning environments under transformation.* Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

Taylor, P.C., & Fraser, B.J. (1991, April). *Development of an instrument for assessing constructivist learning environments.* Paper presented at the annual meeting of the American Educational Research Association, San Fransisco, CA.

Taylor, P.C., Fraser, B.J., & Fisher, D.L. (1997). Monitoring constructivist classroom learning environments. *International Journal of Educational Research. 27*, 293-302

Taylor, P.C., Fraser, B.J., & White, L.R. (1994, April). *The revised CLES: A questionnaire for educators interested in the constructivist reform of school science and mathematics.* Paper presented at the annual meeting of the American Educational Research Association, Atlanta, GA.

Wheatley, G.H. (1991). Constructivist perspectives on science and mathematics learning. *Science Education, 75*(1), 9-21.

Yager, R.E. (1991). The constructivist learning model. *The Science Teacher, September*, 53-57.

Yager, R.E. (April, 1995). *Science/technology/society: A reform arising from learning theory and constructivist research.* Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA.

Yeany, R. (1991). A unifying theme in science education? *NARST News, 33*(2), 1-3.

Yin, R.K. (1989). *Case study research: Design and methods.* Newbury Park, CA: Sage.

Appendix 1

Classroom Environment Descriptions

1. Size of the class (Number of students)

2. Size of the classroom (Is one room larger than the other, be sure that the classroom setup does not simply cause an illusion of difference)

3. Setup (E.g, are the desks set up in linear structure, are they in a circle, are they set up in clusters, or some other form)

4. Lighting (E.g, does the teacher rely on overhead lights, or open the window blinds?)

5. Displays (Note the use, amount, & style of posters, models, or other elements on display in the classroom)

6. Sound (Is one classroom louder than the other, if so, where does the sound come from - e.g., does one classroom seem to have a constant buzz among the students?)

7. Movement (Do the students tend to stay at their desks, or do they move about the room? Does the teacher tend to stay at the desk, blackboard, or lectern, or move about?)

8. Animation (Do the students and/or teacher in one classroom tend to be more animated than those in the other? This could be different from either #7, movement, or #9, engagement; if so, how so?)

9. Engagement (Do the students and/or teacher seem to be more engaged in one classroom than the other? This could include rapt attention versus apparent boredom by the students, rather than mere movement or animation. Describe.)

10. Climate (Does either classroom seem abnormally cold or warm?)

11. Miscellaneous (Are there any other environmental factors that stand out in one classroom or the other, or in comparison between the two?)

Appendix 2

Teachers' Interview Protocol

(In general, engage the teacher in the genial conversation of two professionals, prompting them with the following questions):

How many years have you been teaching?

How many at this level?

How many in this subject?

How long at this school?

Briefly describe your training and background in education.

Have you found that your teaching style has evolved over the years?
(if yes, prompt for elaboration)

What do you feel have been the major influences on your teaching style?

Do you have a personal or guiding philosophy on how a classroom should run? (if yes, elaborate: prompt for views on classroom environment, student participation, lecturing style or preference, reliance on textbooks)

Are you aware of the theories surrounding a constructivist learning environment? (if yes, ask for their description of the theory)

If you had the ability to run your classroom whatever way you saw fit, without any outside interference or input, would you make any changes to what you currently do? (if yes, prompt to elaborate)

Students' Interview Protocol

(The student/researcher relationship is significantly different from the teacher/researcher relationship, and requires a more tightly structured interview protocol. The following script was followed closely for each student interviewed.)

Good Morning (Afternoon)! My name is Vera and I'm going to be studying your classroom over the next few weeks. I'd like to ask you a few questions about how you and your classmates learn in this class. This will only take a few minutes, and I'll be talking to several of your classmates over the next few weeks.

First, do you like to ask questions in class?
In other classes, too, or just this one?
Does your teacher encourage you to ask questions?
Do your other teachers encourage you to ask questions?

Do you get to interact with other students in class?
In other classes, too, or just this one?
Does your teacher encourage you to interact with one another?
Do your other teachers encourage you to interact with one another?
Do you like to interact with other students in class, or would you rather study and learn on your own?

Do you think that its important for teachers to relate your classroom studies to the outside world?
In every class, or just in science?
Does your science teacher do this?
How about other teachers?

In science class, what do you think is the best way to learn; is it through lectures, textbooks, in-class experiments, homework, or something else?
And what is the worst way?

In other classes, what do you think is the best way to learn; is it through lectures, textbooks, in-class examples, homework, or something else?
And what is the worst way?

Do you feel that you have learned a lot about science in this class?
Do you think that you could have learned more if it had been taught differently?
(if yes) What would you change?

Thank you for your time and answers. You have been very helpful and I look forward to watching your class over the next few weeks.

Appendix 3

Classroom Environment Observations

Constructivist Classroom

1. Size of class (number of students).

   25 students

2. Size of classroom

   30 x 45

3. Setup

   Students desk arranged in circle group of four. Each student is assigned a job.

4. Lighting

   Classroom has four large windows with blinds pulled open. There are four sets of straight lights in the ceiling.

5. Displays

   There are four large posters – used to identify the parts of the human body.
   Charts identify the elements.
   Twenty-six plants – students use plants to conduct research projects.
   Four boxes of insects – investigate individual behavior.
   Two cabinets – video equipment, encyclopedia, dictionaries, journals.
   Ten computers – students conduct research.

6. Sound

   Students were very loud. They were very talkative.

7. Movement

   Students seldom remain at their desks. They were constantly moving around the classroom; they were on computers getting material, observing the various projects they were working on.

8. Animation

Students were observing surrounding for points of curiosity looking for information, analyse data, communicate information and ideas.

9. Engagement

Students brainstorm for possible alternatives. Used models and ideas to illicit discussions and acceptance by others.

10. Climate

The classroom was warmer. The students were involved in design and conducting experiments. They made more investigation with physical activities instead of sitting at their desks and writing.

11. Miscellaneous

Students were helping each other and they all appear to be learning science better. Students learn social skills. Students is a peer teacher.

Classroom Environment Observations

Traditional Classroom

1. Size of class (number of students).

   25 students

2. Size of classroom

   30 x 46

3. Setup

   Students desks are arranged in straight rows. Students were seated directly in back of each other.

4. Lighting

   Teacher depends on four large windows with blinds pulled open. Also, long square-shaped lights in the ceiling.

5. Displays

6. Sound

   The sounds are very low. Students involved in very little talking.

7. Movement

   Students remain at their desks. They only move at the permission of teacher.

8. Animation

   Students engage in very little group work. Teacher lectures for 40 minutes, then pass out data sheets. Teacher is always in control of learning environment.

9. Engagement

   In traditional classroom they aren't involved in class experiments. A lot of textbook activities are assigned daily. In Constructivist classroom, the students conduct experiments. By doing experiments, the students find out more and it's more enjoyable and the student can see what they are doing.