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Inclusive pedagogy for diverse learners : science instruction, disability, and the community college.

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INCLUSIVE PEDAGOGY FOR DIVERSE LEARNERS: SCIENCE INSTRUCTION, DISABILITY, AND THE COMMUNITY COLLEGE

A Dissertation Presented

by

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DEDICATION

To Mark
Thank you for your patience, support, sacrifice, and love.

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I would like to express my heartfelt thanks to the many people who made this work possible.

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ABSTRACT

The following study examined the use of inclusive pedagogy by science, technology, engineering, and mathematics (STEM) faculty at three community colleges. The study was developed in response to a gap in existing knowledge about inclusive instruction in two-year colleges. The purpose was to identify barriers to the adoption of inclusive teaching methods for diverse learners and students with disabilities, and to propose ways to break down these barriers. Three research questions designed for the study asked about (a) the current teaching styles and methods of curriculum delivery used by community college STEM faculty, (b) the levels of awareness and knowledge of community college STEM faculty about inclusive teaching practices, and (c) the personal, attitudinal, and environmental factors that inhibit community college STEM faculty from using inclusive pedagogical practices to better serve students with disabilities and other diverse students. A sequential method was used to obtain both quantitative and qualitative data regarding instructional practices, pedagogical knowledge, and beliefs about teaching and learning. Two hundred and eleven STEM faculty members responded to a questionnaire that was administered electronically and

11 faculty members were interviewed, 9 of whom were observed in the classroom. Findings revealed that a significant number of these community college faculty members have an inclusive mindset and believe in adapting their instruction in order to accommodate learner differences. These faculty members also appear more knowledgeable about pedagogical practices than what has been reported in previous literature about four-year faculty. Many of the faculty members are using multimodal instructional methods. However, a significant gap still exists between what they believe and know and what is actually put into instructional practice. A number of barriers that prohibit the use and development of inclusive practices were identified in this study. The most significant among the barriers reported were the lack of an inclusive mindset, lack of knowledge about pedagogy, high teaching loads, and lack of time for instructional development. Implications for practice, policy, and research are discussed.

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CHAPTER 1

INTRODUCTION

Statement of the Problem

Over the past 20 years, the number of students with disabilities enrolled in postsecondary education has grown significantly (Henderson, 2001). Despite this growth, these students are underrepresented in scientific and engineering fields of study (American Association for the Advancement of Science [AAAS], 2001). This underrepresentation not only marginalizes this particular group of students, but also contributes to an overall lack of students in science, technology, engineering, and mathematics (STEM) fields. Although the causes of this underrepresentation are complex, heavy reliance on traditional teaching methods, which typically do not address the varied learning styles of students with disabilities, clearly contributes to the problem (Burgstahler, 1994; Seymour & Hunter, 1998; Stefanich & Norman, 1999).

In response to the lack of students in STEM fields, reports from the National Science Foundation have stressed the critical importance of STEM education for all student groups in postsecondary education. Along with other recommendations, these reports highlight the importance of targeting students with disabilities as one way to increase the total number of students in STEM fields. National science reform efforts have been aimed at reaching a wider range of learner types by promoting greater use of inclusive teaching methods, as well as by encouraging the development of new ones (National Research Council [NRC], 2001, 2003a). Despite these reform efforts, research has shown that widespread use of existing inclusive methods has not yet taken place

(Peterson, 2003; Walczyk & Ramsey, 2003; NCES, 2002b; Kardash & Wallace, 2001; Seymour & Hewitt, 1997).

The limited use of inclusive teaching methods suggests that barriers to the adoption of these methods persist. Therefore, it is imperative to identify and break down these barriers in order to reach a wider range of learner types. We have seen a significant increase in the enrollment of students with disabilities in higher education (Henderson, 2001) and, at the same time, a greater demand for a scientifically literate population (AAAS, 1998). Evidence suggests that increased use of inclusive teaching methods is especially important for community colleges, which typically serve a greater percentage of students with disabilities than do four-year colleges (NCES, 2000; Wolanin & Steele, 2004). Existing research on barriers to the adoption of inclusive methods has only been conducted at the four-year college level. Although it can be speculated that there may be some similarities between two-year and four-year college environments, significant differences exist as well. These differences necessitate further investigation.

Purpose of the Study

The purpose of this multi-site case study is twofold: (a) to identify barriers to the adoption of existing inclusive teaching methods by STEM faculty in the community college environment, and (b) to propose ways to break down these barriers, thus leading to increased use of such teaching methods. A sequential method has been used to obtain quantitative and qualitative results from a sample of community college faculty. This method as defined by Creswell (2003) begins with quantitative methods to seek a broad base of information and is followed by qualitative methods to gain a more in depth understanding. Teaching practices currently in use, knowledge of inclusive teaching practices, and barriers to the adoption of inclusive pedagogy have been identified through a questionnaire administered to STEM faculty, followed by interviews and observations. The relationship between traditional instructional practices, knowledge of inclusive instructional methods, and beliefs about teaching and learning has been explored.

Research Questions

The following questions form the basis of this study.

1. What are the current teaching styles and methods of curriculum delivery used by community college STEM faculty?
2. What are the levels of awareness and knowledge of community college STEM faculty about inclusive teaching practices?
3. What are the personal, attitudinal, and environmental factors that inhibit community college STEM faculty from using inclusive pedagogical practices to serve students with disabilities and other diverse learners?

Significance of the Study

Despite ongoing under-representation and need for better pedagogy, significant gaps exist in the literature about instruction for students with disabilities in STEM disciplines. Moreover, the majority of research that has been conducted to date has been in four-year institutions with very little inclusion of two-year colleges. In addition, while there have been a number of studies on inclusive practices such as inquiry-based learning and reformed science practices, very few studies have included disability as part of the research focus. If we, as researchers and educators, are serious about wanting to improve the experience and learning for students with disabilities in STEM, we need to focus more research at the community college level where many of the students with disabilities begin their postsecondary education.

The first research question asks what teaching styles and methods of curriculum delivery are currently being used by community college faculty. Information obtained from this question will help to establish a baseline of current instructional practices in community college STEM disciplines. The second question looks at levels of awareness and knowledge regarding inclusive teaching practices. Information about awareness is especially critical to administrators and professional development experts who provide training opportunities for faculty. The third research question illicits information regarding the personal, attitudinal, and environmental barriers that inhibit community college STEM faculty from using inclusive pedagogical practices. Information obtained in this area is critical in that it identifies barriers and provides crucial information specific to instruction in the community college setting. With barriers identified they can then be addressed through administrative actions or educational programs.

Research in the area of community college instruction in STEM for students with disabilities is an overlooked area. More extensive research has the potential to identify opportunities for improved and more inclusive instruction in an area where it is critically needed. The findings from this study contribute to the research base and provide community college leaders and STEM faculty members with information that will help to better serve students with disabilities.

Assumptions

Researcher bias and subjectivity are important concerns for any research study. According to Rossman and Rallis (2003), multiple perceptions about the world exist, and we all have assumptions about what we consider to be truth. It is important for both the reader and the researcher to understand the assumptions and worldviews that underline the researcher perspective.

The perspective I have about disability in higher education forms the basis of my view and cannot be entirely separated from my research. Influencing my perceptions are over fifteen years of experience providing services to students with disabilities in higher education as well as my work with faculty members who are seeking to develop more inclusive curriculum. In addition, a number of authors have contributed to my conceptual understanding of the position of individuals with a disability in our society. Authors such as Hahn (1999), Symanski and Trueba (1999), and Longmore and Umansky (2001), have written extensively about the role individuals with disabilities have played in society and in education and have collectively concluded that society needs to begin to view disability from a socially construed perspective. Their work combined with my own observations about what is not working in higher education has led me to conclude that higher education needs to take a new approach toward inclusion of people with disabilities. My hope is that this research will contribute to bringing about necessary social change.

The awareness of my worldview is critically important to maintaining subjectivity in this study. On one hand, it sensitizes me to the possible perceptions of faculty and the relationship of their perspective to pedagogical style. On the other hand, it points to the need for caution in collecting and interpreting data so as to insure that the results are reported objectively and without bias. Multiple methods of data collection and analysis have been built into the study in order to minimize the affects of researcher bias and subjectivity.

Definitions

The following is a list of terms and phrases used in this study. Definitions were compiled from several sources and are cited accordingly.

Americans with Disabilities Act (ADA) of 1990: The ADA is federal antidiscrimination legislation that was passed in 1990. The ADA prohibits discrimination on the basis of disability in employment, state and local government, public accommodations, commercial facilities, transportation, and telecommunications. Title II of the Act applies specifically to discrimination in public higher education. In order to be protected under the ADA, an individual must have a disability, or association with an individual with a disability (U.S. Department of Justice, 2002)

Constructivism: The basic premise of constructivism in education is that learners build knowledge and construct new learning based on current and past knowledge (Brunner, 1990). Students have knowledge based on past education and experience that influence how they think about the world and go about solving problems. Research has indicated that learners are likely to construct interpretations of new phenomenon in ways that agree with prior interpretations (NRC, 2001). According to a report put out by the National Research Council (2003a), constructivism has critical importance for teaching and learning. Teachers need to be aware of the mechanisms by which students create knowledge, and teach in a manner that builds on previous knowledge and challenges misconceptions.

Critical Pedagogy: The term critical pedagogy refers to educational theory and teaching practices that are based on issues of power and equity in the learning environment. According to McLaren (1995), one of the aims of critical pedagogy is to bring about social justice through an approach to teaching and learning that emphasizes respect for individual learners and makes a conscious effort to include underrepresented or non-dominant populations in the learning environment.

Disability: The extensive variations in the nature of disability make it a complicated, multidimensional concept that is difficult to define (Altman, 2003). One approach is to look at disability from a legal perspective. Disability is defined by the ADA (1990) as any physical or mental impairment that substantially limits one or more major life activities. The definition put forth by the ADA does not specifically name all of the disabilities that are covered, nor does it capture all of the subtle nuances associated with disability. Clinical definitions of disability often classify disability in terms of impairments, pathologies, or functional limitations brought about by a medical or physical condition (Altman, 2003). Within this definition, a number of classifications exist, such as learning, physical, mobility, visual, hearing, cognitive and psychiatric disabilities. It is beyond the scope of this study to further define all the commonly used classifications. A broader definition of disability takes into account the developmental and social context in which disability occurs (Martinelli & Dell Orto, 1999). From a social model perspective disability is defined as "limit or loss of opportunities to take part in community life because of physical and social barriers" (Altman, pg. 103).

Inclusive Pedagogy: Tuitt (2003) uses the term inclusive pedagogy to refer to teaching practices that embrace the whole student in the learning process. These practices differ from traditional instruction in that multiple methods of engagement and instructional approaches are used to reach a diversity of student learners. In STEM instruction inquiry-based instruction and reformed pedagogical practices have been labeled as more inclusive pedagogies (NRC, 2003). Although a range of practices might fit under the category of inclusive, for the purposes of this study, these two methods, as well as Universal Design for Learning, will be defined as inclusive pedagogy.

Inquiry-Based Learning: Inquiry-based learning is defined in the National Science Standards (NRC, 2003) as critical to the development of scientific understanding. According to the standards,

> Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigation; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; posing answers; and communicating results. (P.23)

Inquiry-based learning involves the use of different teaching strategies that foster student use of inquiry. These strategies can shift from a teacher guided inquiry through increasing levels of student-directed inquiry as students become more knowledgeable and skilled in the inquiry process (Davis & Irwin, 2001)

Rehabilitation Act of 1973, Section 504: The Rehabilitation Act prohibits discrimination on the basis of disability in federal programs, federal employment, and programs receiving federal financial aid. Section 504 of the Act applies specifically to colleges and universities in that it prohibits discrimination on the basis of disability in any program or activity that receives federal financial assistance (U.S. Department of Justice, 2002).

Universal Design: Universal Design is defined by the Center for Universal Design at North Carolina State University as "The design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" (p. 1). Universal Design for Learning (UDL) is based upon the belief that alternatives to traditional instruction and assessment should be made available and accessible to all students. The alternative instruction will serve to enhance the learning opportunities for individuals from diverse backgrounds, those with varied learning approaches, and individuals with a range of abilities and disabilities.

Overview

The purpose of this study is to identify barriers to the adoption of inclusive and reformed pedagogy by community college STEM faculty. The study is informed by a review of the literature and the identification of gaps in the research. The chapters and sections that follow will provide (a) an analysis of the current state of instruction in STEM disciplines for all student groups and for students with disabilities, (b) a review of theoretical material on diverse learners, (c) an examination of research studies in inclusive and reformed pedagogy, (d) a review of existing research on barriers to the implementation of inclusive pedagogy, and (e) a discussion of the basis for this research.

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

Over the last few years considerable attention has been given to the need for educating a diverse workforce in science, technology, engineering, and mathematics (STEM). Reports from the National Science Foundation (1997, 2000, 2004) have stressed the critical importance of STEM education and identified women, minorities, and individuals with disabilities as underrepresented in STEM fields. Individuals with disabilities are among the most marginalized of these groups (Wolanin & Steele, 2004) and face significant obstacles and barriers to accessing higher education STEM programs (Burgstahler, 1994; National Science Foundation [NSF], 2000). Identification and elimination of these barriers are critical to the success of students with disabilities in postsecondary education, particularly in community colleges, since this is where many students with disabilities begin their postsecondary education (National Center for Educational Statistics [NCES], 2000; Hall & Belch, 2000).

The paradigm that has dominated the treatment of disability both within society and within higher education has emanated from a theoretical approach that looks at disability from a medical perspective (Marinelli & Dell Orto, 1999). The medical approach has contributed to attitudes and systems that may impede the progress of individuals with disabilities in postsecondary education, particularly in STEM fields (Szymanski & Trueba, 1999). More recently, researchers have begun to look at disability from a social theory perspective (Hahn, 1999). The social theory model allows us to think about disability in a new way and opens up avenues for more inclusive teaching and learning.

At the same time, reforms in science education (NRC, 2001, 2003a) and research on diverse learners (Dunn & Wagner, 1996; Gardner, 1999; Sternberg & Grigorenko; 2002) have contributed to recommendations for changes in instruction to meet the needs of a wider range of learner types. In addition, the advent of UDL has provided a framework for instruction that is designed to reach all students, including those with disabilities (Rose & Meyer, 2002).

This chapter provides (a) an overview of descriptive data about students with disabilities, (b) a review of the literature that relates to students with disabilities in postsecondary STEM fields, (c) a description of reformed science instruction and inclusive pedagogical approaches, and (d) an analysis of the current status of reformed and inclusive pedagogy. In order to provide a broad perspective the next section begins with an overview of statistics that compare educational enrollment of individuals with disabilities to that of the general population.

Two major issues arise when reporting disability data: (a) there is no one standard definition of disability, and (b) the existence of multiple sources for collecting disability data. The most commonly accepted definition is that cited in the Americans with Disabilities Act of 1990. The term disability with respect to an individual means "(A) a physical or mental impairment that substantially limits one or more of the major life activities of such an individual; (B) a record of such an impairment; or (C) being regarded as having such an impairment" (ADA, pg.12). Despite this generally accepted broad definition, individual researchers use varying definitions to define the categories that fall under the term disability, such as learning, hearing, visual or medical disability that fall under the term disability. Because no one source exists for collecting disability data, several different data sources are used in this section, and it should be noted that some inconsistencies exist in the data. Differences in the way disability is conceptualized as well as differences in sample size and selection criteria make it difficult to make reasonable comparisons between data sets. Problems associated with definition and comparisons are noted in the text.

Background of Students with Disabilities in Higher Education

General Population Data

An examination of federal data shows that individuals with disabilities represent a significant and growing percentage of both the American general population and the population of students who participate in elementary, secondary, and higher education. General population data indicates that some type of disability is reported by approximately 50 million people over the age of 5 in the United States (U.S. Census, 2000). This figure represents 19% of the population or nearly one in every five individuals. The highest reported disability rates are in the 65 and older age group, 40% for male and 43% for female respondents. Individuals between the ages of 16 and 64 reported rates of 19.6% for men and 17.6% for women, while individuals age 5 to 15 reported rates of 7.2% for boys and 4.3% for girls. Disability rates appear to rise with age. The higher rates may be due to the development of disabling conditions as individuals age as well to an increased likelihood of diagnosis and identification in the older population. It may also be much more difficult to capture disability data in young children from census data. Once children are enrolled in school, data collection from the

U.S. Department of Education provides additional information about the incidence of disability.

Educational Trends

The high rate of disability in the general population translates to high rates of students enrolled in elementary and secondary schools. Students with disabilities are enrolling in American public education in increasing numbers. According to the U.S. Department of Education, in 1990 close to five million children, or 11% of the student population in the United States, participated in federally sponsored programs to support students with disabilities. These same federal programs served over 6 million students or 13% of the student population, between the ages of 6 and 21 in 2000 (NCES, 2002a). Among those students enrolled in elementary and secondary education, 46% reported learning disabilities, 17% reported speech or language impairments, 10% were reported as mentally retarded, and 8 % were comprised of students with emotional disturbance. The remaining students reported having hearing, visual, orthopedic, and other health impairments. The 2002 NCES report indicates that the trend towards increased incidence of disability in elementary and secondary education can be attributed to improved compliance with laws that require service to students with disabilities and improvements in diagnosis and identification of disability.

Transition from Secondary School

While data on the incidence of disability in elementary and secondary education is readily available, less is known about how these students fare after high school. According to data compiled by the U. S. Department of Education, many students with disabilities manage to successfully transition from elementary through secondary education. However, the inclusion of children with disabilities has not necessarily transferred to higher education. Enrollment in higher education is based on choice and eligibility; higher education is voluntary, not compulsory. Also, the admissions, governance, curriculum, and financial structures of higher education are very different (Wolanin & Steele, 2004), making it more of a challenge for students to seamlessly continue their education. A report from the U.S. General Accounting Office (2003) indicates that 68% of students with disabilities finished high school during the 2000-01 school year. No data source that compares completion rates for students with disabilities to that of their peers could be found. However, NCES 2000 data reported by the U.S. General Accounting Office, shows general high school graduation rates in 33 states ranging from 63% to 89%. Of those students with disabilities who graduated, only 57% of students with disabilities left high school with a standard diploma, while the balance (11%) received some other certificate. The corresponding dropout rates showed an overall rate of 29%,[1] the highest proportion of whom had an emotional disturbance (53%), followed by students with learning disabilities (27%), speech/language impairments (26%) and mental retardation (25%).[2] According to the General Accounting Report, those students who do graduate from high school face a variety of problems that impede their transition to higher education. Problems such as low student self-advocacy, insufficient information about the transition process, lack of linkages with community supports, and lack of transportation once they graduate, were reported by students and their parents as contributing to barriers in accessing postsecondary

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[1] Total completion rate does not equal 100 due to rounding errors.
[2] Total numbers of disabilities exceeds 100 because some students had multiple disabilities.

education. Once these students do graduate it is difficult to determine what happens to them.

As of this writing, limited data concerning the transition from high school to college for students with disabilities are available. Wolanin and Steele (2004) report three reasons for the lack of transition data. First, many students with disabilities delay entry into college and college entrance data will not capture this delay. Second, not all students who graduate from high school are qualified for college; and third, many students with disabilities do not self-identify with a disability when they enter college.

One of the few available sources of transition data is the National Education Longitudinal Transition Study (NCES, 1999), which is a longitudinal survey of a national sample of students with disabilities who were in the eighth grade in 1988. The NCES study tracked students with disabilities from 1988 to 2000 and highlighted several important enrollment trends. A total of 21,000 students served as the original sample, with 11,000 resurveyed in subsequent years. The 1992 follow-up identified high school dropouts, the 1994 follow-up identified employment and postsecondary access, and the 2000 follow-up is geared to collect data on graduation rates and careers. The 2000 follow-up data has not yet been released. High school students with disabilities were found to be less likely (63%) than their peers (72%) to have enrolled in postsecondary education. In addition, they had less academic preparation for college, enrolled in more remedial courses, accumulated lower grade point averages, and had lower SAT scores (NCES, 1996b).

Because the1994 resurvey covered a limited time period, persistence rates as opposed to graduation rates were used as an outcome measure. The dropout rate for students with disabilities was greater than that of their peers, with only 53% of students with disabilities receiving a degree or still in school five years after enrollment as compared 64% of their peers. In interpreting the data from this study it is important to note the relatively small size of the follow-up sample (11,000) and the composition of the survey sample. For example, students with severe mental illness, those with limited English proficiency, and those with severe emotional disturbance were excluded from the group. For these reasons, the findings may not be representative of all students with disabilities and may overestimate the transition rates to higher education for students with disabilities.

Enrollment in Higher Education

Despite inconsistencies across different sources, it is clear that data from federal sources on enrollment trends for persons with disabilities in higher education mirrors the increases shown in elementary and secondary education. According to the report, “College Freshman with Disabilities: A Biennial Statistical Report” from the American Council on Education, the percentage of freshman reporting disabilities in the nation’s colleges has increased in recent decades. In 1978, 2% of the college freshman population reported some type of disability while in 2000 over 6% of freshman students in four-year colleges reported a disability, a three-fold increase within a twenty-two year time span (Henderson, 2001). The report describes freshman that enrolled for the first time in 2000 at public and private four-year colleges. Additional data from the National Postsecondary Student Aid Study (NPSAS) (NCES, 1996b) shows that in 1995 about 6% of students reported some type of disability; while in 1999 (NCES, 2000) a total of 9.3 % of students reported a disability. The NAPAS survey, unlike the ACE survey, included students enrolled at two and four-year colleges and universities and shows a difference in incidence rates based on the type of institution. Public four-year colleges and private not-for-profit colleges reported disability rates at 7.8% and 7.5% respectively, while public two-year colleges reported a higher incidence rate of 10.8%. Table 1 shows a comparison of percentage of students reporting a disability from different sources and by institutional type when available.

Table 1 - Percentage of Students with Disabilities in Postsecondary Education: Comparing Data from Different Sources

Date	Source of Data	Percentage of Students with Disabilities	Institutional Type
1978	American Council on Education	2	Four-year
1995	American Council on Education	6	Four year
1995/1996	National Center on Educational Statistics	6	Two- and four-year
1998	American Council on Education	7.1	Four-year
2000	American Council on Education	6	Four-year
1999/2000	National Center on Educational Statistics	9.3 7.8 7.5 10.8	Two- and four-year Public four-year Private four-year Public two-year

Several important cautions should be noted when viewing data on postsecondary incidence of disability: (a) sample sizes are small, (b) survey questions vary among studies, and (c) data on individuals with disabilities in postsecondary education is limited. The percentage of students with disabilities enrolled in postsecondary education is relatively small as compared to the general population of students. Because of the small sample size, differences between the way questions are worded or the way in which disability is defined can make differences between different surveys appear very large (Horn & Bobbitt, 1999). The 2000 NPSAS study was more detailed and asked respondents very different questions than previous studies. For example, questions that related to disability were in categories. After responding, students were queried for specific disability types. Students were also asked about other health related disabilities. These questions differed from previous surveys, which did not probe for more specific details. Therefore, direct comparisons between the NPSAS survey and either previous or other reports may be misleading. In addition, a report from the National Science Foundation (2000) indicates that data on the participation of individuals with disabilities in postsecondary education is less available than data from other groups. According to the report, data are limited for three reasons. First, many institutions use different operational definitions of disability. Different definitions make it difficult to compare data from different sources. Second, data about disabilities are often not kept in institutional records due to confidentiality and information about disabilities is often gathered on self-report survey instruments in which respondents are asked if they have a disability. Therefore, the data collected may be reflective of an individual's decision on whether or not to identify. Third, many students come to higher education from high school without the appropriate records and documentation of disability. Without documentation students are unable to prove their eligibility for postsecondary service and may not ever receive service or be counted in disability data collection (Quick, Lehmann, & Deniston, 2003).

Despite the difficulty in obtaining data, it appears that greater numbers of students with disabilities are entering higher education, particularly in the two-year college. In addition, the advent of the ADA has led to an increased availability of disability service personnel on college campuses (Gamble, 2000) and the potential for greater identification of enrolled students who were not previously identified with a disability.

Application to Community College

The increasing enrollment rates of students with disabilities in postsecondary education are even more prevalent in community colleges where 10.8 % of students have a disability (NCES, 2000). Among the 1999-2000 undergraduates with disabilities 49% attended a public two-year college as compared to 41% of those who did not report a disability, 26% attended a public four-year college as compared to 32% of their peers, 11% attended a private four-year college as compared to 14% of their peers and 6% attended a for-profit, private institution as compared to 5% of their peers (Wolanin & Steele, 2004). [3] The mission, focus, and affordability of the two-year college make it a more likely venue for students with disabilities who may be entering higher education from a disadvantaged perspective. Previously mentioned data from the National Education Longitudinal Transition Study (NCES, 1999) has shown that students with disabilities come to higher education less academically prepared than many of their peers. The open access policies of many community colleges allows for admissions of

[3] Percentages may not add to 100 because some students attended less than 2-year and those reporting more than one institution were listed separately.

many students who may not meet the more rigorous admissions policies of a four-year institution (Bryant, 2001). Thus the community college provides an entrance to postsecondary education for many of these students who might not otherwise be able to attend (Mellow, 2000).

The community college also has other advantages for students with disabilities. First, the community college is more affordable than a four-year institution. The average public two-year college tuition is $1,560 (American Association of Community Colleges [AACC], 2003) while the average tuition at four-year public colleges is $4,645 (College Board, 2003). The demographic data from the National Postsecondary Student Aid Survey (NCES, 2000) revealed that students in the lowest income quartile have the highest rates of disabilities and that students with disabilities are disproportionately low-income as compared to their peers without disabilities. Thus, they have greater financial barriers to higher education, and the reduced financial requirements associated with community colleges may represent less of an obstacle. Second, persons with disabilities often have a variety of medical and personal needs that necessitate a variety of appointments with professionals (Wolanin & Steele, 2004). The closer proximity of many community colleges to the home environment provides a more comfortable transition for some of these students who may have medical or personal issues associated with disability and who can continue to have access to medical providers. Third, current literature suggests that the community college environment offers both opportunity and access, allowing students the possibility of social mobility and academic growth (Byrant, 2003). Community college enrollment opens the door for of participation for students with disabilities in many of today's STEM fields, which are considered to be critical for our nation. However, once students are enrolled in these programs they continue to face significant obstacles (Burgstahler, 1994), and many experience difficulty completing their programs (Stoddem, 2001).

Trends in Science Education

Literature reviewed in the last section shows that there is an imbalance exists in the number of students with disabilities enrolled across institution type. The imbalance also occurs across fields and academic disciplines, most specifically in STEM fields. Historically, persons with disabilities have been underrepresented in science and technology disciplines and have essentially been excluded from the same opportunities as their peers without disabilities (NSF, 2000). Graduation and employment data suggests that students with disabilities are not persisting in STEM disciplines and continue to be underrepresented (AAAS, 2001). The data shows that no significant difference exists between the percentage of undergraduates with disabilities who were interested in scientific and engineering fields as freshman. However, there notable difference does exist when looking at persistence rates and employment rates. For example, although 9% of entering full-time freshman in STEM disciplines indicated having a disability, only 6% of all undergraduates and 3% of graduates and first-time professionals indicated having a disability. Numerous questions about the reasons for poor enrollment and retention of students with disabilities in STEM areas have arisen over the past few years. A National Science Foundation task force reported that negative faculty attitudes are a significant barrier to individuals with disabilities seeking careers in science and engineering (NSF, 1989). Burgstahler (1994) also reported three main factors that cause individuals with disabilities to be underrepresented in the sciences: (a) insufficient academic preparation, (b) limited access to technology and curriculum, and (c) lack of acceptance by faculty. In addition, the pedagogical practices found in science instruction may also contribute to poor retention of students in the science fields (Stefanich & Norman, 1999).

Considerable examination of science instruction for diverse populations has occurred over the last 25 years. Much of the research has related to the examination of underrepresented populations as defined by gender or ethnicity. People with disabilities have experienced marginalization in the same way as individuals from other minority groups (Symanski & Trueba, 1999; Hahn, 1999). Coughlin (1997) and Olkin (2001) have drawn comparisons between the experiences of individuals with disabilities and those of other underrepresented populations, and argue that there are many similarities. Thus, it is important to consider the ways in which underrepresented populations have been addressed in the STEM literature because individuals with disabilities may experience many similarities.

In 1983, the National Commission on Excellence in Education issued an historic report expressing concern over the mediocrity of American schools and calling for fundamental educational reform in science curriculum. The report, "A Nation at Risk," indicated that in a number of educational dimensions American students were falling behind in international comparisons. For example, on 19 academic tests American students were never first or second and, in comparison with other industrialized nations, were last seven times. In addition, at the time of the report the average achievement of high school students on most standardized tests was lower than in the previous 26 years. The report called into question America's ability to produce citizens with the skills, literacy, and training necessary to compete in a growing global economy and issued strong recommendations for reform. The Commission's recommendations were grounded in the belief that everyone can learn, that "all, regardless of race or class or economic status, are entitled to a fair chance and to the tools for developing their individual powers of mind and spirit to the utmost" (p.1). Recommendations included reform in the standards, content, and delivery of science instruction in American schools.

The Nation at Risk report set in motion two decades of examination of K-12 and undergraduate instruction. In the 1980's and early 1990's several publications specifically addressed curriculum reforms in science and mathematics instruction. Included in those reports were "Undergraduate Science, Mathematics, and Engineering Education" (1986) from the National Science Foundation, "Science for All Americans" (1989), and "Benchmarks for Scientific Literacy" (1993) from the American Association for the Advancement of Science. These reports set the stage for long-term reform by defining what science students should know and be able to do, and by determining what constitutes adult science literacy. The emphasis on defining science literacy and setting benchmarks for scientific achievement was combined with recognition of the importance of how students learn and are taught.

Despite the reform initiatives of the 1980's and early 1990's, science and technology literacy has continued to be a concern and a focus of national attention. In 1996, the National Science Foundation issued "Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology." The Shaping the Future report noted that despite improvements in STEM education over the last decade, there was a continued and more urgent need for reform, particularly in undergraduate education. A new emphasis on science inquiry, on active learning, and on new technologies had led to new expectations and a greater need for changes in undergraduate teaching. The report emphasized that all students must attain a higher level of STEM competency and stressed the need for students to learn by direct experience and through the process of inquiry.

It is clear that national efforts to reform science instruction can be seen across all levels of education. However, many view the role of the undergraduate curriculum to be critical to STEM literacy (Ehlers, 1997; Fox, 1998; American Association for the Advancement of Science [AAAS], 1998) and significant in improving our country's ability to be competitive in the global economy (Business-Higher Education Forum, 2003).

Despite the increasing diversity of the undergraduate population and national reform efforts, several reports have indicated that the nation is not attracting and retaining minorities, women, and persons with disabilities in the STEM fields (NSF, 2000, 2002, 2004). The reform efforts of the 1980's and 1990's have begun to bring about some changes in undergraduate science instruction, but these changes have not yet been sufficient to impact the enrollment and retention of women, minorities, and persons with disabilities (NSF, 1996, 2000). In particular, individuals with disabilities continue to face significant social and technical barriers that have deterred them from studying in the fields of science, mathematics, and engineering. In addition to the barriers experienced by other underrepresented groups, attitudinal and physical barriers as well as barriers to the curriculum have created formidable obstacles to access in these areas (Burgstahler, 1994; EASI, 1995; Seymour and Hunter, 1998).

Current Educational Practices for Students with Disabilities in Higher Education

Accommodations, Policies, and Procedures

Since we have no evidence that reform efforts in STEM have improved the enrollment and retention of students with disabilities in postsecondary education, it is important to examine the current practices for instructing these students. An examination of the accommodations, policies, and procedures that affect students with disabilities in higher education reveals that existing practices may not be effective. Since the 1970's, federal legislation has existed to mandate equal access to higher education and reduce the barriers associated with access to college programs and services for individuals with disabilities. Currently, higher education institutions are required by federal law to provide access and accommodation for students with disabilities. Legislation such as Section 504 of the Rehabilitation Act of 1973 and the ADA of 1990 stipulate that colleges and universities must make modifications to ensure that they do not discriminate based on disability. Gamble (2000) provided an analysis of how institutions are meeting their obligations under the law and how they are currently accommodating students with disabilities. According to Gamble, standard modifications include course substitutions, the provision of auxiliary aids, modification in testing procedures, the use of sign language interpreters, the use of tape recorders, readers or writers, and adaptation of instructional methods. These accommodations are provided to individual students based on their type of disability and academic need. However, before students are eligible for modifications they must identify and document their disability and request specific accommodations to the appropriate college personnel (Gordon & Keiser 1998). Institutional requirements regarding documentation of disability as well as legal stipulations under the ADA require that individuals with disabilities prove their need for accommodations. Documentation from a licensed professional must be presented to the college's or university's designated disability services provider who assesses the disability and makes recommendations for accommodation. Notification of disability and the recommended accommodations are then sent to the individual's professors. The types of accommodations provided for students with disabilities as well as other support services offered, vary from institution to institution.

A study conducted by the National Center for the Study of Postsecondary Supports (2000) indicated that the type and actual provision of services to students with disabilities vary widely. The researchers distributed a survey to a national sample of 650 disability support providers and collected data about counseling, testing accommodations, disability assessments, accessible transportation, assistive technology, and academic accommodations. Survey results indicated that public institutions and two-year colleges were more likely than either private or four-year institutions to provide service and accommodations. When comparing the two types of institutions two-year institutions consistently offered more support in most of the areas surveyed than did the four-year institutions. Two-year institutions also reported more community outreach programs, connections with business, and federal programs that support individuals with disabilities. Disability support providers in the study did not typically collect any data on student satisfaction or solicit feedback on the quality of service offered to students with disabilities. Therefore, we have data on the type and extent of service, but we do not know whether the services are effectively meeting the needs of students.

The services described above exist at most of the nation's 3,000 postsecondary institutions (Stodden, 2001). Yet, questions remain as to whether or not these practices are truly effective in improving the educational environment for individuals with disabilities (Szymanski &Trueba, 1999). The current system of providing academic accommodations for students with disabilities focuses on the individual need and does not look at issues of power and equity in education; nor is consideration given to the manner in which disability is viewed and treated in society (Hall & Belch, 2000).

The Categorization of Disability

How society views disability impacts the decisions that are made in educational environments (Szymanski &Trueba, 1999). For example, the special education and rehabilitation models frequently applied to disability are based on the perception of disability as an impairment that needs remediation. In contrast, the independent living model is based on a social model that views disability as a problem residing outside the individual. Each of these models takes a very different approach toward addressing problems associated with disability. There are several theoretical constructs used to classify and define disability. However, in general they fall within two central categories, the medical model and the social theory model. The medical and social theory models can be looked at from a number of perspectives. The ideology behind the models impacts the behavior and attitudes of institutions, attitudes towards clients, as expressed by expectations, and the aims of education (Reiter & Asgad, 1992). The adoption of these different ideologies by individuals in society strongly impacts how they think about disability and the way they approach education for persons with differences. Each of the two major models is described in detail below.

The medical model is based on scientific thinking about health and disease (Shunit, 2000). Within this construct, disability is seen as an individual pathology with a goal of remediation through medical or functional treatment. Within the medical framework, disability incapacity is compared to the capacity of the nondisabled population and inclusion becomes a private individual responsibility. Disability is also seen as an anomaly and social burden (Rioux, 1997). Students with disabilities are often viewed by the dominant culture as having a medical problem that needs remediation. Longmore and Umansky (2001) examined the historical impact of viewing disability as a medical disease or pathology. Impairments were seen as a result of disease, which produced limitations that affected the major life functioning of the individual with a disability. The medical approach casts disability as a deficit and puts the focus on the individual as a deviant rather than on a social structure that defines difference as deviant. Disability is therefore defined as pathological, with individuals within that group being fundamentally different from the norm. The focus on the individual as deviant affects our cultural perception of what is expected of the individual and what is equitable treatment. Szymanski and Trueba (1999) postulated that the medical model for defining disability is most frequently used on college campuses. The medical model fosters an environment where individuals with disabilities are provided a separate service that is designed to address their limitations. A specific adaptation is made for the individual with a disability. The adaptation is usually authorized by someone other than the individual and is provided in a manner that frequently segregates the individual from other students. Under the medical model the individual rather than the system is required to make modifications. The authors postulated that by using a model that focuses on limitations, college campuses foster dependence and contribute to the negative attitudes and perceptions that foster continued discrimination and inequality.

The social theory model is a structural approach that is based on social pathology rather than individual pathology (Rioux, 1997). The underlying assumption is that something is wrong with society that needs to be treated. Within this context, disability is viewed as a difference rather than an anomaly. Disability is also viewed as the interaction between an individual and society, and inclusion is seen as the responsibility of society (Rioux, 1997). Hahn (1999) argued that a challenge to the traditional medical model is based on a social definition of disability. The social theory approach focuses on the social or attitudinal environment. The focus is on public attitude rather than physical limitation as the primary source of difficulties facing individuals with disabilities. The social theory model compares individuals with disabilities to individuals in other minority groups and postulates that existing discrimination in architectural access, employment, and education reflects conscious or unconscious social attitudes that support a "hierarchy of dominance and subordination between nondisabled and disabled segments of the population" (Hahn, 1999, p.7). By attributing the meaning of disability to internal physical limitations, society can justify the inequalities that continue to exist. By shifting the meaning of disability to one that defines disability in relation to the environment, society begins to see individuals in a different light. From a social theory perspective, students with disabilities can be viewed on a continuum of diverse learners with the responsibility for inclusion shifting away from the individual to members of society. From a social theory perspective disability is defined as "limit or loss of opportunities to take part in community life because of physical and social barriers" (Altman, pg. 103). The social theory model suggests a movement away from treating disability as an individual pathology and a move toward a social responsibility perspective in which we all have a responsibility for promoting inclusion.

Theory and Research, Reaching Diverse Populations

The Nature of Diverse Learners

In the past few years, educational researchers have paid considerable attention to the way traditional forms of college instruction have perpetuated a model that views disability in a negative light and places the burden for learning and accommodation on the individual rather than on the system. As we begin to move to a more social responsibility framework for thinking about disability, we begin to see individuals with disabilities as falling within a range of different types of learners. Researchers have challenged traditional views of intelligence and learning as one-dimensional concepts used to measure all learners, and have conceptualized learning in new ways. For example, Gardner (1999) indicates that new educational paradigms have altered the conceptualization of intelligence so that we can no longer look at either intelligence or learning from just one perspective. His theory suggests that

> intelligences are not things that can be seen or counted. Instead they are potentials—Presumably neural ones -- that will or will not be activated depending on the values of a particular culture, the opportunities available in a

culture and the personal decisions made by individuals and/or their families, schoolteachers and others. (p.34)

In 1983, Gardner proposed that, in addition to the verbal/linguistic and logical/mathematical intelligences traditionally measured by I.Q. tests, spatial, bodily-kinesthetic, musical, interpersonal, and intrapersonal intelligences exist as well. In 1994, he reported that ample evidence exists for an eighth intelligence, naturalistic. Gardner presents a multifaceted view of the brain and recognizes that people have many different forms of cognitive strengths. He suggests that students who succeed in school do so because their cognitive styles match that which is fostered in traditional education.

Theory in education also points to the importance of knowing differences in student learning style (Dunn, Griggs, Olson, Beasley, & Gorman 2001; Sarisin, 1999; Miglietti & Stranger, 1998; Dunn & Waggoner, 1996; Kolb, 1984). Sarisin (1999) defines learning style as the way in which individuals take in new information and the manner in which they learn new skills. Learning styles are conceptualized in various ways by different authors. For example, some authors base learning style on a processing perspective (Sims & Sims, 1999), some look at whether students are auditory, visual, or tactile (Sarisin, 1999), some look at learning from an experiential perspective (Kolb, 1984), while others look at individual preference for instructional methods and environments (Dunn & Waggoner, 1996). Many different models of learning style exist and, it is therefore difficult to provide a widely accepted definition. However, one consistency among them is the belief that individuals differ in the way they process information from the environment (Morin, 1991). It is this difference that is critical to the learning environment.

Sternberg and Grigorenko (2002) agree with the positions put forth by Gardner and many of the learning theorists. They suggest that the traditional methods of teaching in academia fail to meet the needs of students. Their proposed theory of successful intelligence postulates that a student's inability to achieve often results from teaching that is narrow in conceptualization and does not take into account student learning styles. In their view, traditional teaching methods are useful for students whose patterns of ability match traditional methods of the dominant culture. Successful intelligence recognizes patterns of abilities that vary within a sociocultural context. According to Sternberg and Grigorenko, the solution to academic difficulties lies in the ability to value culturally nondominant ability patterns and then to change teaching and assessment to accommodate them.

These theories are consistent with cutting edge brain research, which indicates that students do not have one learning capacity, but many multifaceted learning capabilities. Neuroscience research in the areas of brain development (Talaga, 2000; Diamond & Hopson, 1998) and brain structure (Sylvester, 1995) has shown that both developing and mature brains are altered during learning. Learning changes the structure of the brain, and different parts of the brain may be ready to learn at different times (Bransford, Brown, & Cocking, 1999). Recent brain research tells us that learning is distributed across interconnected neural networks. For example, Rose and Meyer (2002) report that Positron Emission Typography (PET) scans demonstrate how different parts of the brain are involved in different types of learning. Visual, oral, and audio activities are highlighted in different parts of the brain. Each of us shares common neural networks. However, individual brains differ in their utilization of these networks. Rose and Meyer go on to say that a disability or challenge in one area may often be balanced by an exceptional ability in another. The differences in brain function and varying abilities have critical implications for teaching and learning. The recognition of varying patterns of abilities is particularly important for science instruction, where engagement and inquiry are considered central to the learning process (NRC, 2001).

The research in the areas of multiple intelligence (Gardner, 1999), learning styles (Dunn, Griggs, Olson, Beasley, & Gorman 2001; Sarisin, 1999; Miglietti & Stranger, 1998; Dunn & Waggoner, 1996; Kolb, 1984), and brain-based learning (Bransford, Brown, & Cocking, 1999) share a common belief in the diversity of learners. Of growing concern is the possibility that the teaching practices at our colleges and universities do not effectively serve these students (Sternberg and Grigorenko, 2002).

Teaching Practices

Critical Pedagogy

The theoretical conceptualization of different intelligences and learning styles leads to questions about pedagogy and the manner in which these issues should be addressed in the educational environment. How do we bring about equity and effective teaching for the many students with varied learning styles, disabilities and abilities? Critical pedagogy is one theoretical position that examines issues of equity in relation to diverse populations and the educational environment. Critical pedagogy emerged out of the social movements of the 1960s and 1970s and was highly influenced by the work of

Paulo Freire. In *Pedagogy of the Oppressed* (1970), Friere explored the relationship between oppression, internalization of societal values, and education. His work impacted the thinking of many current educational theorists who examine power structures and relationships in classrooms and look at education from a social justice position.

McLaren (1995), Giroux (1997), and Reitz (2002) are some contemporary theorists who have explored the relationships between power, unequal social division, and education in contemporary society. Collectively, they postulate that the views held by society about certain groups or cultures often serve to perpetuate a system of oppression that in turn serves to maintain the status quo. In general, critical educational theorists examine education from the perspective of dominant and subordinate positions in society. They look at the existing social and political forces that shape education. From their perspective, educational curriculum is more than just the material presented in the classroom. Curriculum includes teaching and learning styles emphasized in the classroom, the messages that get transmitted to students by the physical and instructional environment, teacher expectations and student learning styles (McLaren, 1994). Often the beliefs, dominant ideologies, and social practices are transmitted through teacher behaviors. These behaviors, whether conscious or not set the tone of a classroom and lead to an environment that has the potential to either encourage or discourage student learning. Students from diverse populations who are outside of the dominant structure are vulnerable to this type of unintended oppression. Most of the literature in critical pedagogy refers to oppression based on race, gender, class, and ethnicity (Giroux, 1983). However, individuals with disabilities have also been in a position in which assumptions about disability have impacted both the ways in which society views them and their educational opportunities. The manner in which disability is viewed and categorized by society impacts the choices we make about treatment and accommodation (Longmore & Umansky, 2001).

Critical pedagogy brings to the forefront the need to recognize the beliefs held by the dominant culture and the critical importance of inclusion in education. The philosophical underpinnings of equity and inclusion upon which critical pedagogy is based also form the basis of many other types of inclusive pedagogies. The following section discusses the application of inclusive pedagogies in STEM instruction for students with disabilities.

STEM Instruction in Higher Education

Much of the research on learning and pedagogy has led to a reformation of the traditional ways we think about teaching. This is particularly true for the sciences, where considerable research has focused on understanding how students learn (NRC, 2002, 2003a). Traditional undergraduate science instruction has tended to construe science teaching as the transmission of knowledge through the delivery of information from faculty to student (Taylor, Gilmer & Tobin, 2002). Through a lecture format, the faculty member would transmit discipline-related information, while the student would obtain knowledge through listening and recording. The role of the learner in this context is seen as passive, with prior learning and world experience de-emphasized. More recent research has emphasized the need for learner participation and engagement in the learning process (American Psychological Association [APA], 2002; NRC, 2002, 2003a). Teaching practices that focus on the student's construction of knowledge are seen to be more effective in the development of science literacy.

Constructivist theory in science is based on the belief that scientific knowledge is constructed from one's own observational experiences (Fensham, Gunstone, & White, 1994). What students already know, feel, and value therefore becomes a critical part of what they will ultimately learn about science. The constructivist perspective promotes the active participation of learners as they attempt to make sense of their environment (Taylor, Gilmer & Tobin, 2002). This approach forms the basis for many of the national recommendations and initiatives in science instruction.

The National Research Council (2002) has identified seven learning principles that are considered to be a synthesis of underlying principles of human learning and are also critical aspects of science comprehension. The following principles are closely related to constructivist theory and represent a learner-centered approach:

1. Learning with understanding is facilitated when new and existing knowledge is constructed around the major concepts and principles of the discipline.
2. Learners use what they already know to construct new understanding.
3. Learning is facilitated through the use of metacognitive strategies that identify, monitor, and regulate cognitive processes.
4. Learners have different strategies, approaches, patterns of abilities, and learning styles that are a function of the interaction between their heredity and their prior experiences.
5. Learners' motivation to learn and sense of self affect what is learned, how much is learned, and how much will be put into the process.

6. The practices and activities in which people engage while learning shape what is learned.
7. Learning is enhanced through socially supported interactions. (p.20)

These principles form a conceptual framework that shapes effective science learning. Learning is strengthened when new information is connected to that which is already known and is facilitated by the recognition of difference in learning strategies and approaches. Learning is enhanced when students have the opportunity to interact and collaborate and when subject matter is connected to real-world situations.

Reform efforts have placed a strong emphasis on teaching practices that foster interactive, learner-centered approaches. The National Science Education Standards (NRC, 2003b) act as a guideline for effective science instruction. These standards emphasize that science is for all students, regardless of age, gender, ethnic background, or disability. Science is an active process that engages the learner both mentally and physically, and scientific inquiry becomes a central tenant of science learning. The National Science Education Standards refer to inquiry as

> ...the diverse ways in which scientists study the natural world and process explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world. (p.23)

The terms inquiry and inquiry-based instruction are often used synonymously. However, the Standards clearly do not recommend a single approach to instruction. Rather, they place an emphasis on the use of different strategies to develop knowledge.

Those strategies should be based on the development of inquiry and should include hands-on activities, learner-centered approaches, and cooperative learning. Jarrett (1997) sees inquiry as a community where students and teachers share responsibility for learning. She sees the practice of inquiry as occurring on a continuum, with structured hands-on activities on one end, and inquiry generated from the student's own questions on the other. Colburn (2000) defined this continuum as ranging from structured inquiry, guided inquiry, open inquiry to learning cycle with increasing levels of student involvement as one progresses down the continuum. According to Colburn, teachers are the key element in inquiry-based instruction because they must support inquiry, believe in a student's ability and be able to assess the appropriate teaching strategies to foster inquiry. Scientific inquiry as a pedagogical technique encompasses a range of strategies and approaches that support inquiry and engage students as active participants.

The effectiveness of inquiry-based instruction on a K-12 level has been clearly documented (NRC, 2001). There is also a growing body of evidence indicating that inquiry-based instruction enhances undergraduate students' performance and attitudes about science (Bleicher, Romance & Haky, 2002; Kenyon, 2003; Lawson, 2002; Oliver-Hoyo, Allen, & Anderson 2004; Reeve, Hammond & Bradshaw, 2004). In 2002, Bleicher, Romance, and Haky used a qualitative and quantitative approach to assess the effectiveness of a curriculum design model for introductory biology and chemistry courses. The model incorporated small-group cooperative learning with an integrated inquiry-based approach into the traditional lecture and laboratory. Researchers examined changes in student learning, achievement, and interest in science through data collection (exam scores, laboratory grades, final course grades) and through survey data collected from students. Results indicated that over 70% of the students reported that the nontraditional cooperative learning component of the course was helpful to their success in the course. An analysis of grades showed a 20% reduction in the percentage of students receiving D's or F's, or withdrawing from the courses, as compared to the previous year. It is important to note that in Bleicher, Romance, and Haky's model the change was in the form of an addition to the traditional format of lecture and laboratory rather than in a redesign of the existing curriculum. The researchers' use of multiple methods to collect data added some credibility to their findings. However, their findings related to a specific project at one university and focused on biology and chemistry students within that project. In addition, findings related specifically to the success of the project rather than to the inquiry-based approach and cannot be generalized to other populations.

Kenyon (2003) took a similar approach, in that he looked at adding inquiry into an existing curriculum. He added scientific inquiry into the curriculum through the addition of a one-credit course called Succeeding in Science. An experimental group enrolled in the course while the control group did not. The objective of the course was to foster the development of scientific inquiry and to assist college freshman in understanding the nature of science. Both experimental and control groups were concurrently enrolled in an introductory biology course, and pretests and posttests determined their understanding of the nature of science. Results indicated that participation in the inquiry-based course did make a significant difference in the students' understanding of the nature of science. While the results clearly pointed to the benefit of the inquiry-based instruction model, their interpretation requires some caution. First, the control and experimental groups were unequal in size (50 experimental participants and 24 control participants). Second, it is difficult to determine if the effects were based entirely on the type of instruction, or whether the addition of seven weeks of instruction had an impact. Other factors that related to individual students' academic experience could also have contributed to the findings. In addition, variations in instructors based on factors such as personality or teaching style were not accounted for. A mixed method research methodology that included observations of faculty and interviews with students could have improved the credibility of their results. Nevertheless, the findings from this study indicated that inquiry-based instruction did improve understanding of the nature of science for this select group of students.

Reeve, Hammond, and Bradshaw (2004) developed a method to promote scientific inquiry in a large enrollment (100 students or more) lecture biology course. To supplement the traditional lecture, they introduced into the curriculum two inquiry-based workshops extending over two consecutive lecture periods. Students received a research focus and were asked to conduct an investigation, for the purpose of developing their problem-solving skills and helping them discover principles in an open-ended inquiry process. The model incorporated small-group discussions that were facilitated by teaching assistants. The researchers surveyed students over the course of three semesters in regard to their impressions of the workshops, and faculty rated the students' conceptual understanding of the workshop topics. Overall, faculty rated the students' conceptual understanding of the workshop topics as high; and most students indicated that participation was a positive experience. Over 76% of the students indicated that the workshops were an enjoyable alternative to the traditional class format, and 73% indicated that the workshops were helpful in learning science. Reeve, Hammond, and Bradshaw's model was somewhat dissimilar from the others in that they added inquiry directly into the course sequence, replacing some of the traditional lectures with inquiry-based workshops. In reviewing Reeve, Hammond, and Bradshaw's study several important points should be kept in mind. First, the authors did not provide information about the construct validity or any pilot testing of the survey instrument. While the findings from the survey appear positive, they should be interpreted with some caution because information about reliability was not provided. The addition of student interviews would also have been helpful in providing information from various sources about what students liked and how they perceived it to be helpful. Second, faculty ratings of student conceptual understanding was used as a measure of the effectiveness of the approach. Although this is helpful information, it is important to note that faculty assessments were based on their subjective perceptions, as opposed to any quantitative data about student improvement. Third, findings apply only to this one university and to biology students in particular. Nevertheless, findings in this study were consistent with those found by Kenyon, and by Bleitcher, Romance and Haky. The addition of an inquiry-based component seems to have a positive effect on student satisfaction and learning.

Lawson (2002) conducted one of the most compelling studies relating to inquiry-based instruction and science. He designed the study to evaluate the effects on college students of a reformed-based instructional method, which was based on the principles of effective learning from the American Association for the Advancement of

Science (AAAS). The AAAS principles include a strong focus on scientific inquiry and on actively engaging student participation. Lawson conducted research on students in introductory physical science, elementary mathematics, introductory physics, and introductory biology courses. The study also evaluated faculty members using a Reformed Teaching Observation Protocol (RTOP) specifically designed to measure the lesson design, content, and classroom culture for utilization of reformed teaching methods. The RTOP allows observers to rate instructors on a 1 to 100 scale and has high inter-rater reliability. The design of the study included a comparison to similar control group courses that used traditional methods. Results indicated that, when implemented, AAAS teaching methods led to improved student achievement in a variety of undergraduate classes. The strong correlation between faculty scores on the RTOP and student achievement on subject matter tests is of particular interest. Faculty members who were evaluated as having the highest degree of AAAS principles implementation also showed the highest level of student achievement. Lawson's study differs from many of the others in that the procedure evaluated instructional changes in faculty. Instead of adding an additional course component in inquiry, faculty members were trained to incorporate the principles into existing curriculum. Lawson's research method incorporated several different subject areas, control and experimental groups, an instrument with high inter-rater reliability, and the use of pretest and posttest performance measures. He presents a convincing picture of the effectiveness of reformed teaching methods.

Some difficulties exist with the research that attempts to determine the effectiveness of specific teaching approaches. As is noted in some of the comments on the above studies, it is often difficult to separate out the various factors that determine student satisfaction and success. Nevertheless, the findings in these studies are significant in that they demonstrate that reformed teaching practices can have a positive impact. Despite some of the study's limitations, the findings indicate that inquiry-based learning positively impacts both undergraduate student achievement and perceptions about science. However, with the exception of Lawson (2002), these attempts to bring about reform in traditional instruction do so by the addition of inquiry components rather than by the alteration of traditional instruction. Research indicates that a traditional lecture format does not meet the needs of today's diverse range of students (Sternburg & Grigorenko, 2002; Taylor, Gilmer, & Tobin, 2002; APA, 2002; NRC, 2001, 2003a). Lawson's findings support this by indicating that student achievement correlates with high levels of faculty reform practices.

The studies on science inquiry-based learning do not address the issues of disability nor do they attempt to differentiate student level of satisfaction or achievement based on issues that relate to disability. Although the National Science Education Standards (NRC, 2003b) specifically state that learners have different strategies, approaches, and patterns of abilities, no attempt has been made in these studies to recognize student differences. Students with differences, in particular students with disabilities, may have learning styles and approaches that differ from the general student population. We can speculate that the addition of inquiry-based components will be as positive for them as it is for other students. However, questions remain as to the accessibility of those components, as well as the impact and effectiveness of the traditional lecture format for students with disabilities.

STEM Instruction for Students with Disabilities

Research concerning inquiry-based learning for the general population of students in STEM has shown that students respond favorably to inquiry-based methods. However, the experience of students with disabilities in postsecondary education appears to be quite different. Despite increasing numbers of students with disabilities in higher education and a national agenda advocating for their inclusion, there is scant literature that directly relates to the experience of students with disabilities in science curricula. Seymour and Hunter conducted one of the few science and disability studies at the University of Minnesota in 1997. They used qualitative methods to examine the experiences of 65 students with disabilities who were enrolled in undergraduate (44 students) and graduate (21 students) programs in science, mathematics, and engineering. The students participated in individual interviews and focus groups designed to elicit information about their college experiences. Findings indicated that students with disabilities have significant obstacles to overcome before they can complete a university science program. The sources of difficulties were identified within three primary categories: financial aid, problems caused by the disability and its limitations, and faculty attitudes. Students cited faculty attitudes as the greatest source of difficulty. Their primary concerns related to faculty attitudes that students felt impeded their academic progress. Faculty refusal to provide academic accommodations that were institutionally authorized, faculty insistence that students defend their right to accommodations, and faculty delay of academic accommodations were all listed as problem areas. Students felt that attitudes, beliefs about disability, and resulting faculty behaviors contributed to an environment that negatively impacted self-esteem and added an extra layer of emotional stress, thus impacting student academic progress. In addition, students expressed problems with financial aid requirements that mandated full-time status, problems with the physical layout of classrooms, classroom acoustics, and dexterity requirements for some lab activities. Seymour and Hunter's study provided some useful information about the lived experience of students with disabilities in science curriculums. However, it has several limitations and omissions that should be noted. First, the methodology used in the study was qualitative, and results could have been impacted by researcher bias. The use of a mixed methods strategy that incorporated some quantitative data might have provided additional support to the findings. Second, the sample size was relatively small and the study was conducted at one university. It is therefore difficult to generalize findings to other colleges or situations. Third, issues that related to curriculum access were not addressed with the students. It appears that neither the students nor the researchers looked at whether or not faculty method of instruction played a part in the difficulties students experienced. The assumption seemed to be that access would be obtained from accommodation rather than from inclusive instruction. The importance placed on accommodation reinforces a medical model that focuses on the functional limitations of individuals with disabilities, as opposed to the social theory model, which places a greater emphasis on the instructor's responsibility for providing an inclusive environment. However, despite any limitations of the study, it identifies the critical importance of faculty attitude in determining the educational environment for students with disabilities.

Stefanich and Norman (1999) also looked at faculty attitudes, with a specific focus on the attitudes and experiences from a faculty perspective. A survey method was used to determine faculty beliefs about teaching individuals with disabilities. A survey instrument that was developed in 1994 by the Association for the Education of Teachers in Science (AETS) was mailed to 100 elementary science teachers, 100 middle school science teachers, 100 high school science teachers, and 100 higher education science faculty. The sample population for the survey was randomly selected from source documents from the National Science Teachers Association Directory, the Association for the Education of Teachers in Science Directory, the Presidential Award Winners for Excellence in Science Teaching Directory, and the National Science Teachers Association Convention Program Directory. The overall return rate was 47.25%, with a 46% return rate for higher education faculty. Findings indicated that most college science educators "have little or no direct experience in teaching disabled students." Many felt that students with disabilities should not be in regular classrooms (30.2%) and that teachers should not be expected to make major adjustments in order to serve the special needs of students with disabilities (29.3%). At the same time, 62% indicated that that they felt inadequate in their preparation for teaching students with disabilities, and 81% indicated that teachers needed special training to overcome prejudices and barriers in working with students with disabilities. Stefanich and Norman's findings are significant in that they highlight several critical factors that relate to science instruction and students with disabilities. First, it seems that many faculty members have only limited exposure to individuals with disabilities and therefore have not been confronted with the need to provide a more inclusive instruction. Second, some fear and stereotyping associated with disabilities appear to exist. This may come from a combination of lack of exposure and a reliance on traditional models of disability that define disability in relation to deficit and functional limitations. It is also significant that a relatively high percentage of faculty feel underprepared to deal with disability and believe that training is necessary in order to overcome prejudices and remove barriers. Stefanich and Norman's study used a national sample of educators who were randomly selected from science teacher databases; the survey was developed by a nationally recognized organization and was reviewed by a panel of national experts in science education. Although specific data on survey development was not made available, it appears that the survey measured what was intended. The use of a national sample aids in generalizability. However, the sample size was relatively small and the location of respondents was not reported.

A study conducted by Leyser, Vogel, and Wyland (1998) showed findings that were in many ways consistent with those of Stefanich and Norman. Utilizing a sample of 420 faculty, they examined the experiences and attitudes toward accommodations for students with disabilities. They modified a survey instrument developed in a 1989 study and sent it to 1,050 faculty in a large mid-western university with a return rate of 40%. Prior to its use, several faculty and staff members reviewed the survey instrument, and modifications were made based on their input. A Chronbach alpha coefficient of reliability for the survey yielded a coefficient of .86. Findings from the study that were consistent with Stefanich and Norman showed that faculty had limited contact and experience with students with disabilities (82%), limited training in the area of disability (82%), little knowledge about accommodations (40%) and about legal issues that impact disability (66%). Findings differed in that most faculty members expressed a willingness to provide accommodations (88%), and some reported that they had made various teaching adaptations. It should be noted that Leyser, Vogel, and Wyland's study differed from the Stefanich and Norman study in the way the surveys were administered. In the Leyser, Vogel, and Wyland study, surveys were administered to faculty across divisions; in the Stenfanich and Norman study, the surveys were administered only to science faculty. Findings that differ from Stefanich and Norman's may therefore relate to faculty differences associated with academic discipline. In both studies, it is interesting to note that faculty have had limited exposure to individuals with disabilities and limited training in how to effectively accommodate them.

These studies provide insight into the concerns and struggles of higher education faculty as it relates to students with disabilities. It is important to note that all of these studies were conducted at four-year universities; and findings clearly cannot be generalized to other types of colleges, especially not to community colleges where faculty may have very different exposure to and experience with students with disabilities.

Techniques Applicable for Students with Disabilities

Critical pedagogy and national reform efforts have placed a strong emphasis on the importance of recognizing different patterns of ability and have advocated for inclusive pedagogical approaches for all students, including those with disabilities. Fortunately, the advent of Universal Design for Learning (UDL) has provided a model that incorporates inclusion as the center of instructional practice. In the last few years, theorists have begun to take a serious look at UDL as a model, which incorporates an understanding of diverse learners and promotes inclusive pedagogy.

Universal Design (UD) as it applies to teaching and learning is one method for reaching a diverse student body made up of varying learning abilities and disabilities. The incorporation of the concepts of Universal Design into teaching methodology has been hailed as a mechanism to improve the access and ultimate success of students with disabilities (Silver, Bourke, & Strehorn, 1998; Center for Applied Special Technology [CAST], 2000; Higbee, 2001). The term Universal Design was coined by Ron Mace (1988) and has its roots in the field of architecture. The original concept centered on making the physical environment accessible to all people, including those with disabilities. Universal Design is defined by the Center for Universal Design at North Carolina State University as "The design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" (Mace, p. 1). This definition and set of principles were based on the Mace's work and are geared to provide guidance in implementing UD in the physical environment. Much of the educational work in UD is based on the above definition and set of principles.

In the late 1990's and early 2000's, educators and researchers began to expand the concepts of barrier-free design from architecture to educational experiences (Burgstahler, 2000; Orkwis & Mclane, 1998; Pisha & Coyne, 2001; Rose, 2000; Stahl & Branamam, 2000). The term Universal Design for Learning (UDL) was developed by the Center for Applied Special Technology (CAST) to refer to the use of UD in the learning environment. Silver, Bourke, & Strehorn (1998) developed the term Universal

Instructional Design (UID) to refer to UD in the instructional environment. Scott, McGuire, and Shaw (2003) adapted the principles of UD developed by the Center for Universal Design to be used in the instructional environment and adopted the term Universal Design for Instruction (UDI). Central to all of these approaches is the philosophical underpinning of inclusiveness and equity for all students. The approaches are similar in that they all focus on creating teaching and learning environments that incorporate the use of multiple methods and strategies to reach a diverse range of students. For consistency, the term Universal Design for Learning (UDL) will be used throughout the remainder of this paper to refer to UD in the teaching and learning environment.

Universal Design for Learning is accomplished by the use of flexible curricular materials that provide alternatives for a diverse range of students. These alternatives are built into the instructional and curriculum design (Orkwis, 1999). UDL as it applies to the educational environment shifts traditional assumptions in three important ways. First, students with disabilities are no longer seen in a separate category. All students are seen as falling on a continuum of learners with differences in learning styles and strengths. Second, adjustments for differences in learning occur for all students, not just those with disabilities. Third, universally designed curriculum materials are diverse and presented in a variety of formats that include traditional and digital (Meyer & O'Neil, 2000). The move to UDL represents a major paradigm shift from treating people with disabilities as part of a medical model needing specialized care to a model in which everyone is treated equally (Sandhu, 1995).

Although considerable literature on the theory and benefits of UDL has been written, the application of UDL constructs in higher education is a relatively new phenomenon. Therefore, little empirical data concerning its effectiveness is available. Testimony from faculty who have incorporated UDL into their instruction provides some interesting feedback as to their perceptions about its effectiveness. McAlexander (2003) from the University of Georgia who incorporated UDL into her college composition class wrote that there "is no doubt that the application of Universal Instructional Design principles to the teaching of composition will result in more students – gifted, average, weak, "disabled" – improving their writing while enjoying the process"(p.113). Brothen and Wambach (2003), from the University of Minnesota, incorporated UDL into a computer-based psychology course. They wrote "the flexibility of our method allows most students with disabilities to complete the course without special treatment (pp. 143-144). Miksch (2003), from the University of Minnesota, also reported positive results from incorporating UDL into her legal studies classroom. She wrote,

> Since incorporating UID principles into my classes, I have had several students bring me letters detailing the accommodations they require. The students notice that the most common accommodations (i.e. copies of lecture notes and additional time on assignments) have already been incorporated into the course design to benefit all students. I explain that I have attempted to incorporate more learning supports into the course with the goal of inclusive pedagogy. I have incorporated multiple ways to participate. (p.168)

Research in the area of UDL has been extremely limited. However, the feedback from faculty who have incorporated UDL into their curriculum is positive and holds promise for improving the educational experience of all students, including those with disabilities. Of particular note are the comments that relate to accommodation. The shift to creating a UDL instructional environment appears to reduce the need for individual accommodations for students with disabilities. Students in these classrooms have been afforded the opportunity to participate in an educational environment without the need for specialized or separate treatment. The feedback from faculty provides a starting point for looking at the practical application of UDL in the classroom. However, overall effectiveness of these approaches is difficult to assess without either empirical data or qualitative comparisons. One approach for examining the potential of the UDL approach is to examine and compare UDL to related methodologies that have been empirically evaluated.

One related curriculum methodology that has been evaluated is that of multimedia instruction. One aspect of multimedia instruction that is similar to UDL is that it promotes the presentation of material in formats other than the traditional lecture. Najjar (1996) defines multimedia as "the use of text, graphics, animation, pictures, video and sound to present information" (p.129). Numerous studies have compared learning via traditional lecture as compared to learning via multimedia instruction. Najjar reports on a meta-analysis of over 200 studies on multimedia instruction. Meta-analysis is defined by Chow (1987) as set of statistical procedures used to summarize and integrate many empirical studies that focus on one issue. The method has both advantages and disadvantages that should be taken into account when reviewing studies using meta-analysis techniques. One of the major advantages of meta-analysis is the ability to draw data from multiple studies in order to determine statistically significant aggregate results. One common criticism of meta-analysis is that liberal inclusion criteria is often used when selecting studies to be in the analysis. When this occurs, the meta-analysis may measure the effects from different dependent variables, even when the actual studies measure different constructs (Bangert-Downs, Rudner & Lawrence, 1991).

It is important to keep the advantages and disadvantages of meta-analysis in mind when reviewing Najarr's study. Students in the studies that formed the meta-analysis ranged from K-12 through higher education. Most of the studies utilized a control group that received traditional lecture instruction and comparison groups that received multimedia instruction. The research studies most often measured learning or performance between the two groups. Overall meta-analysis found that learning was greater when multimedia strategies were utilized. Grouped together the studies in the meta-analysis lead us to conclude that multimedia would be the preferred form of instruction. However, each of these studies differed as to the type of multimedia and how it was implemented. For example, several of the reported studies (Bosco, 1996; Stafford, 1990; Fletcher, 1989) found that the interactivity between the learner and multimedia was a strong contributing factor, while other studies (Mayer & Anderson, 1992) found that animation with verbal narration was effective. In addition, many of the studies looked at the type of information that was being presented and concluded that certain types of presentation were better for certain types of material. For example, in one qualitative study, Bell and Johnson (1992) concluded that pictures were a preferred method for understanding spatial relationships, while Mayer and Anderson (1992) concluded that animation with verbal narration was effective for learning problem-solving information. Much of the research raises some questions as to which type of technology will be appropriate in which learning situations. In examining this meta-analysis, it is important to note that studies were at different grade levels and had varying measures and conclusions. It appears that, overall, multimedia seems to help people to learn. However, these conclusions should be interpreted with some caution. Nevertheless, the findings are consistent with new brain research that acknowledges the activation of different parts of the brain for different types of learning activities as well as the variability among learners (Rose and Meyer, 2002). Findings are also consistent with UD theory that states that

> no single method can reach all learners. Multiple pathways to achieving goals are needed. In a UDL classroom you support multiple pathways by presenting concepts in multiple ways, offering students multiple ways of expressing their knowledge and providing a variety of options to support each student's engagement with learning. (Hitchcock, Meyer, Rose & Jackson, 2002, p.12)

One of the differences between UDL and multimedia instruction lies in the flexibility and multimodal presentation of materials. UDL takes into account the effectiveness of multimedia instruction for certain types of learners in certain situations and incorporates that as an instructional strategy. Another major difference is that UDL takes into account not only the instructional strategy but also the variability in individual learners.

Another curriculum approach that has some similarities to UDL is that of instruction based on learning styles. Both UDL and instruction based on learning styles pay attention to diversity in learners and encourage the use of different methodologies to reach varying learner types. As stated earlier, learning styles are conceptualized in various ways by different authors. The variation in conceptual approaches to learning styles makes it difficult to compare and contrast empirical studies within the learning styles field. However, one meta-analysis by Dunn, Griggs, Olson, Beaskey and Gorman (2001) examined 36 studies that employed experimental design to analyze the effectiveness of the Dunn and Dunn model of learning style preferences. The Dunn and Dunn model is based on the theory that all students have a set of biological and development learning characteristics that are unique to them. The model focuses on identifying individual preferences for instructional environments and methods based on learning styles. The model is complex and made up of five learning elements: environmental, emotionality, sociological, physiological and psychological. Within the elements, 21 characteristics represent individual learning preferences. The studies in the meta-analysis provided 3,181 participants who had been in 36 studies relating to the impact of the model on achievement. When all participants were combined, findings indicated that the overall academic achievement of students whose learning styles had been matched with appropriate teaching strategies was greater than that of students who had not been matched. The research indicated that when the individual learning preferences of students were addressed, students performed better. One of the advantages of this meta-analysis is that all studies were based on the Dunn and Dunn model of learning preferences, allowing for some consistency in the concepts being measured. However, it is important to acknowledge that this meta-analysis, similar to that of Najjar (1996), is based on studies that may be looking at somewhat different measures. The results should therefore be interpreted with some caution.

Despite the need for caution, the results of this meta-analysis have important implications for UDL. The research confirms the importance of considering different learning approaches when designing curriculum and shows that students benefit from different approaches. Differences between the Dunn and Dunn model and UDL exist. Both take into consideration the many and varied learning styles of students. However, the UDL approach differs in that curriculum is presented in multimodal formats that are designed to reach multiple learner types simultaneously, as opposed to the more common approach of matching student and instructor learning style. In addition, UDL takes the concept of disability into account when designing curriculum approaches.

Multimedia instruction and teaching approaches that incorporate learning styles can be quite effective when the student and instructional style are appropriately matched. UDL takes instruction one step further in that instruction is designed for multiple learners at one time and inclusion becomes the responsibility of the faculty member. As a teaching methodology, UDL provides inclusive instructional strategies and a socially responsible approach to access for all students.

Progress in STEM Instruction

The literature is replete with examples of effective inquiry-based pedagogy and recommendations for more inclusive teaching. Many of the studies on inquiry-based methods in science instruction, as well as the research in multimedia instruction, learning styles, and UDL, have shown that, when implemented these techniques are effective. Changing the way science is taught in undergraduate education is at the core of national reform efforts. Through memberships in professional organizations, participation in professional development, and funding opportunities to improve curriculum, some faculty have begun to embrace reform efforts (McCormick, 2004). However, despite over 20 years of reform efforts, much of it sparked by the Nation at Risk report, widespread adoption of reformed pedagogy seems to be limited (Peterson, 2003). Students are the key beneficiaries of reform in undergraduate education and their input is essential in determining the effectiveness of current reforms. The following sections report on students' perceptions of progress in STEM pedagogy, as well as on what instructional methodologies faculty in higher education are currently using.

Student Perceptions of Instructional Methodologies in STEM

Reports from students indicate that they continue to perceive science instruction as less than desirable. Two areas of research that looked at student perceptions of instructional methodologies used by STEM faculty are (a) the work of Seymour and Hewitt (1997) on why undergraduates leave the sciences, and (b) the work of Kardash and Wallace (2001) on undergraduate science reform efforts. Both of these studies looked at the undergraduates' experiences and perceptions of science instruction. Seymour and Hewitt conducted a three-year study that was designed to identify the factors that contribute to an undergraduate's decision to leave science, mathematics, and engineering (S. M. E.) majors. They used an ethnographic research design to determine the experience of 335 undergraduates at 7 four-year institutions of different types and locations. Student participants were randomly selected from lists of potential respondents who met the selection criteria. Over a three-year period, data was gathered by personal interviews and focus groups. Findings indicated that poor teaching was the most common complaint mentioned by students, whether or not they switched out of science majors. Over 90% of those that left the sciences and over 73% of those that remained indicated that there were problems with faculty pedagogy. Seymour and Hewitt indicated that students believed that S.M.E. faculty do not like to teach, that they are preoccupied with research, and that they do not value teaching as a professional activity. Students offered many examples of faculty in other disciplines who took the time to teach well but overwhelmingly felt this was not true in the sciences. Students' perceptions about teaching are reflected in the following quote:

> The classes in my new major seem to be about the same size, but there's so much more interaction between the professors and the students. In the math classes it seemed like the professor would just go up to the chalkboard and start doing problems. And when the bell rang, he'd set down the chalk, and he'd never turn around or say anything to the class. (Seymour & Hewitt, p. 147)

Other examples of ineffective pedagogy reported by students include a lack of interaction between students and faculty, a reliance on lecture format, dullness in presentation, and a lack of concern about student learning. Many students in the study found clear differences between S.M.E. faculty and those in other disciplines whom they identified as being more open to discussion, warmer, and more likely to foster independent inquiry. In addition, Seymour and Hewitt indicated that the straight lecture style did not work particularly well for students, regardless of ethnicity or gender. However, students who had attended minority high schools were less likely to have been socialized to anticipate a lecture format and were more likely to have difficulty with it. Female students were similar to males in their criticisms of S.M.E. pedagogy. However, they differed in the way they defined good teachers, in that they were more concerned with the faculty-student relationship; their loss of interest in the discipline seemed to be more closely related to disappointment in faculty as teachers. The findings from Seymour and Hewitt's study provided some important information about student perception in scientific and engineering fields. Although it should be noted that some potential for researcher subjectivity always exists in a qualitative study, the researchers appeared to take precautions against this occurrence. The methods of data collection included using a large sample of randomly selected participants, combining individual interviews and focus groups, and using a range of four-year institutions in different locations. Participants from two-year colleges were not included in the study. The data was analyzed and coded, and dominant themes were identified and categorized. Emergent themes were discussed with participants, faculty, and staff at the participant colleges. Overall, the study appeared to be well designed and produced reliable data about student experiences.

Findings from Kardash and Wallace's (2001) study of undergraduate perceptions of science classes were consistent with those of Seymour and Hewitt. Kardash and Wallace developed a survey instrument, the Perceptions of Science Classes Survey (PSCS), to gather information from a convenience sample of 922 students who were predominantly in the biological sciences. The survey was developed based on the work of researchers in the field and was reviewed by content experts and STEM faculty; it was modified based on their input. The authors did not report any testing that might have been done on the instrument. Findings indicated that students continued to see science instruction as focusing on lecture and on the acquisition of facts. Kardash and Wallace did not address differences based on ethnicity in their study; however, statistically significant gender differences did emerge. Women were more likely than men to view science classes as instructed by faculty who emphasized lecture and memorization. This is particularly troubling in light of Seymour and Hewitt's findings that point to the greater importance women place on the faculty-student relationship and interaction. Both of these studies clearly indicate that from the students' perspective, efforts to reform science instruction have not yet brought about any significant changes. However, both studies had some limitations that should be taken into account. First, both studies were conducted at four-year institutions, and findings cannot be generalized to all types of higher education institutions. Second, only a small number of minority students participated, and in the case of Kardash and Wallace, they were largely Asian American. With such small sample sizes of minority students, it is difficult to obtain accurate comparisons and impossible to generalize to the general population of underrepresented students.

Reports on Undergraduate Instruction

Findings from research on instructional methods implemented since the promotion of science reform are consistent with student reports about their perceptions of faculty pedagogy. Data from the 1999 National Study of Postsecondary Faculty (NCES, 2002b) was used to determine the kinds of instructional practices used in two- and four-year public and private institutions. The study used a sample consisting of 865 institutions and 18,000 faculty members. Results were consistent with the student findings of Seymour and Hewitt, and Kardash and Wallace. The results indicated that lecture/discussion continued to be the predominant method used by full-time (87%) and part-time (78%) faculty. Little variation between institutional type was noted in the study, with percentages for full-time faculty ranging between 85 and 88%. However, there were some differences between faculty members who had different types of degrees. Individuals who held lower degrees (master's or bachelor's) were more likely to use seminars and labs as part of their instructional methods as compared to faculty with a doctoral or professional degree. In addition, there was some variation by field or academic discipline. For example, engineering faculty at four-year doctoral granting institutions reported the highest percentage (91%) of use of a lecture format and the lowest (15%) use of a lab or clinic as compared to their colleagues in other types of institutions. In addition, the use of seminars as an instructional method was reported lowest among business (5%), natural sciences (7%), and engineering faculty. The findings from the NCES survey support the evidence from the student studies, and indicate that science and engineering faculty from a range of institutional types continue to use a more traditional lecture format, with somewhat higher percentages falling in the science and engineering fields. However, the findings should be interpreted with some caution. Data collected on instructional practices was only one small part of a large amount of data collected in the NCES survey. Faculty were only given the opportunity to rate their pedagogy in four categories: lecture/discussion, seminar, lab/clinic, and apprenticeship. The survey instrument did not provide any type of definition of these activities and therefore left room for individual interpretation. The subtle nuances that might relate to the length of time of lecture as compared to discussion was not collected, nor was any information collected on any types of instructional technologies or innovative techniques that might have been used in the classroom. In addition, many of the faculty in engineering and science at four-year institutions reported having graduate assistants. These assistants may have taken over many of the instructional and laboratory activities. Lastly, faculty in two-year colleges represented only about 19% of the total sample and showed some interesting differences that are in need of further exploration. For example, even though lecture/seminar was given equal weight as a primary instructional methodology as compared to other types of institutions, the use of lab/clinic was rated at 36% as compared to four-year non-doctoral institutions at 22% and doctoral institutions at 16%. This may represent some real difference in the type of instruction received at two-year institutions.

Walczyk and Ramsey (2003) conducted one of the few studies on implementation of innovative instructional strategies specifically in science instruction in higher education. They used a survey format to collect data on the use of learner-centered instruction by undergraduate science and mathematics faculty. They constructed the survey to measure the use of learner-centered planning, delivery, and assessment. The Survey of Instructional and Assessment Strategies (SIAS) was designed to gather data on instructional practices. In order to establish content validity the SIAS was reviewed by a panel of eight science and math faculty and three National Science Foundation (NSF) program officers and was modified based on their input. It was administered electronically to all science and mathematics faculty who had email addresses at four-year colleges and universities in Louisiana. A total of 825 surveys were sent with a return rate of 28% (230). It should be noted that a return rate of 28% is small for this type of study, and interpretation of findings should take that into account.

Such a small return rate leads to concerns about reliability and the ability to generalize results. Nevertheless, findings indicated that faculty who had participated in training workshops in learner-centered pedagogy were slightly more likely to plan for learner-centered instruction and to deliver it. Those who plan to use a variety of techniques are more likely to revise their curriculum. However, the researchers concluded that overall, a lecture format dominates higher education science classrooms. These findings were consistent across institution type, with no difference being found in four-year colleges and research institutions. They are also consistent with findings from the NCES (2002b) postsecondary faculty survey and are supported by the student research of Seymour and Hewitt (1997), and Kardash and Wallace (2001).

Overall, the research on instructional methods in postsecondary education indicates that faculty, particularly faculty in science and engineering, continue to rely on a traditional lecture format for instruction regardless of evidence that indicates students will be more satisfied with their learning and achieve more with learner-centered approaches. Despite research in learning and diverse populations, feedback from those who have implemented UDL, and evidence for improved student satisfaction and learning in reformed science pedagogical practices, faculty have not, for the most part, embraced these innovative technologies. However, it is important to note that the concentration of the research has been conducted at the college and university level, with very little focus on two-year colleges. The absence of research in two-year colleges is noteworthy for several reasons. First, one of the defining characteristics of the community college is its vision of itself as a teaching college (Grubb, 1999). Therefore, one might speculate that there would be a greater interest in innovative teaching strategies. Second, two-year colleges tend to have higher percentages of students who are women, minorities, and persons with disabilities (NCES, 2000). Research has indicated that these are the students who could most benefit from innovative instruction. Third, nearly one half of all undergraduates with disabilities are enrolled in two-year colleges (NCES, 2000), indicating a greater need and perhaps a greater demand for pedagogical methods that will effectively reach these students. The available literature does not tell us much about the possible implementation of reformed practices in community colleges. However, the literature does suggest that there are considerable obstacles to implementing these instructional changes in higher education in general.

Identification of Barriers for Adopting Reformed Pedagogy

With reformed science instruction and UDL, we now have expanded pedagogical tools to reach a wide range of different types of students. Yet, innovative, inquiry-based, and UDL pedagogical strategies essentially remain underutilized (Peterson, 2003; Walczyk and Ramsey, 2003; NCES, 2002b). The reasons for reliance on traditional instruction as opposed to adoption of reformed practices are multiple and complex.

Silver, Bourke, and Strehorn (1997) conducted one of the few studies designed to identify barriers to the adoption of UDL. They had previously conducted considerable research in the theoretical constructs of UD and believed that the adoption of UD approaches would significantly reduce reliance on secondary support systems for students with disabilities. Such support systems are often cumbersome, lack timeliness, and place a burden on students. Their research was conducted at the University of Massachusetts and was primarily qualitative in nature. They used a focus group format to gather information from approximately 100 faculty concerning perceptions about Universal Instructional Design and its implementation in higher education. Faculty in their study reported that they believed that there is a resistance to change, that in general universities tend to maintain the status quo. They noted that change within the university is very difficult. Time was also noted as a crucial factor in adopting new approaches. Faculty felt that the initial phases of planning and implementing UD would be very time-consuming and that many faculty members would not be willing to invest in this kind of change. Attitudinal barriers such as "gate-keeping" and "feeling that some people don't belong" were also identified as barriers. In addition, faculty in the study noted that professors are not trained to teach, and therefore lack awareness and knowledge about new pedagogical methods and diverse learning styles. Silver, Bourke, and Strehorn's study is one of the few sources of literature on the barriers to implementing UD. However, the study has several deficiencies that should be noted. First, faculty participants were chosen from a list of faculty and friends that was maintained by the college's Learning Disabilities Support Services (LDSS). The group had worked closely with the disabilities office and this may have influenced their perceptions. Second, although the group represented many disciplines, their affiliation with LDSS suggests that they may not have been representative of other faculty. Third, no information is provided as to whether or not this group of faculty has any experience or knowledge about inclusive practices or whether they are speaking from a purely hypothetical perspective. Fourth, the method used for data collection was strictly qualitative and while it provides a useful starting point it is not triangulated with any other source of data.

Nevertheless, other authors agree with some of Silver, Bourke, and Strehorn's findings. For example, Jensen, McCrary, Krampe and Cooper, (2004) believe that most college faculty teach the way they were taught and consider the techniques used by their professors to be appropriate for college-level work. Faculty are educated in their discipline, and for the most part, do not have exposure to or knowledge of pedagogical techniques (Sunal, Hodges, Sunal, Whitaker, Freeman, Edwards, & Johnston, 2001). Therefore, they are inclined to believe that what worked for them will work for all students. Many of these faculty members are working from the assumption that the curriculum, student representation, and diversity are essentially unrelated. According to Smith (1997), this belief results from the certainty that the discipline, not the student, should define the curriculum. While to a certain extent different curriculums require different approaches, this belief separates the curriculum as a discipline based entity and does not take into account the approach or strategies used to assist students in learning the discipline-based material. Moreover, as Smith indicates, today's students are more pluralistic, and today's classrooms may be very different from those experienced by many professors.

In addition to beliefs about teaching, the assumptions faculty make about who can learn and how students learn is critical. Campbell (2002) believes that the assumptions made about who can or cannot learn are at the root of our nation's problem in delivering science education. He believes that the most fundamental assumption, held by many scientists, is that there is a measurable innate intelligence that is determined at birth and nothing can be done to change it. In his view, this belief contributes to ability grouping that is used "consciously or subconsciously, as a mechanism to perpetuate racial and economic class segregation in higher education too" (p.26). These beliefs would also contribute to a faculty member's unwillingness to adopt instructional approaches to reach a wider range of diverse students. In addition, the belief about how students learn can be critical. There is considerable debate about what constitutes learning and what causes learning to take place (Blackburn & Lawrence, 1995). Some faculty believe that students learn through memorization and the acquisition of facts, while others believe that learning occurs best when students are actively engaged in the process (Grubb, 1999). The range of beliefs about learning impacts the manner in which one teaches, as well as the willingness to adopt innovative strategies.

Sunal et al. (2001) focused their research on understanding the change process necessary for successful university science reform. They used surveys, questionnaires, and interviews to determine the effects of a faculty development model. The 75 faculty participants were from 30 institutions, from 26 states representing all regions of the United States, and a range of research, comprehensive and baccalaureate institutions. All participants had been part of a training model designed to improve instruction practices. The researchers found that beliefs about learning, knowledge of pedagogy, and exposure to innovative course design were critical to successful adoption of innovative methodologies. Faculty in the study who described themselves as facilitators of learning were much more likely to implement innovative course changes, as compared to faculty who described themselves as disseminators of the discipline, lecturers, or information providers. Faculty beliefs about their teaching role as well as about student learning impacted their willingness to adopt more reformed methods. In addition, they found that "change will not occur unless faculty experience dissatisfaction with their existing conceptions of science teaching" (p. 254). Therefore, perceptions and awareness of the need for change are important to the process of adopting any reformed instructional practices.

Even when awareness and desire to change are present, a number of variables still impact whether or not actual implementation of inclusive practices will occur. Bianchini, Whitney, Brenton, and Hilton-Brown (1999) examined the kinds of constraints encountered by faculty as they attempted to provide more inclusive science instruction. They used questionnaires and interviews to investigate the views of 18 science faculty from a large urban university who had been involved in a project to reform science instruction. Faculty in the study reported a number of obstacles. Among them were large class size, lack of time and resources to research and create inclusive curriculum, lack of time to cover required material, and constraints placed on them by university and discipline related requirements. Some faculty, for example, taught in large classes of 100 or more students and felt it was difficult in such an environment to do anything but a more traditional presentation or lecture. In addition, the time pressures associated with creating new curriculum increased faculty workload and became difficult in light of other university responsibilities, such as research. Time was also an issue for faculty who felt that using innovative strategies restricted their ability to cover the amount of material required by their university or discipline. The researchers in this study also noted that, in order for reform efforts to be successful, institutional support is needed. Factors such as class size, instructor course loads, and financial and instructional support are all part of the university structure and are administrative factors outside the control of individual faculty. These factors also can be significant barriers to the adoption of innovative pedagogical approaches. These findings are consistent with those of Silver, Bourke, and Strehorn (1997) who stated in their conclusion that "the entire University must be viewed as part of the process. Acceptance of students with diverse learning needs must be part of the transformation in order for UID to be successful" (p.50). In order for reformed teaching practices, and specifically Universal Instructional Design to be incorporated into college instruction, mainstream campus environments will need transformation of existing organizational structures and academic processes (Berger & Van Thanh, 2004). Until this occurs, the campus environment itself may represent a barrier to the adoption of reformed or innovative methods.

These studies provide critical information about the barriers associated with adopting innovative curriculums. However, some cautions, differences, and additional questions arise out of the findings. First, it should be noted that the actual type of innovation being studied differs in each of the three studies. Silver, Bourke, and Strehorn studied Universal Instructional Design, while Bianchini, Whitney, Brenton, and Hilton-Brown studied inclusive instruction specifically as it relates to gender and ethnicity; and Sunal et al. examined faculty who had participated in specific reformed science practice training. Despite these differences, barriers identified between the three studies are surprisingly similar. First, faculty may find any innovative practice difficult to implement. Second, all three of the studies had participants who had some knowledge and exposure to the innovation being studied. Faculty who have little or no knowledge of pedagogy and reformed practices may have very different responses. Third, all of the reported research took place in four-year institutions. Barriers to implementation may be very different in the community college setting. The research does not provide us with answers that specifically relate to how, or even if, reformed or innovative practices are being used in the community college.

Basis for Further Research

A review of the available literature indicates a need for reformed science instruction, particularly for diverse populations and specifically for students with disabilities. When utilized these reformed practices have been shown to be effective in improving both student perception about STEM and student achievement (Bleicher, Romance & Haky, 2002; Kenyon, 2003; Lawson, 2002; Oliver-Hoyo, Allen, & Anderson 2004; Reeve, Hammond & Bradshaw, 2004). Yet, research has shown that widespread adoption of these approaches has not occurred (Peterson, 2003; Walczyk & Ramsey, 2003; NCES, 2002b; Kardash & Wallace, 2001; Seymour & Hewitt, 1997). The majority of the research conducted was done at four-year colleges. Thus, very little information is available concerning adoption and implementation of reformed practices or UDL in community colleges, which enroll the greatest diversity and numbers of students with disabilities. In addition, very little research has been conducted that relates specifically to students with disabilities in STEM disciplines, and more specifically to students with disabilities in STEM in the community college setting.

Research has shown that, among faculty at four-year institutions, a number of practical, attitudinal, and environmental barriers exist that prohibit the adoption of innovative and inclusive pedagogy (Silver, Bourke, & Strehorn, 1997; Jensen, McCrary, Krampe & Cooper, 2004; Sunal, et al., 2001). Barriers such as class size, time, assumptions about teaching and learning, knowledge about pedagogy, and college resources and supports, all have significant impact on teaching. These are real and practical considerations that impact STEM pedagogy. We can speculate that community college faculty may indeed face similar barriers. However, the focus on teaching in the two-year college, the differences in responsibilities between two- and four-year faculty, and the differences in the types of students enrolled may all serve to create a very different pedagogical environment. The review of literature supports the need for additional research in the area of inclusive pedagogy in STEM, particularly in two-year colleges. The development of a conceptual model and a description of the research design, analysis, and findings are detailed in the next chapters.

CHAPTER 3

METHODOLOGY

Overview

Chapter 3 presents a framework for the research. The chapter begins with a review of the conceptual framework and presents a model for the design of the research study. The design of the research study, data collection, and data analysis methods are also described in detail.

Conceptual Framework

The conceptual framework presented here is directly derived from the literature reviewed in the previous sections. As previously indicated, there is a notable lack of participation in postsecondary STEM programs by individuals with disabilities (NSF, 2000, 2004). The review of the literature has shown that a contributing factor to this low participation is the presence of significant barriers to accessing higher education STEM programs by students with disabilities. These barriers include negative attitudes, limited access to technology and the curriculum, and current STEM pedagogical practices (Burgstahler, 1994; Seymour & Hunter, 1998; Stefanich & Norman, 1999; NSF, 2000).

As noted in the literature, the social theory perspective as put forth by Hahn (1999) allows us to think about disability in a new way. The social theory model defines disability in relation to the environment, and places individuals with disabilities on a continuum of diverse learners with varying abilities and disabilities. The movement to a social theory model creates a shift to a social responsibility perspective within which we all have a responsibility for promoting inclusion.

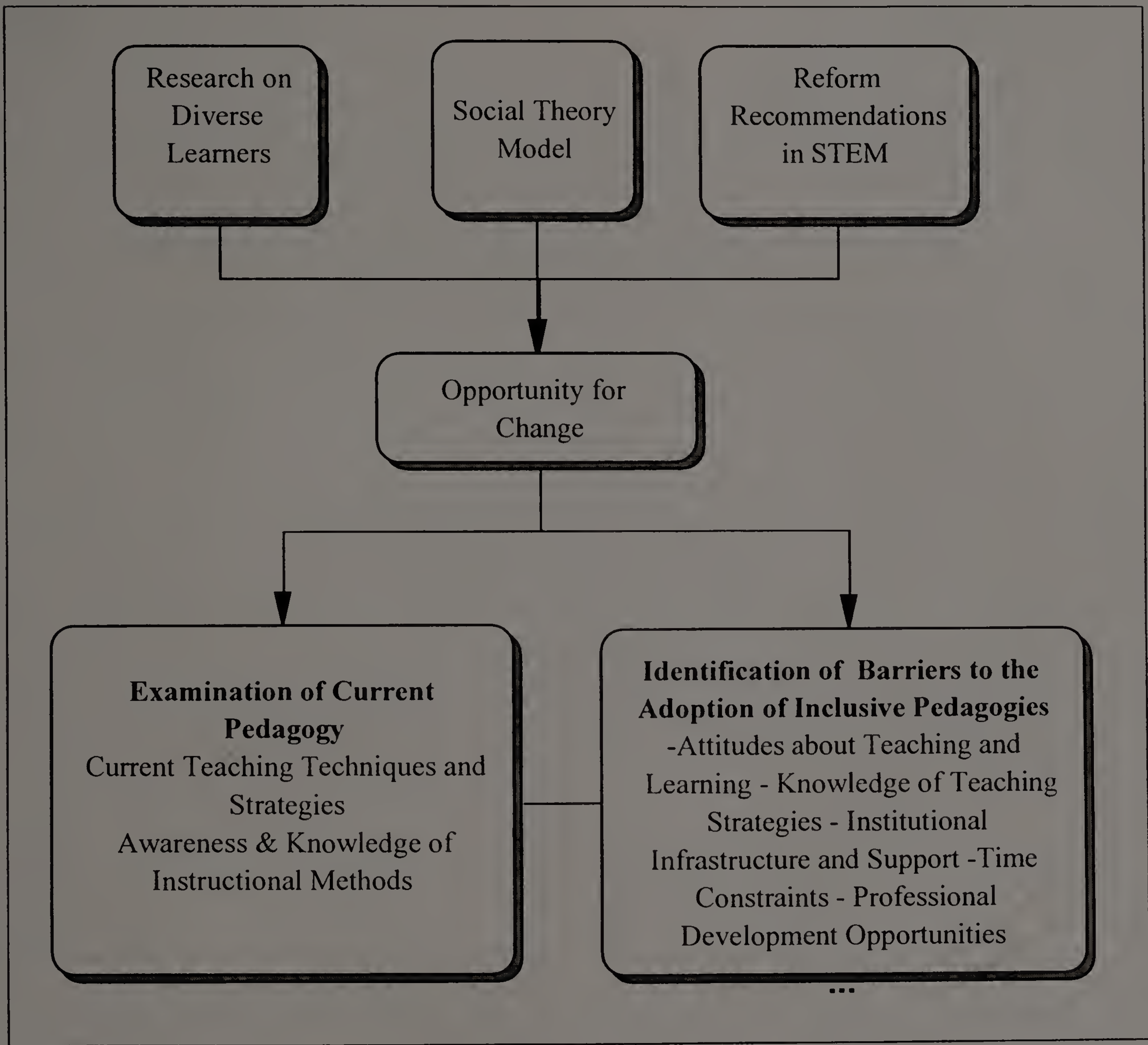
When we begin to view disability within a social theory context, it allows for an opportunity to explore how changes in the classroom environment might impact the experience of students with disabilities. When we view instruction in light of contemporary educational research on diverse learners, learning style, and brain-based learning, the pedagogical approach shifts to one that is more inclusive of all learners. As reviewed in the literature, Gardner's (1999) research on multiple intelligences, Rose and Meyer's (2002) review of brain research and Universal Design for Learning, research in learning style differences (Dunn, Griggs, Olson, Beasley, & Gorman 2001; Sarisin, 1999; Kolb, 1984), and constructivist theory in science instruction (Taylor, Gilmer & Tobin, 2002) all point to the need for change in postsecondary instruction to meet the needs of a range of different types of learners, including students with disabilities.

In response to the call for changes in instruction a number of reformed, inquiry-based, and inclusive curriculum approaches have been recommended in STEM and shown to be effective when implemented (Bleicher, Romance & Haky, 2002; Lawson, 2002; Brothen & Wambash, 2003; Miksch, 2003; Oliver-Hoyo, Allen, & Anderson 2004). However, research has shown that adoption of these approaches is not widespread; and in fact, most instruction continues to be quite traditional, particularly in the sciences (NCES, 2002b; Walczyk & Ramsey, 2003).

As previously indicated, existing research, while limited, has shown that a number of barriers exist that prohibit the adoption of innovative and inclusive pedagogy (Silver, Bourke, & Strehorn, 1997; Jensen, McCrary, Krampe & Cooper, 2004; Sunal, et al., 2001). Barriers have been identified in a number of areas but for the sake of clarity can be grouped into two main categories, personal and environmental. Personal barriers are related to attitudes and beliefs about teaching and learning, attitudes about students, and discomfort and unfamiliarity with new pedagogy. Environmental barriers are related to institutional infrastructure and support, administrative demands, discipline related and course load time constraints, and limited professional development opportunities. The review of literature has revealed a number of omissions and deficiencies in the research that relates to barriers. Of particular importance to this is research is the fact that existing research on barriers to implementation of inclusive pedagogy has only been conducted at the four-year college level. Although we can speculate that similarities may exist, there are significant differences between the two and four-year environments that necessitate further investigation.

The model presented in Figure 1 is a visual representation of the conceptual framework and rationale for the research.

Figure 1 - Conceptual Framework Model



The top of the model represents the background literature on the social theory model of disability, the research on diverse learners, and the recommendations for more inclusive pedagogies in STEM. The review of literature clearly indicates a need for change in instructional practices and points to the potential benefits of more inclusive pedagogy for all students, including students with disabilities. The research questions, which are described in greater detail in the next section, are a means for identifying current practices and barriers to implementing more inclusive pedagogies by community college STEM faculty. Research has shown that, when implemented, inclusive pedagogies have a positive impact on students (Bleicher, Romance & Haky, 2002; Lawson, 2002; Brothen & Wambash, 2003; Miksch, 2003; Oliver-Hoyo, Allen, & Anderson 2004), and the potential benefits for recipients could be enormous.

Research Questions

The purpose of this study is to identify barriers to the adoption of inclusive and reformed pedagogy by community college STEM faculty. The following questions form the basis of this study.

1. What are the current teaching styles and methods of curriculum delivery used by community college STEM faculty?
2. What are the levels of awareness and knowledge of community college STEM faculty about inclusive teaching practices?
3. What are the personal, attitudinal, and environmental factors that inhibit community college STEM faculty from using inclusive pedagogical practices to serve students with disabilities and other diverse learners?

Research Design

A multi-site case study method was used to collect data and explore the teaching practices, perceptions, and barriers to the adoption of inclusive pedagogy by community college STEM faculty. Yin (2003) indicates that case study research is appropriate when, "the boundaries between phenomenon and context are not clearly evident" (p. 13), and when multiple sources of evidence are needed in order to effectively study a complex phenomenon. In other words, the case study method is useful when the context and phenomenon are intertwined, and when both are considered critical to addressing the research question. Multiple sources of evidence allow the researcher the benefit of looking at the phenomenon from different angles and sources. The case study method is used to seek understanding of a larger phenomenon through close examination of a specific case (Rossman & Rallis, 2003). The case study is a method of inquiry that seeks an in-depth exploration of a single unit or case in order to gain insight and understanding (Merriam, 1998). In this study, the case is defined as community college STEM faculty from a selected region in the Northeast. The use of a case study method in this study is particularly important in order to take a close look at teaching practices within the context of the community college. The method uses multiple sources of evidence that provide an overview of practices and an in-depth understanding of barriers to implementing inclusive pedagogy in the community college setting.

Consistent with the case study approach, I sought an in-depth understanding of community college STEM faculty from three selected community colleges in western Massachusetts. Questionnaire, interviews, observations, and document analyses were used as methods of data collection. The use of multiple data collection methods provides triangulation and helps to ensure that the researcher looks at the phenomenon and context to the fullest extent possible (Rossman & Rallis, 2003). According to Merriam (2003), the use of triangulation and multiple methods of data collection and analysis strengthen reliability as well as external validity of a qualitative study. Data were collected in a sequential manner. Using the sequential method as described by Creswell (2003), the researcher seeks to elaborate on the findings from one method by using another method. In this case, a quantitative method was used to gain a broad overview, followed by a qualitative method involving a smaller group to gain a more detailed perspective. The integration of all data collected occurred in the final analysis phase.

Site and Participant Selection

Three community colleges in western Massachusetts were selected for the multi-site case study. The colleges were Greenfield Community College (GCC), Holyoke Community College (HCC) and Springfield Technical Community College (STCC). Greenfield Community College has 13 degree or certificate programs that fit into the STEM classification and approximately 28 STEM faculty members. Holyoke Community College has 38 degree or certificate programs and 76 STEM faculty. Springfield Technical Community College has 45 degree or certificate programs that would fit into the STEM classification and approximately 107 instructors teaching in these disciplines.

The three institutions combined allowed for a purposeful sample of approximately 211 full and part-time instructors from STEM disciplines. Johnson and Christensen (2004) define purposeful or purposive sampling as the process used when cases are selected because they provide information needed to address the research question. The target population consisted of all STEM faculty at the three institutions and the high response rate (72%) almost qualifies the data as census. The 211 STEM faculty members made up the sample for the questionnaire portion of the research. In addition, eleven faculty members from different STEM disciplines were selected for interviews and nine for observations. One of the eleven interviewed faculty members taught online and could not be observed and one faculty member declined to be observed. The interview sample consisted of faculty members who teach Anatomy and Physiology, Biology, Physics, Chemistry, Developmental Mathematics, Calculus, Computer Information Systems and Engineering. Five faculty members were from HCC and six were from GCC. Of these, one faculty member teaches online. Six of the faculty members were male and five were female. Selection criteria for the qualitative portion of the study included, full-time teaching status, a minimum of three years teaching, and a willingness to participate in interviews and observations. The selection criteria were designed to ensure that interview participants had enough experience to be able to effectively respond to the research questions. A total of 41 instructors met these criteria, and of them 11agreed to be interviewed. HCC and GCC were used as sites for the qualitative portion of the study because the researcher is employed at STCC and known by many of the STEM faculty. In order to minimize bias STCC was only used as a questionnaire site.

Data Collection

Survey Instrument

A questionnaire was developed to collect data about the instructional techniques, teaching approaches, and barriers to the adoption of inclusive pedagogy by community college STEM faculty. The instrument was specifically designed for the study and was, in part, a modification of several questionnaires used in similar studies. Stefanich and Norman's (1999) survey of faculty attitudes, Walczyk and Ramsey's (2003) survey of innovative instructional practices in science instruction, and Sunal, Hodges, Sunal, Whitaker, Freeman, Johnson and Odell's (2001) survey of faculty inquiry-based teaching practices were used as models for item selection. Research on the barriers to implementing inclusive pedagogy in four-year colleges was also used to develop questionnaire items.

The questionnaire (included in Appendix A) was designed to address the research questions and elicited information on demographics, instructional practices, knowledge of pedagogical approaches, interest in adopting inclusive and innovative strategies, and barriers to the adoption of inclusive approaches. The demographics section was designed to gather background characteristics that were necessary for data analysis and included: subject area taught, number of years teaching, full or part-time status, number of classes taught per semester, gender, race/ethnicity, and highest degree obtained.

Instructional practices in this context were defined as the techniques by which content is delivered to students and the manner in which learning is facilitated. Items were designed from the research based on Universal Design for Learning (Rose & Meyer, 2002; Scott, McGuire & Shaw, 2003) and from the work of Walczyk and Ramsey (2003) on learner-centered instruction and inquiry-based learning. Walczyk and Ramsey developed the Survey of Instructional and Assessment Strategies (SIAS) to gather data on instructional practices. Content validity and internal consistency were determined and found adequate for the SIAS (Walczyk & Ramsey, 2003).

Pedagogical approaches were defined as a model that is built on philosophical underpinnings or learning theory and includes accompanying strategies for teaching and learning. Approaches mentioned in the questionnaire were limited to those directly relating to the research on Universal Design for Learning, and inclusive and reformed

STEM instruction. Each approach was briefly defined in the questionnaire. Items used to assess interest in and barriers to the adoption of inclusive pedagogy were based on the research and drawn from three main sources: (a) barriers identified in studies on faculty from four-year colleges listed in the review of literature (b) a survey used by Stefanich and Norman (1996) that was developed by the Committee for the Inclusion of Challenged Populations of the Association Education of Teachers in Science (AETS) in 1994 and used to identify faculty attitudes about teaching students with disabilities, and (c) a questionnaire used by Sunal et.al (2001) in their study of faculty barriers to change. Sunal et al. used a modified version of the Science Teaching Efficacy Belief Instrument (STEBI) developed by Enochs and Riggs in 1990. The STEBI was used to determine faculty beliefs about their ability to teach and impact students and was shown to have a test-retest reliability of 0.83. The barriers identified in the questionnaire were grouped into two main categories, personal and environmental. Personal barriers were related to attitudes and beliefs about teaching and learning, attitudes about students, and discomfort and unfamiliarity with techniques and technology. Environmental barriers concerned institutional infrastructure and support, administrative, discipline related and course load time constraints, and lack of professional development opportunities.

The questionnaire was self-administered via a website, was cross-sectional, and contained many items that were based on a Likert scale. The Likert scale is a summated rating scale in which several items are used to measure the same construct. The items on surveys used in the development of the questionnaire used a Likert scale, and Likert items generally are considered easy for respondents to understand (Patten, 2001). In addition, according to Johnson and Christensen (2004), Likert scales provide a more consistent score that helps the researcher to make distinctions between participants.

A questionnaire data collection method is considered to be advantageous for several reasons. It is an efficient method of data collection; responses are usually easy to tabulate; and it is economical as compared to other forms of data collection (Patten, 2001). The instrument was formally pilot tested in May of 2005 with a group of twelve health division faculty at Springfield Technical Community College and modifications were made based on their input and responses.

Following the pilot test and modification the questionnaire was administered electronically to 211 STEM faculty members currently working at the three community colleges. The web survey was administered in a manner that ensured the confidentiality of all participants. A series of reminder email messages, phone calls, and postcard reminders were sent in order to obtain a high response rate. The initial survey was sent on May 25, 2005, and follow-up email, phone and mail reminders were sent on June1, 2005, June 8, 2005, June 15, 2005, July 6, 2005 and July 25, 2005. The survey return rate was 72% (N = 152). Sixteen percent of respondents were from GCC, 32% were from HCC and 52% were from STCC. The response rate for GCC was 85% (N =24), HCC, 48% (N=48) and STCC 74% (N=80). Respondents were nearly equal in gender with 49%reported as male, 50%fifty percent as female, and 1% percent not reported. Faculty ages ranged from 20 to 65, with 70% reporting ages between 41 and 60. Science faculty represented 40%of the respondents, technology 24%, engineering 11%, and mathematics 25%. Ninety-two percent of respondents were White or Caucasian with only 4% Asian, 1%Hispanic or Latino/a, and 3% listed as other. Fifty- seven percent of respondents were listed as full-time faculty and 42% reported part-time status. The majority of faculty (66%) holds a Master or Doctorate (25%) degree, with only small percentages of respondents reporting an Associates (2%) or Bachelors (7%) degree. The three campuses are very different in terms of size, geographic location, and academic focus. Despite these differences the overall demographics of faculty are very similar indicating a greater level of confidence in the generalizability of results. Faculty respondents reported a wide range of numbers of students with disabilities in their classes over the last four semesters. The largest reported number was sixty students with disabilities. The majority reported between four and eight students and 20% reported having no students with known disabilities in their classes.

Interviews and Observations

In addition to the quantitative method, a qualitative method was used to obtain more in-depth information regarding instructional practices, beliefs, and barriers to implementing inclusive practices. Selection of STEM interviewees from HCC and GCC was done randomly by email. The participating institutions provided email addresses of all STEM faculty. Forty-one faculty members representing a range of STEM disciplines were selected and sent emails requesting their participation in the study. The final qualitative sample consisted of eleven faculty who agreed to be interviewed, nine of whom were also observed in the classroom setting.

Each of the eleven faculty participants was formally interviewed for approximately one hour. Consistent with the emergent nature of a qualitative study, faculty interviews were semi-structured to provide for adaptation as the study developed. Initial questions were designed to reflect the research questions. They fall into three categories: questions about teaching methods and strategies, questions about attitudes and perceptions, and questions about barriers to implementing inclusive instruction. Questions had been reviewed by a panel of three STEM faculty members prior to the commencement of the qualitative portion of the study and were modified based on their input. All interviews were audio taped and transcribed. (See Appendix B for a copy of the interview guide).

Nine of the eleven participants who were interviewed were observed in the classroom in order to gain additional information about teaching techniques. One faculty member taught online and although access to her website was provided, observation was not possible. One faculty member declined to be observed. Observations served primarily as a source of data triangulation and verification. An observation guide was developed based on the following: an observation checklist compiled by Merriam (1998), the Reformed Teaching Observational Protocol (RTOP) developed at the University of Arizona (Lawson, 2002), and the STEMTEC – Core Evaluation Classroom Observational Protocol adopted by Berger (Sireci, Zanetti, Slater, & Berger, 2001). The observation instruments were modified to include observation criteria that relates to Universal Design for Learning. Observations were guided by the research questions and focused on the physical setting, faculty activities and interactions, and specific techniques used in the classroom. (See Appendix C for a copy of the observation protocol).

In addition, document analysis of materials such as class syllabi, handouts, supplemental materials, faculty web pages, CDs and other electronic documents were reviewed to determine whether or not they would be accessible to students with disabilities. A checklist indicating the type of material or technology used and whether or not it would be accessible to a range of different users was used to gain a basic measure of accessibility. Accessibility as it relates to vision, hearing, and mobility was the primary consideration

Field notes were maintained for all observations and documents analyzed. The use of qualitative methods to obtain data allows for an opportunity to obtain in-depth, detailed information that could not be obtained from quantitative methods. The combined use of qualitative and quantitative data collection methods in this study provided for greater depth and a broader empirical perspective at the same time.

Data Measurement and Analysis

Quantitative data analysis was used to evaluate data collected through the questionnaires. Questionnaire responses were recorded in Microsoft Excel and analyzed using the SPSS statistical software. A number of statistical methods were used to analyze data. Factor analysis was used to discover patterns in the relationships among variables and to reduce data to a manageable form. In order to answer the research questions descriptive statistics and frequencies were calculated for each variable and correlations among variables were determined. Multiple regression analysis was used to determine the relationships between the dependent and independent variables.

Qualitative analysis of data was ongoing and began with designing of the research questions and conducting the initial interview. Rossman and Rallis (2003) believe that analysis begins at this conceptualization phase and that it should be ongoing throughout the course of the study. Data were collected from interviews, observations, questionnaires and related artifacts. As interviews and observations were completed, they were carefully transcribed and analyzed. Each transcript and field note was individually analyzed, important sections underlined, comments written; and data were coded for categories that relate to the research questions. The constant comparative method developed by Glaser and Strauss (1967) was used to analyze data. This method encourages the gradual development of categories, subcategories and themes through a process of analysis that begins with the initial collection of data. The data were broken down and sorted into categories and subcategories that were used for theme development. Taxonomical analysis developed by Spradley (1980) was used as a method of analyzing the meaning and relationships between categories and subcategories. Final data analysis integrated data collected from questionnaires, interviews, observations, and document analysis.

Limitations

One of the major limitations in this type of study relates to the complex nature of disability. As previously indicated, educators may hold different sets of beliefs about different types of disabilities. Therefore, there is a possibility that instructors may have different beliefs about teaching students with different disabilities. For example, an instructor may be more positively inclined to work with a student with a physical disability rather than one with learning disabilities. However, the focus of this study is on instruction and so it is outside the scope of this study to explore the relationship of instruction as it applies to students with different types of disabilities. A second limitation relates to the selection process for the qualitative portion of the study. Selection of STEM interviewees from HCC and GCC was done randomly by email. However, it should be noted that it is likely that those faculty who responded to the request were most likely those who were interested in the topic of inclusive pedagogy. The effect of this self-selection is minimized through triangulation of questionnaire, interview, and observation data.

In addition, there are two major limitations specific to the case study method. First, the case study method is context dependent; and as such, conclusions cannot be generalized to other situations (Rossman & Rallis, 2003). Therefore, we cannot conclude that findings from this study will necessarily apply to other community colleges' faculty. However, Rossman and Rallis also point out that when a case is seen as sufficiently similar to another we can logically reason that some findings might apply to those situations. Therefore, there is some transferable knowledge that may be useful in other settings. In addition, findings from the case study can be used to formulate the direction for broader studies that include larger samples of the population. Second, the case study is considered to be interpretive research (Creswell, 2003). As such, there is a danger of results being impacted by researcher bias or subjectivity (Merriam, 1998). However, maintaining rigor in data collection and analysis, as well as obtaining ongoing feedback from other professionals, can minimize the effect of researcher subjectivity. Rossman and Rallis (2003) recommend a number of strategies for insuring that a study is credible and rigorous. Among the strategies that were employed are audit trails documenting the process of gathering, analyzing, and interpreting data, member checks for participant verification, and the use of multiple methods of data collection and analysis.

Conclusion

This study is a step in closing the research gap that relates to inclusive pedagogy in STEM at community colleges. It is designed as a case study that explores the teaching practices and barriers to implementing reformed or inclusive teaching at three community colleges. Data were collected utilizing a questionnaire, interviews, observations, and document analysis. The final analysis integrates findings from all data collection sources. Findings from this study will contribute to the research base and provide information on inclusive pedagogy to faculty, professional development experts, and community college administrators. Improvement in pedagogical practices is important to the satisfaction of all STEM students, but it is critical to the enrollment, persistence, and success of students with disabilities in postsecondary education.

CHAPTER 4

QUANTITATIVE DATA ANALYSIS AND RESULTS

Overview

This chapter describes the results of the data analysis for the quantitative portion of the study. A combination of descriptive and multivariate statistics was used to gain a more complete picture of instructional practices and beliefs of community college STEM faculty and to identify barriers to the adoption of inclusive pedagogies. The chapter is divided into three main sections. The first section describes the construction of factor analysis scales and reports on dimensions of instructional practice, attitudes and beliefs, and pedagogical practices. Factor analysis was used as a method of constructing latent measures of the dimensions of instructional practices, beliefs, and approaches. The second section summarizes the descriptive statistics and compares means and standard deviations for practices, beliefs, and environmental variables. The final section describes the correlational relationships for all of the variables used in subsequent quantitative analysis. The final section also includes a report on the results of the multiple regression analysis that was used to explore the relationship between the independent and dependent variables.

Factor Analysis

Key variables of interest in this study include questionnaire items that relate to instructional practices, knowledge about pedagogical approaches, and attitudes and beliefs about teaching and learning. In order to develop a more meaningful set of indicators, factor analysis was used to group questionnaire items into related scales. Exploratory factor analysis was used as a method to determine clusters of interrelated data and to define patterns of common variation within the set of questionnaire variables. According to Kim and Mueller (1978), factor analysis is an expedient way to determine the minimum number of factors that account for the covariation, and is used as a means to explore the data for data reduction. Factor analysis is a technique used to identify common patterns and associations that can be used to group many variables into groupings that maximize in-group commonality and between-group variability. This type of analysis generates factor loadings that indicate the strength of the association that each variable has with a larger group of variables. Once the factor analysis has been completed, alpha reliabilities are used to show the collective strength of the association for all the variables in that grouping. Each of the three variable categories derived from the questionnaire data were analyzed. Instructional practices consisted of 26 items, beliefs about teaching and learning consisted of 28 items, and knowledge about pedagogical approaches consisted of 7 items. The items used in the exploratory factor analysis were rotated orthogonally, using the varimax method, resulting in variable dimensions within each category. Some items were dropped as the result of conducting a reliability analysis using Chronbach's alpha to determine strength of reliable association among grouped variables.

Dimensions of Instructional Practices

The conceptual framework outlined in chapter 3 specifically points to the need for an examination of current pedagogy in STEM instruction. The combined dimensions of instructional practices identified through factor analysis revealed five scales, each of which relate to specific practices used in community college STEM classrooms. These five scales account for 52% of the variance. Chronbach's alpha reliability was used to determine reliability of each scale. Table 2 shows the factor loading and reliability for each scale.

Table 2
Results of Factor Analysis for Dimensions of Instructional Practices

Factor Names and Items	Factor Loading
Technology Utilization	
Provide handouts and other print material in an electronic format	.861
Provide the class syllabus to students in an electronic format	.795
Use technology (computer software or programs) in the class to enhance instruction	.710
Use computer-assisted instruction (tutorial, or simulation activities offered as a supplement to traditional, teacher directed instruction)	.623
Have students communicate online in chats or discussion forums	.561
Use multimedia (the combined use of text, graphics, animation, pictures, video and sound to present information)	.538
Alpha Reliability	**.826**
Varied Presentation Strategies	
Explain the same material in multiple ways (lecture, demonstration, activities, discussion)	.741
Use manipulatives (hands-on instructional aids) in class	.683
Alpha Reliability	.588
Interactive Learning	
Have students form discussion groups during class	.760
Have students work on problem solving projects during class	.749
Alpha Reliability	.714
Student Engagement	
Use an engaging problem, question, or unusual fact in order to gain student interest	.710
Spend time in class having students discuss the concepts they are learning	.644
Use techniques (pretests, surveys, discussion) to determine what students know when introducing new concepts	.537
Have students form discussion groups outside of class	.398
Alpha Reliability	.629
Diversified Instruction	
Provide students with a written plan of what is to be covered in class each day	.725
Provide outlines and cues for students with different abilities	.543
Perform assessment of student learning styles or preferences at least once per semester	.464
Alpha Reliability	.563

Table 2 (Continued)
Results of Factor Analysis for Dimensions of Instructional Practices

Individual Items
Traditional Teaching
Spend the entire class period primarily in a lecture format
Alternative Assessment
Provide alternatives during the semester in the way students express what they know (portfolios, exams, projects, presentations)

The technology utilization scale has six items and describes ways in which technology is used to enhance instruction. The varied presentation strategies scale has two items and describes techniques that are used to reach different types of learners. The interactive learning scale has two items and relates to ways in which faculty have students participate in the class. The student engagement scale has four items and describes ways in which student interest and connection to learning is fostered. The diversified instruction scale is comprised of three items that relate to specific techniques that might be used for learners with different abilities or learning preferences.

In addition to the dimensions of instructional practice, two additional single items are included. The two items are not grouped because the reliability analysis did not show a reliable relationship to other variables. However, as single items the issues that they address are central to the research question about instructional practices. These variables relate to traditional methods of instruction and assessment and to the discussion of traditional vs. innovative instruction in chapter 3. The single variables are also listed in Table 2 and will be used as single item indicators in subsequent analysis.

Dimensions of Knowledge of Pedagogical Approaches

As indicated in the conceptual framework, it is important to understand faculty awareness and knowledge about pedagogical approaches in order to effectively assess the adoption of and barriers to the adoption of inclusive pedagogy. Factor analysis yielded one dimension scale that is listed in Table 3 along with the factor loadings and alpha reliability. The dimension of knowledge of pedagogical approaches is made up of six of the seven items within this category and depicts common innovative instructional approaches. One additional instructional approach, multimedia instruction did not show a significant relationship to the other approaches and will therefore be used as a single item indicator in subsequent analysis. Pedagogical variety and multimedia instruction accounted for 63% of the variance in this category.

Table 3
Results of Factor Analysis for Knowledge of Pedagogical Approaches

Factor Names and Items	Factor Loading
Pedagogical Variety	
Learner-Centered Instruction	.795
Cooperative Learning	.752
Inquiry-Based Learning	.718
Active Learning	.715
Universal Design for Learning	.713
Constructivism	.657
Alpha Reliability	**.823**
Individual Item	
Multimedia Instruction	

Dimensions of Beliefs about Teaching and Learning

Exploratory factor analysis was also used to construct the scales for dimensions of beliefs about teaching and learning. Analysis revealed six scales within this category. These six scales account for 53% of the variance. The inclusive mindset scale is made up of eight items and depicts a set of beliefs that relate to the desire and willingness to adopt methodological approaches that are inclusive of diverse learners in general, and students with disabilities in particular. The comfort with technology scale has four items and reflects faculty comfort level with the use of various technologies in the classroom. The dimension of time for instructional development scale has three items that specifically relate to issues of time to develop innovative instructional material. Likewise, the dimension of institutional resources has three items that relate to faculty perception about whether or not their respective institutions provide the necessary support and resources for developing inclusive pedagogies. The teacher responsibility scale also has three items and is reflective of the level of responsibility faculty feel for the success and academic achievement of students in their class. The last dimensional scale, pedagogical competency, is made up of two items and relates to faculty perception about their knowledge of teaching and actions they have taken to improve pedagogical skills. Factor loadings and alpha reliabilities for each dimension are listed in Table 4. Two additional single items are also listed in Table 4. These items relate to faculty perception about the need for change. Previous research indicated that faculty belief about the need for change is a critical factor in adopting inclusive pedagogies. The two items, need for change - discipline and need for change – institution, have been included because of the importance given to them in previous research. They will be used as single item indicators in subsequent analysis.

Table 4
Results of Factor Analysis for Dimensions of Beliefs about Teaching and Learning

Factor Names and Items	Factor Loading
Inclusive Mindset	
I am receptive to making changes in my curriculum in order to accommodate students with disabilities	.789
I continually look for better ways to teach	.703
I am open to learning new forms of instruction	.655
I believe that most students, regardless of disability, are capable of learning the material in my classes	.589
Faculty should be expected to make adjustments for individuals with disabilities	.494
For the most part I do not teach the way I was taught	.415
In most instances students do not learn best by memorization	.377
I try to match my teaching methods to my students' learning styles	.356
Alpha Reliability	.783
Technology Comfort Level	
I am comfortable using the following technologies in the classroom: Slides	.788
I am comfortable using the following technologies in the classroom: Video/DVD	.749
I am comfortable using the following technologies in the classroom: PowerPoint	.748
I am comfortable using the following technologies in the classroom: Computers	.725
Alpha Reliability	.788
Time for Instructional Development	
I have the time to develop new teaching methods	.675
My discipline does not demand that so much material be covered that I can not spare a moment in class for alternative approaches	.656
I do not have so many administrative responsibilities that I have little time to spend on developing new teaching techniques	.610
Alpha Reliability	.568
Teacher Responsibility	
Most inadequacy in a student's academic background can usually be overcome by good teaching	.779
The teacher is generally responsible for students' success in their class	.772
When the grades of a student improve it is often due to their teacher having found a more effective teaching approach	.449
Alpha Reliability	.595

Table 4 (Continued)
Results of Factor Analysis for Dimensions of Beliefs about Teaching and Learning

Institutional Resources	
My institution is supportive of the expansion of instructional techniques to enhance teaching	.749
There are professional development opportunities in pedagogy available to me	.701
There are adequate resources at my institution to support the development of new teaching techniques	.560
Alpha Reliability	**.598**
Pedagogical Competency	
I am knowledgeable about different teaching approaches	.723
I have taken workshops or courses that relate to teaching	.559
Alpha Reliability	**.623**
Individual Items	
Need for Change - Discipline	
I believe there is a need to change instruction in my field	
Need for Change - Institution	
I believe current instruction in my field at this institution is effective	

Descriptive Statistics

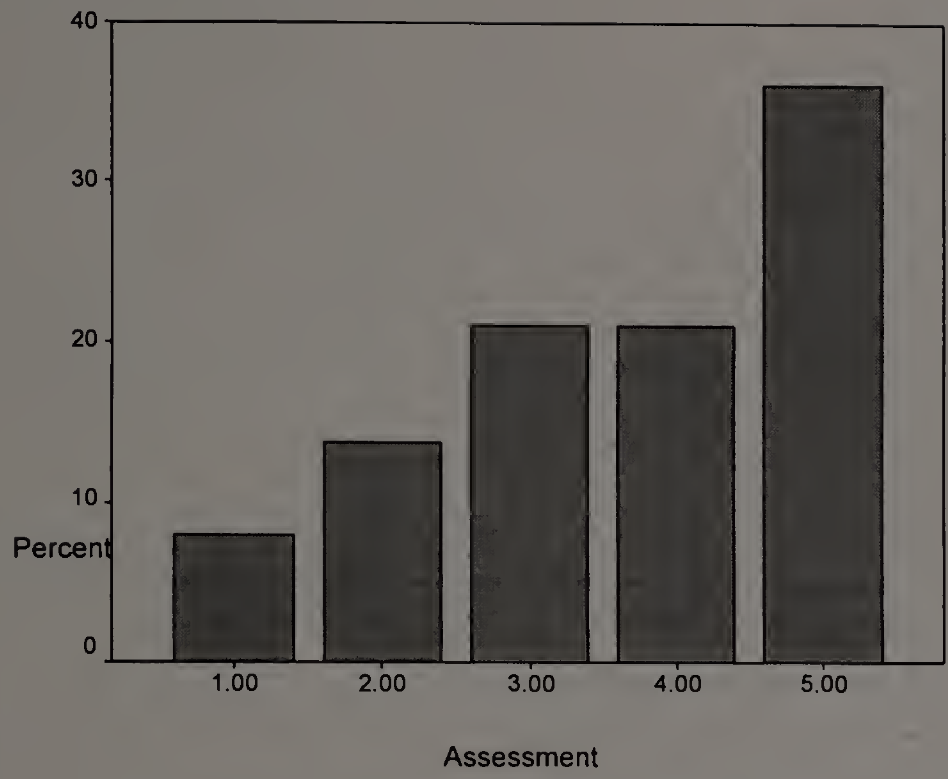
The first two research questions ask about the current teaching practices and level of awareness concerning inclusive teaching practices of community college STEM faculty. Descriptive statistics provide a means for examining the range and level of use of different instructional practices as well as an analysis of the relationship between variables. Frequencies, means, and standard deviations for the variables were analyzed in order to further examine the nine instructional practices, six beliefs about teaching and learning, and two environmental factors. Table 5 lists the rank order-adjusted means and standard deviation of each of the scales. The scales are composed of varying numbers of questionnaire items. In order to provide a meaningful comparison each scale mean was adjusted by combining the indicated questionnaire items and calculating the combined mean. Each of the scales in Table 5 are categorized into practices, beliefs, and environmental factors in order to conform to the research questions and theoretical framework outlined in chapter 3. Further analysis will follow this categorization.

Table 5
Adjusted Means and Standard Deviations for Instructional Practices, Beliefs and Environmental Scales

Practices	Mean	SD
Varied Presentation Strategies	3.93	.900
Multimedia Instruction	3.71	1.15
Alternative Assessment	3.63	1.30
Pedagogical Variety	3.63	.864
Interactive Learning	3.40	1.09
Diversified Instruction	3.22	.971
Traditional Teaching	3.17	1.15
Technology Utilization	3.13	1.00
Student Engagement	3.08	.773
Beliefs		
Technology Comfort Level	4.14	.893
Pedagogical Competency	4.11	.771
Inclusive Mindset	3.99	.620
Need for Change - Institution	3.85	.965
Need for Change - Discipline	3.16	1.10
Teacher Responsibility	3.12	.724
Environmental Factors		
Time for Instructional Development	3.64	.781
Institutional Resources	3.55	.757

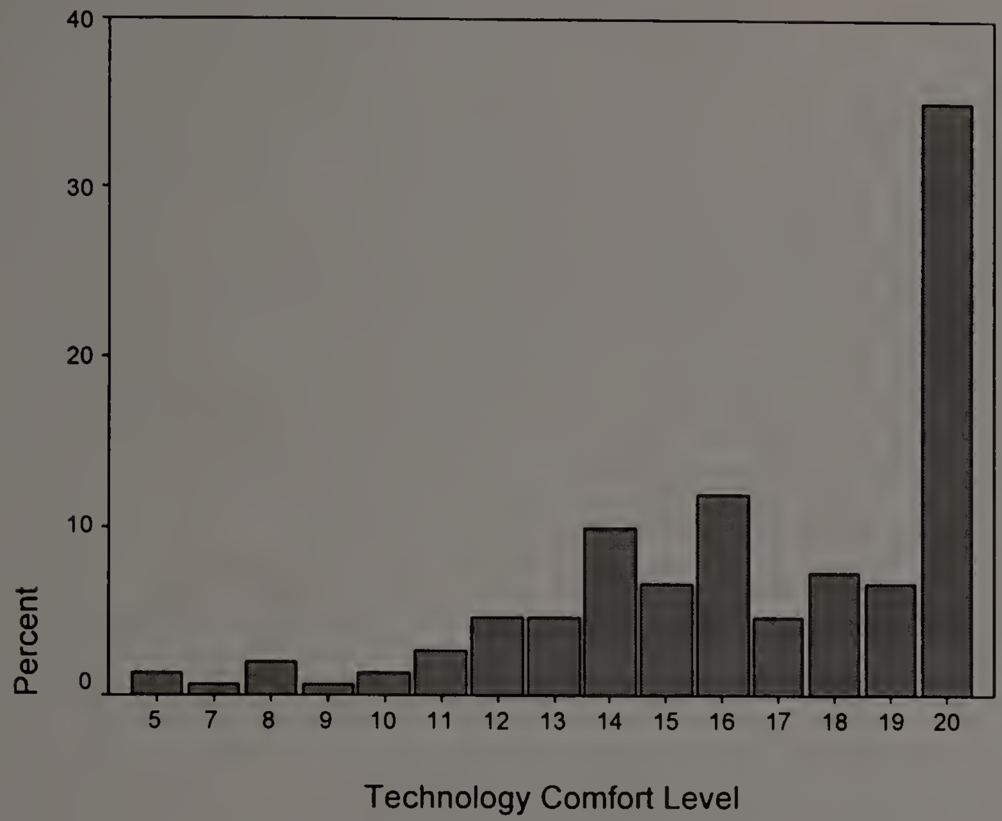
An examination of the practices data in Table 5 shows the use of practices to be within a standard distribution; varied presentation strategies, interactive learning, alternative assessment, pedagogical variety, and multimedia instruction are slightly skewed in a positive direction, indicating a trend toward higher reported use of those practices. Varied presentation strategies with a mean of 3.93 shows the highest reported use within this category. Varied presentation strategies include presenting material in multiple ways and using hands-on instructional aids in class. The traditional teaching scale has a mean of 3.17 with only 42% of respondents indicating that the class period is spent primarily in a lecture format. The alternative assessment scale with a mean of 3.63 is shown in Figure 2. A first glance of the graph would lead to the conclusion that 57% of STEM faculty provided alternatives (such as portfolios, projects, exams, and presentations) in the way in which students express what they know. However, a closer examination of other questionnaire items reveals that traditional forms of assessment are most commonly used. For example, 89% of respondents indicated that exams are frequently or always used as assessment, while 56% indicated that projects were frequently or always used. Papers were used by 37% of the respondents and portfolios were used by only 19% of STEM faculty. The findings suggest that even though 57% of STEM faculty indicate that they provide alternatives, the alternatives consist primarily of exams, followed by projects. It is not clear that there is a wide range of alternative forms of assessment used by these faculty.

Figure 2
Adjusted Mean Assessment



A similar pattern of distribution is shown within the beliefs category with many of the distributions slightly skewed in a positive direction, indicating a trend toward agreement with those beliefs. Technology comfort level and the pedagogical competency show the highest means, followed by inclusive mindset and need for change – discipline. Technology comfort level, as indicated in Figure 3, presents the most interesting pattern with 35% of respondents reporting a strong agreement, while the remainder of the respondents distributed across the remainder of the means in relatively small percentages.

Figure 3
Adjusted Mean Technology Comfort Level



The inclusive mindset scale is made up of a combined set of beliefs that relate to the desire and willingness to adopt methodological approaches that are inclusive of diverse learners in general, and students with disabilities in particular. A positive skew is indicative of a trend toward embracing those beliefs. Within this scale, 78% of respondents indicated that they agree or strongly agree that they are receptive to making changes to accommodate students with disabilities, and 75% agree that students with disabilities are capable of learning the material in their class. Respondents also agreed that they try to match their teaching styles to accommodate students' learning needs (74%), and they agree that they continually look for better ways to teach and are open to new forms of instruction (88%). Pedagogical competency relates to the belief that one is knowledgeable about different teaching approaches and that actions have been taken to improve teaching skills. Over 79% of the respondents indicated that they agree or strongly agree that they are knowledgeable about different teaching practices, and 82% agree or strongly agree that they have taken part in workshops that relate to teaching.

The final scales indicate dimensions of environmental factors. The two dimensions, time for instructional development and institutional resources, also fall within a normal distribution with slight positive skews, indicating a slight trend toward beliefs that relate to having time to develop new teaching approaches and the resources with which to do so.

Correlation and Regression Analysis

The third research question asked what the personal, attitudinal, and environmental factors are that inhibit community college STEM faculty from using inclusive pedagogical practices. Correlation and regression analysis was used to address this question and to determine the relationship among the variables. Table 6 describes the definitions for all the variables used in the analysis. One variable was collapsed in order to provide dichotomous variables for further analysis. The degree variable combined masters and doctorate since relatively few respondents (25%) indicated a doctorate degree and an analysis of frequencies showed little variability between the responses of respondents who indicated masters and doctorate degrees. In addition, an examination of frequencies showed little difference between the responses across campuses. Therefore, the campus variable was not included in the analysis. Future research may reveal some existing differences across campuses.

Table 6
Variable Definitions with Means and Standard Deviations

Variable Name	
Personal Characteristics	
1. Subject (SCIENCE)	Single item identifying subject currently taught (1 = Science, 0 = All else) Science = 40%
2. Subject (TECH)	Single item identifying subject currently taught (1 = Technology, 0 = All else) Technology =24%
3. Subject (MATH)	Single item identifying subject currently taught (1 = Mathematics, 0 = All else) Mathematics = 25%
4. Status- Full-Time (STATF)	Single item indicating employment status (1 = Full-Time, 2= Part-Time) Full-time = 57%
5. Degree (DEG)	Single item indicating highest degree obtained (1= Associates or Bachelors, 2 = Masters or Doctorate) Masters or Doctorate = 91%
6. Gender- Male (GENM)	Single item identifying gender (1 = male, 2 = female) Female = 51%
Environmental Factors	
7. Time for Instructional Development (TIMDEV)	Three item scale that describes institutional factors that limit innovation Standardized alpha reliability = .56, Mean = 10.93, S.D. = 2.34
8. Institutional Resources (INSRES)	Three item scale that describes institutional support and resources Standardized alpha reliability = .59, Mean = 10.67, S.D. = 2.27

Table 6
Variable Definitions with Means and Standard Deviations (Continued)

Attitudes and Beliefs	
9. Inclusive Mindsets (INCMIN)	Eight item scale indicating a propensity towards inclusive thinking Standardized alpha reliability = .78, Mean = 28.01, S.D. = 4.30
10. Technology Comfort Level (TECCL)	Four item scale describing the level of comfort with technology use Standardized alpha reliability = .78, Mean = 16.58, S.D. = 3.57
11. Teacher Responsibility (TERES)	Three item scale describing beliefs about faculty responsibility Standardized alpha reliability = .59, Mean = 9.38, S.D. = 2.17
12. Pedagogical Competency (PEDCOM)	Two item scale that indicates self-assessed participation and knowledge of pedagogy. Standardized alpha reliability = .62, Mean = 8.23, S.D.= 1.54
13. Need for Change (NECH-I) (NECH-D)	Two single items indicating beliefs about the need for change (1 = Strongly Disagree to 5 = Strongly Agree) Institutional – Mean = 3.86, S. D = .966 Discipline – Mean = 3.16, S.D. = 1.10
Instructional Practices	
14. Technology Utilization (TECUTIL)	Six item scale describing ways in which technology is used to enhance instruction Standardized alpha reliability = .82, Mean = 18.7 S.D. = 6.03
15. Varied Presentation Strategies (VPRESTR)	Two item scale describing techniques that are used to reach different types of learners Standardized alpha reliability = .58, Mean = 7.87, S.D. = 1.80
16. Interactive Learning (INTLERN)	Two item scale describing student participation and interaction in class Standardized alpha reliability = .71, Mean = 6.79, S.D. = 2.19

Table 6
Variable Definitions with Means and Standard Deviations (Continued)

17. Student Engagement (STUENG)	Four item scale describing ways in which student interest and connection to learning are fostered Standardized alpha reliability = .62, Mean = 14.16, S.D. = 3.77
18. Diversified Instruction (DIVINST)	Three item scale describing techniques used for different learner types Standardized alpha reliability = .56, Mean = 9.6, S.D. = 2.92
19. Traditional Teaching (TRATEA)	Single item indicating class time used primarily in a lecture format (1 = Never to 5 = Almost Always) Mean = 3.17, S.D. = 1.15
20. Alternative Assessment (ALTAS)	Single items indicating alternatives in the way students express what they know (1 = Never to 5 = Almost Always) Mean = 3.64, S.D. = 1.31
21. Pedagogical Variety (PEDVAR)	Six item scale indicates use of a variety of innovative pedagogical approaches Standardized alpha reliability = 8.23, Mean = 21.8, S.D. = 5.20
22. Multimedia Instruction (MULINST)	Single item scale indicates level of use of multimedia instruction. (1= I have never heard of it, to 5 = I know what the approach is and I use it on a regular basis) Mean = 3.72, S.D. = 1.15

Table 7 provides the correlation coefficients for all of the above listed variables. The correlation matrices were used to formulate the regression analysis that will be discussed in more detail in the next section. However, a few noteworthy correlations are of interest. Of particular interest are the correlations between beliefs and instructional practices. For example, inclusive mindset is positively correlated with eight of the nine instructional practices, technology utilization (r_s=.244**), varied presentation strategies

(r_s=.390**), interactive learning (r_s=.327**), student engagement (r_s=.432**), diversified instruction (r_s=.244**), alternative assessment (r_s=.295**), pedagogical variety (r_s=.508**), and multimedia instruction (r_s=.320**). Inclusive mindset is negatively correlated with traditional teaching (r_s=-.306**). Similarly, technology comfort level is positively correlated with seven of the nine instructional practices, technology utilization (r_s=.566**), varied presentation strategies (r_s=.300**), student engagement (r_s=.181*), diversified instruction (r_s=.226**), alternative assessment (r_s=.329**), pedagogical variety (r_s=.162*), and multimedia instruction (r_s=.487**). Pedagogical competency is also positively correlated with eight of the nine instructional practices, technology utilization (r_s=.206*), varied presentation strategies (r_s=.260**), interactive learning (r_s=.189*), student engagement (r_s=.333**), diversified instruction (r_s=.280**), alternative assessment (r_s=.194*), (pedagogical variety (r_s=.630*), and multimedia instruction (r_s=.263**). Pedagogical competency is negatively correlated with traditional teaching (r_s=-214**). Interactive learning (r_s=-.284**) and alternative assessment (r_s=-.182*) are also negatively correlated with traditional teaching.

An examination of the correlations suggests that there is a significant relationship among beliefs about teaching and learning, the use of traditional methods, and the actual provision of more innovative instructional practices. This relationship as well as the relationship of personal and environmental factors is further explored in the section on regression analysis.

Table 7
Correlation Matrix – Nonparametric, Spearman's rho

	1	2	3	4	5	6	7	8	9	10	11	12
1. SCIENCE												
2. TECH	-.464**											
3. MATH	-.473**	-.327**										
4. STATF	-.025	.087	-.146									
5. DEG	-.018	-.031	.131	.368**								
6. GENM	-.099	.214**	-.106	-.063	.037							
7. AGE	-.117	.128	.021	.063	.217**	.161*						
8. INSRES	.029	.033	-.042	.231**	.065	-.059	.036					
9. ITINDEV	.002	.168*	.003	-.078	-.058	.107	.049	.200*				
10. INCMIN	-.002	.068	-.057	.056	.012	-.063	-.148	.242**	.494**			
11. TECCL	.076	.302**	-.480**	.022	-.094	-.012	-.038	.009	.054	.275**		
12. TESRES	-.067	.153	-.175*	-.222**	-.107	.129	.032	.003	.056	.044	.168*	
13. PEDCOM	.053	.030	-.063	.271**	.242**	-.094	.050	.323**	.314**	.447**	.181*	.041
14. NECH-I	.170*	-.136	-.039	.014	-.159	-.024	.017	.143	.077	.068	-.092	-.132
15. NECH-D	-.014	.052	-.016	.099	.048	-.077	.181*	.010	-.103	-.145	-.048	-.209**
16. TECUTIL	-.226**	.403**	-.239**	.176*	-.073	-.053	-.112	.090	.131	.244**	.566**	.151
17. VPRESTR	.029	.118	-.234**	-.009	-.104	-.006	-.063	.107	.263**	.390**	.300**	.132
18. INTLERN	-.260**	.118	.074	.133	-.003	-.065	-.149	.038	.211**	.327**	.069	.129
19. STUENG	-.001	.003	-.031	.083	.073	-.144	-.032	.150	.319**	.432**	.181*	.170*
20. DIVINST	-.039	.060	-.072	-.154	-.125	-.107	-.062	.079	.144	.244**	.226**	.322**
21. TRATEA	.261**	-.245**	-.127	.042	-.071	-.001	.007	-.049	-.295**	-.306**	-.105	-.017
22. ALTAS	.001	.031	-.133	.161*	-.031	-.193*	-.187*	.014	.019	.295**	.329**	.101
23. PEDVAR	.038	-.048	.007	.235**	.114	-.055	-.144	.195*	.359**	.508**	.162*	.141
24. MULINST	.020	.219**	-.305**	.214**	.066	-.106	-.047	.083	.093	.320**	.487**	.032

* ≤ .05, * ≤ .01, **

Table 7
Correlation Matrix - Nonparametric, Spearman's rho (Continued)

	13	14	15	16	17	18	19	20	21	22	23	24
1. SCIENCE												
2. TECH												
3. MATH												
4. STATF												
5. DEG												
6. GENM												
7. AGE												
8. INSRES												
9. TIMDEV												
10. INCMIN												
11. TECCL												
12. TERES												
13. PEDCOM												
14. NECH-I	.183*											
15. NECH-D	-.108	.266**										
16. TECUTIL	.206*	-.097	-.101									
17. VPRESTR	.260**	.221**	-.156	.197*								
18. INTLERN	.189*	-.199*	-.287**	.233**	.360**							
19. STUENG	.333**	.016	-.114	.346**	.436**	.464**						
20. DIVINST	.280**	.040	-.142	.332**	.432**	.206*	.475**					
21. TRATEA	-.214**	.045	.028	-.130	-.203*	-.284**	-.092	.041				
22. ALTAS	.194*	.051	-.147	.431**	.360**	.314**	.351**	.333**	-.182*			
23. PEDVAR	.630**	.078	-.279**	.244**	.478**	.511**	.557**	.350**	-.186*	.429**		
24. MULINST	.263**	.110	.098	.497**	.363**	.004	.352**	. 233**	.010	.430**	.254**	

* ≤ .05, * ≤. 01, **

Multiple linear regression was used to identify the relationship between dependent and independent variables. A blocked hierarchical ordinary least squared multiple regression was used to identify the predictive relationship between these variables.

Instructional practices and attitudes and beliefs were identified as dependant variables. A regression analysis was run for each practice as a dependant variable using personal characteristics, beliefs, and environmental factors as independent variables. A regression analysis was also run for each belief as a dependent variable with personal characteristics and environmental factors as independent variables. Table 8 shows the results of the regression analysis for practices as the dependent variable. Table 9 shows the results of the regression analysis for beliefs as the dependent variable.

Table 8
Results of Regression Analysis with Practices as Dependent Variables

Practices Variables									
Variables	**TECUTIL**	**VPRESTR**	**INTLERN**	**STUENG**	**DIVINST**	**TRATEA**	**ALTAS**	**PEDVAR**	**MULINST**
Personal	β	β	β	β	β	β	β	β	β
SCIENCE	-.309**	-.154	-.341*	-.112	-.216	.030	-.161	.047	-.110
TECH	.186	-.041	-.056	-.017	-.039	-.324**	-.070	-.071	.071
MATH	-.306**	-.315*	-.113	-.095	-.209	-.197	-.238	.072	-.311**
STAT	.118	-.006	.112	.038	-.179	.096	.158	.263**	.148
DEG	-.040	-.056	-.003	.063	-.029	-.105	-.032	.049	.076
GEN (M)	-.125	-.057	-.084	-.142	-.155	.086	-.169*	-.027	-.153*
AGE	-.104	-.002	-.099	-.012	-.009	.043	-.135	-.106	-.020
R^2	**.246*** **	**.071**	**.094***	**.031**	**.074**	**.128** **	**.104** **	**.099***	**.153*** **
Environmental									
TIMDEV	.125	.320***	.315***	.378***	.102	-.282***	.094	.396***	.147
INSRES	.019	.063	-.064	.011	.097	.015	.013	.021	.020
R^2	**.015**	**.107*** **	**.086** **	**.132*** **	**.023**	**.071** **	**.008**	**.147*** **	**.019**
Belief									
INCMIN	.011	.301***	.152*	.263**	.171*	-.196***	.208*	.212**	.235**
TECCL	.505***	.147*	-.017	.077	.089	-.061	.204*	-.084	.362***
TERES	.071	.066	.094	.151	.227**	.059	.108	.154	.032
PEDCOM	.053	.007	.144	.135	.244**	-.083	.019	.435***	.066
NECH-I	-.017	-.145	-.170	-.036	.007	.013	.069	.003	.130*
NECH-D	-.030	.244**	-.189*	-.043	-.052	-.007	-.100	-.153*	.121
R^2	**.218*** **	**.168*** **	**.141*** **	**.123** **	**.165*** **	**.052** **	**.110** **	**.311*** **	**.212*** **
Total R^2	**.479*** **	**.346*** **	**.321*** **	**.286** **	**.262*** **	**.251*** **	**.222** **	**.557*** **	**.384*** **

* ≤.05, * ≤.01, ** ≤.001***

Table 9
Results of Regression Analysis with Beliefs as Dependent Variables

	Belief Variables					
Variables	**INCMIN**	**TECCL**	**TERES**	**PEDCOM**	**NECH-I**	**NECH-D**
Personal	β	β	β	β	β	β
SCIENCE	.008	-.120	-.318**	.057	.185	.041
TECH	.093	.094	-.091	.059	-.071	.071
MATH	.015	-.492***	-.394**	.001	.062	.055
STAT	.053	-.003	-.296***	.131	.104	.086
DEG	.012	-.033	.012	.237**	-.194*	-.048
GEN (M)	-.078	-.139	.006	-.097	.012	-.115
AGE	-.115	-.054	.012	.099	.129	.207*
R^2	**.027**	**.257*** **	**.143** **	**.129** **	**.073**	**.060**
Environmental						
TIMDEV	.499***	.099	.075	.279***	.039	.134
INSRES	.065	.013	.083	.190**	.111	.022
R^2	**.247*** **	**.008**	**.015**	**.121*** **	**.015**	**.019**
Total R^2	**.274*** **	**.265*** **	**.158** **	**.260*** **	**.088**	**.079**

* ≤ .05, * ≤. 01, ** ≤ .001***

The regression analysis indicates some interesting relationships. For example, technology comfort level as an independent variable significantly predicts technology utilization (β = .505***), indicating that when faculty are more comfortable with technology they are more likely to use it in their instruction. Teaching science (β=-.309**) and math (β=-.306**) are both negatively associated with technology utilization, indicating that faculty in these disciplines are less likely than their peers in engineering and technology to use technology for instruction. Personal variables account for 24% of the variance, environmental factors account for only 1% of the variance, beliefs account for 21% of the variance, with a total variance of 47% for the technology utilization scale.

Varied presentation strategies has several important predictors. The beliefs predicting varied presentation strategies explain 16% of the variance. Inclusive mindset (β=.301***), technology comfort level (β=.147*), and need for change - discipline (β=.244**) are all positively associated with varied presentation strategies. These findings suggest that faculty members who have more inclusive beliefs and who are comfortable with technology are more likely to use presentation strategies that include presenting material in multiple ways to reach a variety of learners, including the use of technology. These faculty members are also more likely to believe that change in instruction is needed in their field. Time for instructional development is also a very significant predictor of varied presentation strategies (β=.320***) and explains 10 %of the variance, indicating that having the time to develop new instructional materials is critical to a variety of presentation strategies. A negative association with math instruction (β=-.315) is also shown indicating that math instructors are less likely to use a variety of presentation strategies. Personal variables accounted for only 7% of the variance. The total variance for the varied presentation strategies scale is 34%.

Inclusive mindset (β=.152*) and need for change - discipline (β= -.189*) are also significant predictors of interactive learning. Faculty who have a more inclusive mindset are more likely to use interactive strategies. Faculty who believe that no change in their discipline is needed are less likely to use interactive learning strategies. Fourteen percent of the explained variance is within the belief category. Environmental factors explain 8% of the variance. Time for instruction is significantly associated (β=.315***) with interactive learning. Science instruction falls within the personal scale that accounts for 9% of the variance. Science is a negative predictor (β=-.341*) of interactive learning, indicating that science instructors are less likely to use interactive learning methods than are their peers in technology and mathematics.

Inclusive mindset (β= .263**) is also significantly associated with and predictive of student engagement indicating that inclusive beliefs lead to increased engagement of students in the learning process. The beliefs category explains 12% of the variance. The environmental factor of time for instructional development explains 13% of the variance and is also a positive predictor (β=.378***), once again pointing to the importance of time in instructional practice.

Similarly, inclusive mindset (β=.171*) and pedagogical competency (β=.244**) are predictive of diversified instruction. In addition, teacher responsibility is also positively associated (β=.227**), indicating that faculty sense of responsibility for teaching and student learning combined with inclusive beliefs and knowledge about pedagogy leads to instruction that takes into account different learning abilities. The belief factors explain 16% of the variance in this category. The total explained variance for diversified instruction is 26%.

On the other hand, traditional teaching is negatively associated with inclusive mindset (β=-.196***), technology instruction (β=-.324**), and time for instructional development (β=-.282***), with respective variances at 5% for beliefs, 12% for personal variables, and 7% for environmental, with a total explained variance of 25%. These predictors suggest that faculty who report lower levels of inclusive beliefs and those that report that they do not have time to develop new teaching methods due to discipline or to administrative responsibilities, are more likely to teach using a traditional lecture format. Technology faculty are also less likely to teach using a traditional lecture format than are faculty in science and mathematics.

The alternative assessment scale refers to the use of multiple strategies in assessing what students know. As previously mentioned, there are some indications that even though faculty reported using multiple strategies, exams remained the most frequently used method of assessment. Nevertheless, it is worthwhile to analyze the predictive relationship between personal, environmental, and belief scales in relation to alternative assessment. Males are negatively associated (β-.169*), (R^2=.10) with alternative assessment. Findings suggest that 66% of the females as compared to 48% of males indicate that they frequently or always used multiple forms of assessment. The two beliefs that are positive predictors of alternative assessment are inclusive mindset (β=.208*) and technology comfort level (β=.204*), with a variance of11%. The total variance for alternative assessment is 22%.

Full time status is positively associated (β=.263**) with the scale pedagogical variety with a variance of 9%, indicating that faculty who are full-time are more likely than their part-time peers to report knowledge and use of a variety of pedagogical approaches. Inclusive mindset (β=.212**) and pedagogical competency (β=.435***) are also predictors of pedagogical variety, while need for change - discipline is negatively associated (β=-.153*). These beliefs account for 31% percent of the variance. Time for instructional development is also predictive (β=.396***), with an environmental variance of 14%, indicating that time is a critical factor in knowledge and use of pedagogical practices.

The last instructional practices scale is multimedia. Inclusive mindset (β=.235**), technology comfort level (β=.362***), and need for change - institution (β=.130*) are predictive of multimedia with a variance of 21%. These findings suggest that comfort with technology combined with an inclusive philosophy will increase the likelihood that faculty will use multimedia in the classroom. Faculty in this category are also more likely to believe that no change is needed in instruction at their institutions. In addition, women more than men (β=-.153) and science and technology faculty as opposed to mathematics faculty (β=-.311**), are more likely to use multimedia. The variance for personal factors is 15%, with a total variance of 38% for the multimedia scale.

In reviewing the effect of the belief scales across all nine instructional practices variable patterns begin to emerge. As indicated by the Beta scores listed above, the belief scales inclusive mindset, technology comfort level, need for change-discipline and pedagogical competency are the three variables that are most predictive of a range of instructional practices. Inclusive mindset predicts eight of the nine instructional practices and has significant positive associations with presentation strategies, interactive learning, student engagement, diversified instruction, alternative assessment, pedagogical variety, and multimedia instruction. Inclusive mindset is negatively correlated with traditional teaching. These findings suggest that faculty who possess a set of beliefs about teaching and learning that includes openness to different learner types are more likely to use a variety of instructional techniques to reach them. In addition, they are more likely to use a variety of assessment techniques in order to measure what students are learning in class. Technology comfort level predicts four of the nine instructional practices and is positively associated with presentation strategies, alternative assessment, technology utilization, and multimedia, indicating the importance of technology comfort in both instruction and assessment. Faculty comfort with the use of technology may be an important factor in the move away from traditional forms of assessment such as exams and papers. Portfolios and projects are more likely to include the use of technology. Need for change-discipline positively predicts three of the nine instructional practices with positive association with varied presentation strategies and negative association with interactive learning and pedagogical variety. Pedagogical competency predicts two of the nine instructional practices with significant positive associations with pedagogical variety, and diversified instruction, indicating that knowledge of instructional methodologies is critical to the ability to understand student learning needs and to engage students in the learning environment.

Environmental factors are also predictive of a number of beliefs as well as instructional practices. Time for instructional development is significantly predictive of inclusive mindset (β=.499***) and pedagogical competency (β=.279***) in the belief category, with respective variances of 24% and 12%. As indicated in Table 8, time for instructional development is also predictive of presentation strategies, interactive learning, student engagement, and pedagogical variety. These findings once again point to the critical nature of time in the development of inclusive practices. The scale institutional resources is also predictive of pedagogical competency (β=.190**), (R^2=.12) indicating the importance of the combination of institutional support, resources, professional development and time in the development of knowledge and application of different teaching approaches.

Personal factors accounted for the smallest amount of variance among all the variables, particularly within the belief scales. No personal factors are predictive of inclusive mindset, or need for change - discipline. Highest degree (β= .237**) is predictive of pedagogical competency, suggesting that those with either a masters or doctorate degree are more likely to report knowledge about different teaching approaches. However, the number of respondents (N=14) with associate or bachelor degrees was so small that making comparisons is difficult. As was the case in the practices category, math is negatively associated with a number of the beliefs, technology comfort level (β=-.492***), (R^2=.25) and teacher responsibility (β=-.394**), (R^2=.14), suggesting that math faculty tend to be less comfortable with technology and perhaps feel less responsible for the success of students in their classes. This finding is consistent with findings within the practices scales in which math has a negative association with technology utilization, presentation strategies, and multimedia. Science is also negatively correlated with teacher responsibility (β=-.318**), (R^2=.14) suggesting that technology faculty may have a stronger sense of the importance of the impact of their teaching on student success.

Summary of Quantitative Data Analysis

The findings from the quantitative data analysis in this study provide valuable information about community college STEM instruction. The findings indicate that in addition to traditional instruction a variety of innovative instructional practices are currently used by STEM faculty. Findings also suggest that inclusive beliefs combined with comfort with technology and pedagogical competency is positively associated with the use of a range of instructional practices. Time for the development of inclusive practices is also shown to be a critical factor, suggesting that when discipline and administrative demands are minimized faculty are more likely to develop new teaching methods.

The quantitative analysis has provided data that it very useful in understanding current instructional practices. In order to gain a more complete and in-depth understanding, qualitative methods were also employed. The next section reports the results of the qualitative analysis.

CHAPTER 5

QUALITATIVE DATA ANALYSIS AND RESULTS

Overview

Chapter 5 describes the results of the data analysis for the qualitative portion of the study. The constant comparative method developed by Glaser and Strauss (1967) was used to develop categories, subcategories, and themes based on the interviews, observations, and document analysis. Taxonomical analysis developed by Spradley (1980) was used as a method of analyzing the meaning and relationships between categories and subcategories. The observation protocol described in chapter 3 was used to collect and analyze observation data. The first section of this chapter describes the interview sample and construction of themes and categories. The second section reports on the results of the theme analysis. The final section reports on the observation results. Final analysis integrated data collected from interviews, observations, and document analysis.

Interview Participants

Interview data were collected from 11 STEM faculty members at HCC and GCC who have been teaching from 6 to 26 years, with an average of 18 years teaching. The interview sample consisted of faculty who teach Anatomy and Physiology, Biology, Physics, Chemistry, Developmental Algebra, Calculus, Computer Information Systems and Engineering. Five faculty members were from HCC and 6were from GCC, 1 faculty member teaches online. Six of the faculty members were male and 5 were female. Each of the 11 faculty members was interviewed for 1hour. Interviews were audio taped and transcribed.

Category Development

Data from interviews, observations, and documents collected were analyzed and sorted into categories and subcategories. Anfara, Brown and Mangione (2002) recommend the use of tabular strategies for documenting the relationship between data sources and categories in order to strengthen credibility and provide the reader with a visual representation of methodological rigor. To that end, Table 10 was created to represent the stages in category conceptualization. The model was adapted from the work of Constas (1992) and Brown (1999) and shows three levels of analysis. Level 1 depicts open coding. The open coding method enables the researcher to reduce the number of units on which she is working and begins the process of explaining and predicting (Strauss and Corbin, 1998). Level 2 depicts the consolidation of those units into more manageable and workable units. Level 3 shows the final iteration of category development. In level 3, central categories that best addressed the research questions were developed. Each of these categories and subcategories were defined and diagramed to identify the relationship between data. The sources used to develop each unit are indicated in parentheses next to the category. For the most part the naming source originated either directly from the participant interview and observation or from the research questions. I looked for linkages, similarities and differences between participants and created analytic memos to begin to conceptualize key themes from the data. Graphs and charts were developed to organize data and establish relationships between interviews, observations, and documents.

Table 10
Documentation for Category Consolidation

Level 1 Initial Open Coding	LEVEL 2 CATEGORY CONSOLIDATION	LEVEL 3 FINAL CATEGORIZATION	LEVEL 3 SUBCATEGORIES
Background (I) Learning to teach (I) Personal experience (I) Prior experience (I)	Learning to Teach (I)	**Instructional Methods/ Strategies (I, Q)**	**Traditional Interactive Hands-On Technology**
Assessment (I) Connecting (I, O) Hands-on (I) Interaction (I, O) Paying attention (I) Methods (I, O) Multi-modal (I, O) Strategies (I) Teaching methods (I, O) Teaching style (I, O) Technology (I, O, D) Trying new methods (I)	Teaching Practices (I, O, D)		
Accommodation (I) Attitudes (I) Curiosity (I) How students learn (I) Learning styles (I, O) Philosophy (I) Responsibility (I)	Accommodation (I) Disability (I) Philosophy (I)	**Inclusion (I, Q)**	**Attitudes Practices Accommodation**
Accessibility (I, O, D) Administrative (I) Atmosphere (I, O) Barriers (I, O) Challenges (I) Institutional support (I) Money (I) Opportunity (I) Time (I) Resources (I, O)	Barriers (I, O) Environment (I, O) Finance (I) Professional Development (I) Resources (I, O)	**Barriers (I, Q)**	**Attitudinal Physical Setting Finance Institutional-Demands Resources Requirements**

I = Interview Data, O = Observation, D = Document, Q = Research Questions

The process of categorization created three main areas for further exploration: instructional methods and strategies, inclusion, and barriers. These areas were designated as domains and broken down into categories and subcategories. A domain is an important basic unit upon which further analysis is built. Taxonomical analysis developed by Spradley (1980) was then used to analyze the meaning and relationship among domains, categories and subcategories. The analysis of each of the three main domains is described below.

Instructional Methods and Strategies

Similar to findings from the quantitative analysis, a number of different instructional methods and strategies were and reported by faculty members during interviews. Using taxonomical analysis the domain, instructional methods and strategies were broken down into categories based on the data provided from interviews. Table 11 is taxonomy for the domain of instructional methods and strategies. The number of respondents who reported a particular subcategory is listed in parentheses.

Table 11
Taxonomy – Instructional Methods and Strategies

Domain	Category	Subcategories
	Traditional Methods	Lecture (1)*
Instructional Methods and Strategies	Interactive Methods	Group Work (3) Lecture-questions (5) Lecture-discussion (5) Student engagement and connection (6) Experiential learning (2)
	Hands-on Methods	Problem Based Learning (4) Participatory demonstration (4) Manipulatives (3) Projects (3) Portfolios (2) Visualizations (4) Student presentations (2)
	Technological Methods	Video/DVD (1) Course Management Systems (4) Internet (2) PowerPoint (2) Discussion Boards (3) Computer Assisted Instruction (1) Video lectures (1) Interactive computer problems (2) Calculators (2) Course material available electronically (4) Email (1) Online Labs (1) Computer demonstrations (2) Slides (1)

* Indicates the number of faculty reporting the use of each method

As is shown by the qualitative data in Table11, the faculty members in this study are not, for the most part, relying on traditional instructional practices. The majority of faculty members who use lecture defined it as lecture-discussion or interactive lecture. The difference is best described by one of the interviewees who described it in the following way:

Discussion lecturing is more of an evolving thing. I have a concept, and I want to come to a place of understanding. I will begin the discussion, and I want you to give me feedback on what you think and what you understand. So, I can embellish and bring in examples and see if we are in agreement about this particular topic. It is different than lecturing from the pulpit in which you have the idea that you have a lot of knowledge that no one else has, and you are just going to give it to them.

A number of the faculty members echoed similar thoughts and indicated that they viewed the classroom environment as one in which interaction was critical to the learning process. One instructor indicated, "The less I talk the more my students learn." Most of the instructors' classes are discussion orientated; they use problem solving, case studies, and demonstrations. They also appear to recognize that there are many different types of learners in the classroom. Only 1 of the 11 faculty members interviewed employed a straight lecture technique.

As indicated in Table 11 faculty members in varying degrees use a wide variety of techniques incorporating interactive and hands-on activities. Technology is used by most of the faculty but frequency of use varies considerably. Three of the 11 faculty members use technology in the classroom every day, and 4 of the faculty use technology in the classroom occasionally. Two of the faculty members use technology only as a supplement to classroom activities, in the form of either internet information, electronic course material or electronic discussion boards. Two of the faculty members report no use of technology, one of them indicates that they would like to use technology, but they have a low comfort level.

Inclusion

Even though many of the faculty members interviewed use interactive, hands-on, and technology-based strategies to teach, other factors are important to inclusive teaching. For example, one faculty member pointed out that he uses constructivist techniques but indicated that they may not always be appropriate. He stated that

> If the world were full of one type of self-directed learner, I would be completely constructivist and say, "Here are some interesting things to explore; go explore them and see what you come up with." If the world were full of another type of student, I would say "Here is step1, here is step 2, here is step 3; how do you put it together? Let's do it with our hands, let's do it outside, let's be active." I am recognizing through my own personal and professional experience that students are very, very different. The question was, "How do I think students learn?" The answer is differently.

Table 12 shows a taxonomy of faculty beliefs and actions as it relates to the inclusion of diverse students. The number of respondents who reported a particular subcategory is listed in parentheses.

Table 12
Taxonomy - Inclusion

Domain	Category	SubCategories
Inclusion	Beliefs	Importance of learner type (8)* Adapting to instructor methods (1)
	Inclusive Practices	Use of multimodal methods (5) Connection, Interaction (9) Real life examples (6)
	Methods of Accommodation	Integrated with instruction (7) Separate from instruction (4)

* Indicates the number of instructors reporting each belief

As is indicated by the data in Table 12, the majority of faculty interviewed share a belief in the importance of recognizing and adapting to different learner types. Only 1of the 11 instructors felt that students should adapt to the teaching style of the instructor. Six of the instructors stressed the importance of connecting the course material to the real life experience of their students, and 9 of them expressed the importance of connecting and interacting with students. The use of multimodal methods in order to reach a variety of learner types was stressed by 5 of the faculty. The use of multimodal methods is best described by one faculty member who stated:

> I try to present the materials in lots of different ways with the faith that some of those ways will connect with students. I believe that students learn in different ways so I try to present in different ways. I have some lecture, some group work, some hands-on, and tools to visualize the concepts.

In addition, one instructor indicated that the use of multimodal methods negated the need for additional accommodations for students with differences in her classes. She indicated that

> I've had many, many students who are disabled over the years in various ways. What I found is that they typically do fine in my class because of the fact that there are lots of different approaches to what is going on.

The majority of faculty members expressed views that were similar, indicating that instruction should be modified to be inclusive of students with disabilities and that "if you do a bunch of different things, it doesn't matter if they do or don't have a disability." However, 4 of the faculty members implied that it was more appropriate for modification to come as a separate service, though they all agreed that accommodations were appropriate. One faculty member was quick to point out that not all instructors feel that disability should be accommodated. She indicated that

> A couple of my colleagues are the standard, traditional conservatives and they do it this way: this is the lab, this is it, this is what you get; you are going to get everything that anybody else gets, no more, no less, end of discussion. They believe that they should be just like everybody else. Why should we give them special treatment?

Nevertheless, the overall consensus of the faculty members interviewed is that students learn in a variety of different ways, and that teaching that incorporates student engagement and multiple methods best serves all the students. At the same time, they indicated that numerous barriers that prevent faculty members from developing more inclusive pedagogy.

Barriers

Barriers Table 13 shows taxonomy of the central category barrier derived from faculty interviews. The number of respondents who reported a particular subcategory is listed in parentheses

Table 13
Taxonomy - Barriers

Domain	Categories	Sub Categories
Barriers	Attitudinal	Beliefs of Science Faculty (1)* Culture of Department (2) Student Resistance (1) Faculty Resistance (1)
	Physical Setting	Equipment (2) Classroom Design (1) Availability of Instructional Material (2)
	Requirements	Proliferation of information (1) Standards/learning outcomes (1) Administrative Constructs (1)
	Resources	Professional Development ((4) Not knowing what to do (2) Lack of experience with diversity (3)
	Finance	Faculty Pay (4) Lack of State Support (3)
	Institutional Demands	Class Size (2) Faculty Teaching Loads (7) Size of school (1) Part-time instructors (1) Time (10)

* Indicates the number of instructors reporting each barrier

As is evident from the data, instructors believe that multiple factors that influence the adoption of inclusive pedagogy. The complexity of the problem is highlighted by the range and diversity of beliefs about what prevents faculty from developing new methods. Some instructors indicated that departmental cultures discourage change. Sometimes "it is a problem in Academia itself of what is valued and what is not valued. Tinkering with teaching may not typically be accepted." Resistance to change may come both from faculty members who "don't have much respect for the stuff coming out of the educational world" or from students who "are more comfortable with going to a lecture and taking notes."

Physical setting was also listed as a barrier. One faculty member noted that very often classrooms are not designed to foster interactive learning. Some faculty members mentioned the lack of availability of instructional material or equipment. However, it should be noted that other faculty members felt that availability of material and equipment was more than adequate. Availability may vary widely between institutions and within departments at the same institution.

Additional barriers cited included administrative requirements and resources. The following was reported as barriers: institutional requirements for learning outcomes, the quantity of information to be covered, length of time for course completion, lack of knowledge or experience with diversity, and lack of appropriate professional development opportunities. Among these barriers, professional development was cited most frequently as being problematic. Most of the faculty members felt that professional development opportunities were available on their campus. However, some felt that those opportunities did not specifically meet the needs of instructors in their departments. Workshops specifically geared for untenured teachers or for teachers with little experience, as well as workshops that are offered at times when faculty are not teaching were described as most helpful. One faculty member also pointed out that community colleges have a "smaller scale of professional development" than most colleges or universities. The funding is usually available for local workshops that cost two or three hundred dollars but is not available for attendance at a national conference, where faculty might be exposed to national experts in teaching and learning.

By far the greatest number of barriers listed by faculty members related to finance and the associated institutional demands. Some of the faculty members indicated that low faculty pay and lack of state support has had a negative effect on their colleagues. They felt that these factors led to low moral, negativity, and a lack of interest in doing anything that would require extra time and effort. Lack of time to develop new methods or material was the most cited barrier reported by faculty members who were interviewed. Ten of the 11 faculty members cited time and, of these 7 indicated that high teaching loads was a significant contributor. One faculty member stated

> Our teaching load is too big so there is just no time to do anything innovative. There is very little time for professional development activities and very little time to change your courses. There is also no time to collaborate.

Another faculty member stated that he was "frankly exhausted" and that he "barely had time to keep up with his current teaching load never mind create anything new." The concerns about time were echoed by many of the other faculty who felt that time and energy were critical to the process of being able to create more inclusive curriculums. Other faculty members felt that the size of one's class as well as the size of one's school also contributed to the lack of time. One faculty member reported having class sizes of 50 to 80 students and indicated that it was exhausting trying to connect with that many students. Another faculty member indicated that being in a small school sometimes adds responsibilities that create time barriers. She stated that

> When you work in a small school you have to wear a lot more hats as a faculty. You have to work relatively harder because there are fewer of you to do the same amount of jobs, not just the teaching but other jobs. So you end up being on several committees, then you have your advising load....It is a lot more work.

Despite the time pressures and other barriers the faculty members interviewed seemed genuinely concerned about their students and reported using a number of techniques and strategies to make their classes more inclusive. Many of them expressed concern about the barriers associated with developing new strategies and thought that current pedagogy in the STEM fields was mixed when it came to innovation or inclusiveness. One faculty member articulated the current situation in STEM education as a 50/50 split. She indicated that

> There are fewer people who would identify themselves as reformed than there are that would identify themselves as traditional. The bulk of the people would actually say they are walking a middle path of some sort. Most people would say "Well I really believe in the traditional approach because I am not going to give up this, and this, and this, but I really like the reform ideas over here so I am going to do both of these." I think the majority of people fit in here and then there are a core of real strong reform people and people who are strong traditionalists.

Yet another faculty member felt that the split between traditionalists and reformed educators is beginning to change as new instructors enter the field. He believes that

> We are transitioning, as we see the older generation and their basically didactic approach kind of fade away into oblivion, you've got a new cohort that is

recognizing the power of alternative ways. I don't see many young faculty members who just do straight lecture anymore.

However, the evidence from the interviews suggests, that at least for the cohort of faculty who agreed to be interviewed, a number of inclusive practices are currently being utilized. The range of practices does not appear to differ between disciplines, number of years teaching or age of faculty. The classroom observations provide some additional evidence concerning instructional practice.

Observations

Classroom observations were conducted in nine of the faculty participant's classrooms during the summer and fall of 2005. The purpose of the observations was to assess the types and inclusiveness of instructional practices occurring in the community college STEM classes and to provide a method of data triangulation. The Inclusive Pedagogy Observation Protocol (Appendix C) was used to assess the observed level of inclusive practices. The protocol was developed based on the following: an observation checklist compiled by Merriam (1998); the Reformed Teaching Observational Protocol (RTOP) developed at the University of Arizona (Lawson, 2002); and the STEMTEC – Core Evaluation Classroom Observational Protocol developed by Berger (Sireci, Zanetti, Slater, & Berger, 2001). The protocol consists of three major components: (1) background information about the instructor and class; (2) contextual information such as the physical environment, description of setting and events, accessibility of materials and technologies used, and classroom checklist; and (3) a rating of key indicators for inclusive pedagogy.

Observation Participants

Observation data were collected from nine STEM classes at GCC and HCC. The sample consisted of faculty members who have been teaching from 6 to 26, with an average of 18 years teaching. Five of them are female and 4 are male and they represent a subset of the 11 instructors who were interviewed. Table14 summarizes the description of the sample discipline, number of students in each class, and length of observation.

Table 14
Observation Sample

Discipline	Number of Students	Length of Observation
Algebra	21	50 min.
Algebra	14	70 min.
Anatomy & Physiology	41	50 min.
Biology	32	70 min.
Calculus	12	70 min.
Chemistry	22	70 min.
Computer Information Systems	14	50 min.
Software Applications	8	50 min.
Engineering	16	50 min.

Observed Instructional Practices

Consistent with information reported in the faculty interviews a variety of instructional practices were observed in the STEM classes. Instructional activities were recorded on a classroom checklist using a 5-minute partial-interval recording schedule. Table 15 provides a summary of each type of instruction, as well as the number of classes in which the activity was observed, and the total percent of time faculty members were engaged in each activity.

Table 15
Instructional Activities

Activity Code	Type of Instruction	Number of Classes in Which Observed	% of Time in Which Activity was Observed
LWD	Lecture with discussion	8	26%
HOA	Hands-on activities	5	24%
UT	Utilizing technology	3	24%
L	Lecture	2	15%
D	Demonstration	5	13%
CL	Cooperative learning	3	9%
P	Preparation activities	7	7%
SGD	Small group discussion	3	6%
I	Inquiry activities	3	6%
SP	Student presentation	1	3%
CD	Classroom discussion	1	3%
A	Assessment	1	3%
UM	Utilizing multimedia	0	0%
W	Writing activities	0	0%

It should be noted that there is some overlap in the amount of time for different activities reported in Table15. For example, utilizing technology accounted for 100% of one class in which computer-aided instruction occurred. At the same time there were preparation activities and hands-on activities that included the use of technology. The total percentage of time spent in activities is therefore greater than100%. In addition, the length of observation varied from class to class resulting in a slightly greater representation from some faculty observations. Nevertheless some interesting patterns emerged from the data. First, lecture with discussion is the most frequently used instructional method (28%) and is used by 8 of the 9 faculty members observed. This finding is consistent with findings from the interviews and suggests that this is a common method of instruction. Hand-on activities were used 24% of the time by 5 of the faculty members, again suggesting a common method of instruction. Lecture was observed 15% of the time in 2 faculty member observations. However, it should be noted that one class consisted almost entirely of lecture; while in the second class lecture was used for a short time before another activity was introduced. Demonstrations were observed 13% of the time in a total of five classes. Demonstrations varied in that, at times, the instructor used demonstration to show a particular concept while at other times students participated in the activity. Cooperative learning was used 9% of the time by 3 faculty members and consisted mostly of small group activities where students were focused on solving a particular problem. Preparation activities were used 7% of the time by 7 of the instructors. Preparation consisted primarily of 5-or 10-minute segments during which faculty members reviewed previous material or provided an outline for planned activities. Small group and inquiry activities occurred 6% of the time and were conducted by 3 of the 11 faculty members. The activities that occurred less frequently were student presentation, classroom discussion, and assessment; each accounted for less than 3% of the time.

Accessibility of Materials and Technologies

In order to gain a measure of the accessibility of material and technologies, a simple checklist was used. The checklist included (a) the types of material and technologies used, (b) whether or not the material and technologies were accessible to a range of different learners. It should be noted that a wide range of accessibility issues relate to individuals with disabilities. Therefore, the checklist used for this study should be considered in only a broad context. Accessibility as it relates to vision, hearing, and mobility was the primary consideration. In addition, the observation protocol designed for the study included a checklist that rated the extent of accessibility on a scale from 1 to 5. The rating scale was found to be ineffective, in that items were either found to be accessible or not. Therefore, the checklist was modified to a simple yes or no format.

Two of the three classrooms in which students used computers provided accessibility options such as large monitors, magnification, and screen readers. None of the rooms had tables that could be adjusted for students in wheelchairs. Software used for the most part, seemed to be such that it could be accessible with assistive technology. However, online labs that were used as a classroom supplement were not accessible. In addition, one video was used without captioning, reducing accessibility to students who are deaf.

Materials used for demonstrations were accessible for most individuals, with the exception of students who are low vision or blind and would not be able to see or touch some of the materials. Four of the 9 faculty made printed handouts and syllabi available to students electronically, thereby increasing accessibility. Five provided them only in print, thereby reducing accessibility. Of the six rooms that did not include computer technology, two contained tables and chairs that provided an accessible and flexible classroom design. Four contained standard desks with attached tops. The standard desk design does not provide accessibility or flexibility in the classroom setting.

Key Indicators for Inclusive Pedagogy

The key indicators rating was used as an observation tool to assess how well instructors met key indicators that were developed based on reformed practices in STEM instruction and Universal Design for Learning. The scale for the key indicators ranged from 1 to 5 (where 1= not at all and 5 = to a great extent). Each item listed on the scale included a segment for evidence in order to minimize the researcher subjectivity and bias. Table16 provides the means and standard deviation for each of the items.

Table 16
Ratings of Key Indicators by Classroom

Item		Mean	SD
1	The instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein	4.4	0.72
2	The lesson was designed to engage students as members of a learning community	3.7	1.71
3	The lesson encouraged students to seek and value alternative modes of investigation or problem solving	3.3	1.65
4	Faculty used a variety of methods to engage students	3.8	1.27
5	Appropriate connections were made to other areas of mathematics/science and/or other disciplines	3.8	1.05
6	Appropriate connections were made to real-world contexts, social issues, and global concerns	4.1	0.60
7	Interactions reflected collaborative working relationships among students and between teacher and students	3.2	1.71
8	Faculty used a variety of means to instruct (lecture, discussion, demonstration)	3.6	1.65
9	Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives) to represent phenomena	2.4	1.92
10	The teacher's questions triggered divergent means of thinking	3.2	1.20
11	Active participation of students was encouraged	4.4	1.13
12	Material (print and electronic) was presented in a manner that would be accessible to all students	4.0	1.15
13	Outlines and cues were used to support different learner backgrounds	3.6	1.22
14	Students demonstrated their knowledge through a variety of means (projects, portfolios, discussion, presentations)	2.6	2.08
15	Faculty demonstrated flexibility in presenting the same material in multiple ways (images, activities, video, demonstration, etc.)	3.1	1.1

An analysis of the data about classroom observations in Table 16 shows some interesting findings. First, items 1 and 6 both have means of 4 or higher with no ratings of 1 or 2. This indicates that to some extent all faculty members are using strategies that respect students' prior knowledge and that make real world connections. In addition, faculty interviews and questionnaire responses consistently indicate the importance of connecting to the real world. Second, with the exception of item 9 and 14, the mean average rating is over 3.00 for all items, indicating that a variety of inclusive indicators are being used. Items 9 and 14 relate to specific ways students demonstrate what they know. Each of these items has a mean below 3.00, indicating a lower use of a variety of assessment strategies. These findings are also consistent with findings from both the interview and the questionnaire portions of the study. Third, many of the items do not show a standard distribution, suggesting considerable variability in use. Items 2, 4, 5, 7, 8, 10, 11, 12, and 13 are all positively skewed with greater numbers rated at the top of the scale, indicating that the number of faculty members engaging in these practices is greater than those who are not. Item 15 shows a mean of 3.1 with 56% rated at 3 and small numbers rated on both ends, indicating an average use of presenting the same material in multiple ways.

Summary of Qualitative Results

Overall results of interviews and classroom observations suggest that participating STEM faculty from HCC and GCC appear to use a variety of instructional practices and strategies. It appears, that for the most part, instructors are aware of diversity and the need for inclusion and attempt to teach in ways that reach a diverse population of students. Nevertheless, findings related to use of materials and technologies in the classroom suggests that improvement is needed in the area of accessibility. Faculty reported a number of barriers that prevent them and their colleagues from developing and using more inclusive methods. By far the greatest number of barriers listed by faculty members are related to finance and institutional demands. Instructors indicated that high teaching loads and lack of time to develop new methods are the greatest barriers to inclusive pedagogy.

The findings suggest that reaching a diverse population is important to community college STEM faculty. However, the qualitative sample was small in numbers and may have consisted of only faculty members who were interested in the topic of inclusion; thus, it is impossible to generalize findings to other community college faculty. The final chapter provides additional information by summarizing and comparing the results of the qualitative and quantitative portions of the study.

CHAPTER 6

SUMMARY AND CONCLUSIONS

The purpose of this study was to (a) to identify barriers to the adoption of inclusive teaching methods by STEM faculty in the community college environment; (b) to propose ways to break down these barriers; thus leading to increased use of such teaching methods; and (c) to add to the research base on community college STEM instruction for students with disabilities. Quantitative and qualitative methods were used in order to identify current teaching practices, determine levels of awareness about inclusive pedagogy, and identify barriers to the adoption of inclusive methods in community college STEM instruction. This chapter begins with a review of the previous five chapters in order to provide a background for discussion and analysis. The findings from the quantitative and qualitative sections of the study are then discussed in relation to each other and the three main research questions. The significance for practice and policy and the implications for further research are discussed in the final sections.

Review of the Study

This study addressed an existing gap in knowledge regarding instruction for diverse learners and students with disabilities in STEM disciplines. Chapter 1 discusses this existing gap in knowledge and provides evidence regarding the need for additional research. Although, studies on inquiry-based learning and reformed science practices do exist, few studies have included disability as part of the research focus. Most of these studies have been conducted at four-year institutions, and provide no information about instruction in the two-year college environment. In general, there is a notable lack of empirical research that looks at inclusive pedagogical practices in higher education in general, and two-year colleges in particular.

The literature reviewed in chapter 2 addressed several areas of research that informed the conceptual framework for this study. First, an overview of statistics that relate to the general population and to the enrollment of individuals with disabilities in higher education was looked at in order to provide a broad perspective and a context for the study. The data showed increasing enrollment rates of students with disabilities in postsecondary education, with higher enrollments in two-year colleges. Second, a review of current trends in STEM instruction, and educational trends and educational experiences for students with disabilities was presented in order to provide background data. The literature revealed that students with disabilities in STEM disciplines continue to be underrepresented, despite reform efforts in STEM instruction and existing accommodation practices for students with disabilities. Third, a review of the literature on the categorization of disability and on the research about diverse learners provided a context in which to view the current state of education for students with disabilities. The literature suggests that traditional ways of viewing disability in higher education have tended to foster exclusion and have perpetuated methods of instruction that do not benefit students who learn in nontraditional ways. Many theorists propose a move towards a social responsibility perspective in which we all have a responsibility for promoting inclusion (Hahn, 1999, Szymanski & Trueba, 1999). This responsibility includes teaching in ways that reach all learners. The research on diverse learners supports this position and advocates for more nontraditional and inclusive teaching.

These recommendations are consistent with those proposed for postsecondary STEM instruction (NRC, 2001, 2003a).

The final sections of the review presented research that relates to current STEM instruction in higher education and examined studies concerning barriers to the adoption of reformed or innovative pedagogy. The available research indicates that when utilized, reformed practices have been shown to be effective; however adoption of these approaches has not been widespread. The research has also shown that a number of barriers prohibit the adoption of innovative and inclusive pedagogies at four-year institutions. Findings from the research on reformed practices and barriers were used as a source for identifying variables that should be used in the design and analysis of this study.

Given the state of knowledge, a conceptual framework was developed out of the literature and helped to define the appropriate data collection strategies. Chapters 3, 4, and 5 detailed these strategies and reported results from the quantitative and qualitative portions of the study. The results of the analysis are discussed in the following sections.

Research Questions

Three research questions were introduced in chapter 1 to form the basis for this study. The following sections revisit these questions and use the findings from the quantitative and qualitative analysis to answer each of these questions.

1) What Are the Current Teaching Methods?

Findings from this study revealed some significant results that pertain to STEM instructional approaches in community colleges. Findings indicated that (a) community college instruction at the studied institutions is different than that reported in previous studies conducted primarily at four-year institutions, (b) the use of a variety of instructional methods is greater than expected, (c) many community college STEM faculty recognize differences in learner types and attempt to design instruction to meet learner variation, and (d) a gap between knowledge of pedagogy and the actual application of instructional practices in the classroom exists.

Previous research highlighted the continued reliance on traditional lecture as the primary form of instruction used by full-time and part-time STEM faculty. Findings from Walczyk and Ramsey (2003), the NCES (2002b) postsecondary faculty survey, Kardash and Wallace (2001), and Seymour and Hewitt (1997) all indicated that four-year STEM faculty had continued to rely on a traditional lecture format. This practice continues despite evidence that students are more satisfied with their learning and achieve more when learner-centered approaches are used. Community college STEM faculty members in this study appear to be very different. Both quantitative and qualitative findings suggest the use of multiple methods by these faculty members. Descriptive statistics showed slightly more faculty than not reported using a variety of pedagogical methods and presentation strategies. Of those faculty members, 30% of faculty members never use a traditional lecture format, while 28% occasionally use, and 42% frequently use a lecture format. Although the lecture format continues to be reported by faculty members as an important method of instruction, it is often used in conjunction with other methods. Some faculty members indicated that lecture is seen as a starting point that is used to engage and involve students in inquiry and discussion. Interviews and observations showed that faculty rarely use a straight lecture format and often combine lecture with discussion and with hands-on activities, technology and demonstrations.

Community college faculty members use multimodal methods in greater numbers than previous research had indicated. Although the need for improvement continues, the findings suggest that more instructors in this study are using varied instructional approaches than are using a traditional lecture format. Multiple regression analysis showed that personal characteristic do not appear to constrain or enable instructors in the adoption of inclusive approaches, the one exception is full-time status, which is associated with knowledge of and adoption of a variety of pedagogical methods. However, multiple regression analysis does show that some environmental factors do influence the adoption of these methods. Not surprisingly, faculty members who report having time to develop new teaching methods and who have reduced administrative and discipline related demands are more likely to use a variety of instructional methods. Also, a number of beliefs, such as inclusive mindset, pedagogical competency, and technology comfort level are associated with the use of a variety of instructional practices. The importance of these associations is discussed in more detail in later sections of this chapter.

As noted above, a review of the findings has shown that the community college faculty in this study are different in a number of ways than their colleagues in four-year institutions and that they are adopting a variety of different practices in larger numbers than expected. A brief discussion of some of the factors associated with the way community college STEM faculty members view their students further clarifies this difference. The qualitative findings revealed that these faculty members think about inclusion, the way students learn, and how to best reach them. The majority of faculty members interviewed indicated that instruction should be modified to be inclusive of students with disabilities and students who learn in different ways. The overall consensus was that teaching that promotes student engagement and incorporates multiple methods best serves all students. Of course, because the instructors were voluntary participants there may have been some bias and findings should be followed up in future research. Nevertheless, these findings are supported by quantitative data that showed inclusive beliefs to be held by many faculty members and positively correlated with the adoption of multiple methods of instruction. Descriptive statistics showed the adjusted mean for inclusive mindset to be 3.99 with 59% of faculty showing that they had a strong propensity toward inclusive thinking. Multiple regression analysis showed a positive association between inclusive mindset and 8 of the 9 instructional practices and a negative association with the ninth practice, traditional teaching. Within the inclusive mindset scale, over 78% of faculty members agreed that they would be receptive to making changes to accommodate students with disabilities. These findings are significant in that they highlight an awareness and willingness on the part of many community college faculty members to adapt their teaching to the needs of their students. However, willingness does not necessarily translate to practice. Do instructors have the necessary knowledge about pedagogy to be able to effectively modify their instruction and what other factors might influence them?

2) What Are the Levels Of Awareness Regarding Teaching Practices?

Awareness and knowledge of teaching practices are central to the use of a variety of instructional methods by faculty. Findings from multiple regression analysis in this study showed that pedagogical competency or knowledge about different teaching was positively associated with the use of a variety of pedagogical practices, student engagement, and diversified instruction. The literature review indicated that most college faculty members teach the way they were taught (Silver, Bourke, &Strehorn, 1997) and for the most part, do not have exposure to or knowledge of pedagogical techniques and diverse learners (Sunal, Hodges, Sunal, Whitaker, Freeman, Edwards, & Johnston, 2001). The findings in this study were quite different. Over 79% of the faculty members in this study indicate that they agree or strongly agree that they are knowledgeable about different teaching practices. A number of them indicated that they know and use many of the pedagogical practices listed in this study. In addition, 58% reported teaching in a ways that are different from the way they were taught. The community college STEM faculty members in this study appear to be more knowledgeable about pedagogical practices than what was noted in previous literature about four-year faculty. However, it is important to note that significant numbers continue to teach in traditional ways, and the extent to which instructional practices are used varies considerably among faculty members and among disciplines. For example, mathematics instructors reported an overall lower use of technology, multimedia, and varied presentation strategies but they seemed more likely than science instructors to use interactive learning. In addition, classroom observations showed that even when inclusive practices were in place some technologies and materials remained inaccessible to individuals with disabilities. For instance, online labs could not be used with assistive technology, reducing accessibility for blind or low vision users. Materials used in the classroom, such as small print graphs and charts and a video clip without captioning would also be inaccessible to some students with disabilities. Overall, the results suggest that the adoption of inclusive pedagogy is complex and a number of factors come into play. As Bianchini, Whitney, Brenton, and Hilton-Brown (1999) found in their study of innovative science instruction, a number of factors can prohibit the adoption of more inclusive pedagogy.

3) What Are the Factors That Inhibit Faculty from Using Inclusive Practices?

This study used two methods to identify existing barriers to the adoption of inclusive teaching practices, (a) quantitative identification of predictive relationships, and (b) qualitative analysis of interview data. An analysis of the quantitative results revealed that both beliefs and environmental factors are associated with the use of different pedagogical practices. Having an inclusive mindset clearly points to the use of the greatest number of instructional practices, followed by technology comfort level and pedagogical competency. The absence of an inclusive mindset is associated with lower reported use and is a barrier to implementation of inclusive pedagogy. If faculty do not have an inclusive mindset they are much more likely to teach in traditional ways. If faculty reported discomfort in the use of technology they were less likely to use varied teaching strategies, technology in the classroom, or multimedia instruction. If faculty members reported that that they were not knowledgeable about teaching approaches they were also less likely to understand student learning needs, to implement practices that engage students or to be in tune with the needs of different learners. Even when faculty members do possess these beliefs, other environmental influences may prevent the adoption of inclusive practices. Most notable among these factors is time for instructional development. Time has been reported as a barrier to the implementation of innovative and inclusive practices in a number of the studies listed in the review of literature (Bianchini, Whitney, Brenton, & Hilton-Brown, 1999; Silver, Bourke, &Strehorn, 1997). The findings from this study support the conclusion that time is a significant barrier. Time combined with the lack of institutional resources such as financial support and professional development represent important barriers to the development of pedagogical knowledge and application of different teaching practices.

The findings from the qualitative portion of this study support the quantitative findings and provide further clarification. Administrative and discipline related demands as well as the high teaching loads of community college faculty members were the most frequently cited barriers to inclusive pedagogy reported in faculty interviews. Many of the faculty members reported that it was difficult to keep up with current course loads and felt that even though they might want to develop new methods, time constraints prevented them from doing so. Instructors reported the lack of both institutional and system-wide support. On a systems level, lack of state financial support and low faculty pay scales were reported as barriers because they both impacted morale and made it difficult to obtain necessary funding. On an institutional level, faculty members reported inconsistent support and lack of funding as barriers. The levels of support and funding varied between institutions and between departments at the same institution. In addition, lack of appropriate professional development opportunities was seen as a deterrent in that professional development is limited and often not geared to the specific needs of faculty.

Implications for Practice and Policy

Practice

This study sheds new light on the extent to which belief, knowledge, and environmental factors converge with each other in the process of community college STEM instruction. The study shows that these factors are important and they all contribute to the likelihood that a faculty member will use multimodal teaching methods. The findings from this study indicate that, within these three institutions, there is a strong inclusive mindset, and a desire to teach in a way that reaches all students, suggesting a potential for the continued development of inclusive strategies. The identification of barriers and obstacles that impede the development of more inclusive teaching methods provides insight into possible new directions and solutions to improve practice.

This study has shown that in order to effectively develop new instructional approaches, practitioners need an inclusive belief system, knowledge of pedagogy, familiarity with new techniques and technologies, time, and resources. Although need for improvement continues to exist, many of the community college STEM faculty in this study appear to believe in the importance of teaching in a way that better serves a diverse student population, including students with disabilities. How does the community college continue to foster that belief and create an environment where inclusive pedagogy can thrive? The findings from this study point to a number of specific activities that would be helpful to faculty: (a) provide information on diversity, disability, accessibility, and learning styles to make faculty aware of the nature of the student body and their learning needs; (b) provide opportunities for faculty to learn more about instructional methods; (c) create opportunities for faculty to become more familiar and comfortable with the use of technology in the classroom; (d) establish policies that give faculty the time and resources needed to develop new instructional methods; and (e) create awards and incentives for faculty who do develop multimodal teaching method. In order for these activities to be successful, they must be provided in a way that respects the needs and time demands faculty currently face. For example, offering generic professional development opportunities during peak teaching hours or busy times during the semester may not be helpful to faculty. A more useful approach might be to provide educational opportunities based on needs assessments from individual departments and to offer at them at convenient times for faculty. Once new techniques are learned, faculty must be provided with the time and resources needed to fully develop them. The priorities and policies that institutions set around time and resources are critical to the implementation of new instructional practices.

Policy

What is the commitment to improving the quality of higher education STEM instruction? A number of national sources have stressed the need for improved and more inclusive STEM instruction (NRC, 2001, 2003a; NSF 1997, 2000, 2004). This study revealed that institutional and administrative constraints have hampered the efforts of many faculty members to be more inclusive. In order to implement fully the national call for improved STEM instruction, policy that specifically addresses the concerns of faculty must be developed. It is important to note that instructional improvement is not the sole responsibility of faculty members. There is a great deal that can be done by administrators and legislators to ensure that inclusive pedagogy becomes integrated into the community college mission. The findings from this study help to highlight several important implications for institutional, state, and federal policy makers. For all three areas (institutional, state, and federal), emphasis must be placed on two levels. First, administrators and legislators must develop new ways of thinking about inclusion. They need to become sensitive, cognizant, and knowledgeable about the importance of inclusive pedagogy for the future. Second, this knowledge must be backed by initiatives and budget resources that directly support the development of inclusive instruction.

On an institutional level, policy makers must examine their reward and incentive structures, resource allocations, and policies and practices for professional development. Community colleges could do a great deal to increase the likelihood that instructors will develop more inclusive instructional practices. First, institutions could establish policies that increase the likelihood that a faculty member will want to be more inclusive. These policies would begin to set an institutional tone that rewards faculty members who develop more inclusive instructional techniques. For example, faculty evaluations could include a measure for inclusion; thereby setting a criterion that becomes part of instructional practice. Financial incentives or course release time could be offered to faculty members who meet certain metrics, such as, developing proficiency in a new technique, incorporating new technology that assists students with disabilities into classroom instruction, or the development of accessible course materials. Given the need to justify the additional costs of any new initiative, these incentives could include a research requirement that would help to build empirical evidence about the value added benefits of more inclusive instruction. Second, reprioritizing financial resources to include inclusive pedagogy would help to provide materials, equipment, and technology needed for development. It is importance to restructure the budget to include specific allocations for inclusive pedagogy. Inclusion must be recognized as a core academic requirement that is supported by institutional financial boards. Third, restructuring professional development activities to better meet faculty needs would increase the likelihood of faculty participation. Faculty professional development also needs to be provided to new hires in order to orient them to the importance of using multimodal methods and being inclusive. Fifth, hiring practices must be modified in order to make quality inclusive teaching an institutional priority. Community colleges need to seek out instructors that will provide the best instruction to the widest range of student learners and help to establish an ongoing benchmark for inclusion.

There is also much that can be done on a state level to further the use of inclusive pedagogy. Most state boards of higher education have the responsibility of informing academic policy and conducting systematic program reviews. The establishment of an initiative to review and reward inclusive pedagogy would promote inclusion on a systems level. For example, existing teacher quality initiatives could be revised to provide support for faculty who are more inclusive or for the development of innovative instructional methods. In addition, state policy makers must examine whether current funding levels are adequate and whether or not current teaching loads are best serving the needs of our students. In order to promote the development of an inclusive learning environment adequate funds must be allocated and faculty must have adequate time to teach and develop new techniques.

On a federal level, policy makers need to examine federal funding priorities and opportunities and requirements for accessibility and inclusion. Federal priorities set the tone for what happens on state and local levels. Policy makers must ask if federal funding opportunities are available for the further development and research in the area of inclusive pedagogy and if financial resource allocation is best serving the needs of all students in higher education STEM programs. Do the funding priorities match the recommendations for more inclusive STEM instruction and are requirements for inclusion built into federal programs and proposals? In addition, policy makers may want to revisit the impact of the ADA. Under the ADA higher education institutions are required to provide academic accommodations for students with disabilities. Although, the law has helped to provide access for many students with disabilities, the law has also helped to establish accommodation as a separate practice rather than as integrated into the curriculum. When access is provided through inclusive pedagogy using the principles of Universal Design for Learning the need for separate accommodation may be reduced.

Implications for Further Research

The topic of inclusive pedagogy in postsecondary STEM education has not been well researched. This study is one step in closing the research gap and findings suggest the need for continued research in this area. There are several important directions this research should take. First, this study focused on instructional practices as they pertain to a broad group of learners with differences and disabilities. The next step would be to determine whether any differences based on the type of disability exist. For example, do faculty think about and respond differently to students with different types of disabilities? Does instruction change for students with learning disabilities as opposed to students who may be blind or mobility impaired? These are important distinctions that warrant future investigation. Second, through the use of factor analysis this study identified clusters of related data that specifically relate to instructional practices, knowledge of pedagogical approaches, and beliefs about teaching and learning. The clusters represent dimensions of practice that could provide a base upon which future research in STEM instruction could be built. For example, the three dimensional scales could be used in the development of a target profile for levels of inclusive pedagogy. Faculty members could then be assessed against this profile to determine areas where improvement is needed. The profile could also form the base for evaluation criteria at the institutional level. Third, this study established that a relationship exists between beliefs, knowledge, and environmental factors, and instructional practice. The extent of those relationships bears further investigation. For example, how much knowledge is needed in order for an instructor to begin to implement new practices and what types of knowledge prove most useful? At what point do beliefs become critical in the process of developing new instructional strategies and are there specific ways to encourage more inclusion? More research is needed to better understand the complex interplay between and among these factors. Fourth, the relationship between inclusive pedagogy and learning outcomes must be investigated. The research reviewed in this study showed that students in general do learn best in environments where learner-centered and nontraditional teaching occurs. However, no research currently exists that looks at the relationship between learning outcomes for students with disabilities and inclusive teaching methods within postsecondary education. Although, we can speculate that a relationship does exist, empirical evidence is needed. Fifth, future research should include a component that evaluates community college administrators' views about inclusive teaching. The actions of administrators are critical to any institutional systemic change and their views about inclusion may influence the success of any program. Further research is needed to clarify their beliefs and attitudes about investing in inclusive teaching practices. Sixth, this study was conducted at three community colleges in the northeast, we cannot generalize findings to other two-year institutions or to four-year colleges. Expanded research involving a larger number of institutions is needed in order to gain a more complete picture of postsecondary STEM instruction.

Conclusions

The primary purpose of this study was to investigate community college STEM instruction in order to increase knowledge about inclusive pedagogy and provide recommendations for improved pedagogy. Previous studies of postsecondary STEM instruction largely ignored two-year colleges and did not include a focus on disability. An examination of community college STEM instruction has provided new insights and has pointed to difference among two-year and four-year STEM instructors.

Findings revealed that a significant number of these community college faculty members have an inclusive mindset and believe in adapting their instruction in order to accommodate learner differences. These faculty members also appear more knowledgeable about pedagogical practices than what has been reported in previous literature about four-year faculty. Many of the faculty members are using multimodal instructional methods. However, a significant gap still exists between what they believe and know and what is actually put into instructional practice. A number of barriers that prohibit the use and development of inclusive practices were identified in this study. The most significant among the barriers reported were the lack of an inclusive mindset, lack of knowledge about pedagogy, high teaching loads, and lack of time for instructional development.

The findings from this study are merely a first step in explaining the complex relationship between beliefs, knowledge, environment, and instruction. I hope that the findings from this study will stimulate further thought and investigation about inclusive pedagogy and the critical role it plays in STEM instruction for students with disabilities.

APPENDICES

APPENDIX A

SURVEY OF INSTRUCTIOANL PRACTICES, APPROACHES, AND BELIEFS

Demographic Information

Please take a few minutes to provide your confidential responses to the questions below.

1. At what campus is your primary employment? GCC___ HCC___ STCC___
2. What subject area do you currently teach? ___________________
3. What is your status? ___Full-Time ___Part-Time
4. How many classes do you teach this semester? _____
5. How many labs do you teach per semester? _____
6. What is your highest degree obtained? Associates __Bachelors ___ Masters ___ Doctorate____
7. In what subject area did you obtain your last degree? ______________
8. What is your gender? ___Male ____Female
9. What is your age?
   20-25___ 26-30___ 31-35___ 36-40___ 41-45___46-50___ 51-55___
   56-60___ 61-65___ 66-70__ Over 71___
10. What is your ethnicity? (Please select ALL that apply.)
   __African American or Black
   __Asian
   __Caucasian or White
   __Hispanic or Latino/a
   __Native American or Alaskan Native
   __Native Hawaiian or Other Pacific Islander
   __Other ___________________________

Instructional Practices

Please respond to the following questions by indicating the frequency with which you employ the following techniques in your class.

1 = "Never", 2 ="Seldom", 3 = "Occasionally", 4 =, "Frequently" 5 = " Almost Always"

11	Use technology (computer software or programs) in the class to enhance instruction	1	2	3	4	5
12	Explain the same material in multiple ways (lecture, demonstration, activities, discussion)	1	2	3	4	5
13	Provide an alternative format for information you write on the blackboard or white board	1	3	3	4	5
14	Provide students with a written plan of what is to be covered in class each day	1	2	3	4	5
15	Provide the class syllabus to students in an electronic format	1	2	3	4	5
16	Provide handouts and other print material in an electronic format					
17	Perform assessment of student learning styles or preferences at least once per semester	1	2	3	4	5

18	Use manipulatives (hand-on instructional aids) in class	1	2	3	4	5
19	Spend the class period primarily in a lecture format	1	2	3	4	5
20	Use an engaging problem, question, or unusual fact in order to gain student interest	1	2	3	4	5
21	Use computer-assisted instruction (tutorial, or simulation activities offered as a supplement to traditional, teacher directed instruction)	1	2	3	4	5
22	Use multimedia (the combined use of text, graphics, animation, pictures, video and sound to present information)	1	2	3	4	5
23	Spend time in class having students discuss the concepts they are learning	1	2	3	4	5
24	Provide outlines and cues for students with different abilities	1	2	3	4	5
25	Provide alternatives during the semester in the way students express what they know (portfolios, exams, projects, presentations)	1	2	3	4	5
26	Have students work on problem solving projects during class	1	2	3	4	5
27	Have students form discussion groups during class	1	2	3	4	5
28	Have students form discussion groups outside of class	1	2	3	4	5
29	Have students communicate online in chats or discussion forums	1	2	3	4	5
30	Use techniques (pretests, surveys, discussion) to determine what students know when introducing new concepts	1	2	3	4	5
31	Make lecture notes available to students before the beginning of class	1	2	3	4	5
32	Use the following assessment strategies in your class: Projects	1	2	3	4	5
33	Portfolios	1	2	3	4	5
34	Papers	1	2	3	4	5
35	Exams	1	2	3	4	5
36	Quizzes	1	2	3	4	5

Please respond to the following by indicating the level at which you are familiar with the following teaching approaches

1 = I have never heard of it	2 = I have heard of it but I am not familiar with the approach	3 = I know what the approach is	4 = I know what the approach is and I use it occasionally	5 = I know what the approach is and I use it on a regular basis

37	**Constructivism** (New information is connected to what students already know and includes active participation of learners and collaboration between students)	1	2	3	4	5
38	**Inquiry-Based Learning** (Emphasizes experiential learning and problem solving)	1	2	3	4	5
39	**Learner-Centered Instruction** (The facilitation of the student's knowledge through active student participation)	1	2	3	4	5
40	**Cooperative Learning** (Instruction that involves students working in teams to accomplish a common goal, solve problems, and complete projects)	1	2	3	4	5
41	**Universal Design for Learning** (The use of flexible materials and multiple methods of presentation to reach a diverse student body)	1	2	3	4	5
42	**Multimedia Instruction** (The combined use of text, graphics, animation, pictures, video and sound to present information)	1	2	3	4	5
43	**Active Learning** (Students solve problems, answer questions, formulate questions, discuss and debate during class)	1	2	3	4	5

Beliefs about Teaching and Learning

Please respond to the following statements by indicating your level of agreement

1 = "Strongly Disagree", 2 = "Disagree", 3 = "Neutral/No Opinion", 4 = "Agree", 5 = "Strongly Agree"

44	In most instances students learn best by memorization	1	2	3	4	5
45	I believe current instruction in my field at this institution is effective	1	2	3	4	5
46	For the most part I teach the way I was taught	1	2	3	4	5

47	I try to match my teaching methods to my students' learning styles	1	2	3	4	5
48	The subject I teach determines how I teach	1	2	3	4	5
49	I am knowledgeable about different teaching approaches	1	2	3	4	5
50	I believe that instruction should be built on students' previous knowledge	1	2	3	4	5
51	I believe that most students, regardless of disability, are capable of learning the material in my classes	1	2	3	4	5
52	I believe there is a need to change instruction in my field	1	2	3	4	5
53	I am open to learning new forms of instruction	1	2	3	4	5
54	I have taken workshops or courses that relate to teaching	1	2	3	4	5
55	My institution is supportive of the expansion of instructional techniques to enhance teaching	1	2	3	4	5
56	The teacher is generally responsible for students' success in their class	1	2	3	4	5
57	I continually look for better ways to teach	1	2	3	4	5
58	Most inadequacy in a student's academic background can usually be overcome by good teaching	1	2	3	4	5
59	Ineffective teaching contributes to the lack of student achievement	1	2	3	4	5
60	I do not have the time to develop new teaching methods	1	2	3	4	5
61	I am receptive to making changes in my curriculum in order to accommodate students with disabilities	1	2	3	4	5
62	When the grades of a student improve it is often due to their teacher having found a more effective teaching approach	1	2	3	4	5
63	My discipline demands that so much material be covered that I can not spare a moment in class for alternative approaches to teaching	1	2	3	4	5
64	Faculty should not be expected to make adjustments for individuals with disabilities	1	2	3	4	5
65	I have so many administrative responsibilities that I have little time to spend on developing new teaching techniques	1	2	3	4	5
66	There are adequate resources at my institution to support the development of new teaching techniques	1	2	3	4	5
67	There are professional development opportunities in pedagogy available to me	1	2	3	4	5
68	I am comfortable using the following technologies in the classroom:	1	2	3	4	5

	PowerPoint					
69	Video/DVD	1	2	3	4	5
70	Slides	1	2	3	4	5
71	Computers	1	2	3	4	5

72. **Over the last four (4) semesters, how many students with disabilities have you had in your classes?** _____

Comments

APPENDIX B

INTERVIEW GUIDE

1	Tell me about your approach to teaching. Prompts: Instructional methods used in the classroom Technologies used The manner in which you teach (lecture, discussion, group work) The manner in which you assess student learning
2	If possible, what would you do to improve your teaching?
3	Describe your philosophy of how students learn. Prompts: What about students who don't seem to be able to grasp the material? How did you gain an understanding of how students' learn (education, experience)?
4	What do you think is unique about teaching in (subject area)?
5	How do you think teaching in the field of (subject area) can be improved?
6	How aware are you of different teaching approaches such as, inquiry-based learning, group learning, reformed science pedagogy, Universal Design for Learning. How do you incorporate these approaches or others like them into your teaching?
7	Reflect back to how you learned to teach, what kinds of things impacted the way you teach and how. Prompts: Faculty members Mentors Formal educational opportunities Student evaluations
8	What are some of the barriers that might prevent you from further developing or incorporating new teaching strategies and approaches? Prompts: What are some of the barriers that might impact other faculty? How does time impact the decision to implement new approaches Availability of professional development Support from colleagues
9	What kind of supports and resources are available on this campus for faculty who want to develop new instructional approaches?
10	Tell me about your experience with students with disabilities or differences. Prompts: What are some of the challenges students with disabilities face in your class? How do you deal with that? What is the faculty responsibility and what is the student's responsibility for making sure that students understand the material being presented in class?
11	What more do I need to know about teaching students with disabilities in your field?

APPENDIX C

INCLUSIVE PEDAGOGY OBSERVATION PROTOCOL

A. BACKGROUND INFORMATION

Institution__________________________ Date of Observation________________________

Course Observed ____________________ Scheduled Length of Class ____________

Length of Observation ______________ Number of Students _________________

Students with Disabilities_____________

Faculty Demographics

1. Gender: Male Female

2. Number of years teaching __________

3. Highest degree obtained ______________

Artifacts collected:

____

____

B. CONTEXTUAL BACKGROUND AND ACTIVITIES

1. DRAWING OF THE CLASSROOM ENVIRONMENT

2 DESCRIPTION OF PHYSICAL SETTING (space, seating acoustics, lighting, accessibility)

3 DESCRIPTION OF CLASS SESSION AND EVENTS

4 **TYPES AND ACESSIBILITY OF MATERIALS AND TECHNOLOGIES USED**	Accessibility				
	Not at all ←		**→**	**Completely**	
	1	**2**	**3**	**4**	**5**
1 Materials*					
	1	**2**	**3**	**4**	**5**
	1	**2**	**3**	**4**	**5**
	1	**2**	**3**	**4**	**5**
2 Technology*					
	1	**2**	**3**	**4**	**5**
	1	**2**	**3**	**4**	**5**
	1	**2**	**3**	**4**	**5**

*Accessibility refers to the degree to which the materials and technology would be accessible to people with a wide range of disabilities.

*Materials refers to classroom materials such as handouts, models, and demonstration tools that might be used in the classroom or lab.

*Technology refers to computers, hardware and software, instructional technology, video or multimedia that might be used in the classroom or lab.

5 CLASSROOM CHECKLIST

	Type of Instruction	0-5	5-10	10-15	15-20	20-25	25-30	35-40
L	Lecture							
LWD	Lecture with discussion							
CD	Classroom discussion							
HOA	Hands-on activities							
SGD	Small group discussion							
D	Demonstration							
UT	Utilizing technology							
UM	Utilizing multimedia							
CL	Cooperative learning							
SP	Student presentation							
W	Writing activities							
I	Inquiry activities							
A	Assessment							
P	Preparation activities (reviewing days activities)							

Adapted from the Classroom Observation Protocol (Sireci, Zanetti, Cadman Slater & Berger, 2001). *The instrument has cells to record activity up to 115 minutes

B. RATINGS OF KEY INDICATORS FOR INCLUSIVE PEDAGOGY

In the following sections a number of key indicators as descriptive of the lesson are rated in 5 categories, from 1 (not at all) to 5 (to a great extent). DK (Don't know) is used when there is not enough evidence to make a judgment and NA (Not applicable) is used when the indicator is not appropriate given the purpose and context

1. The instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein............ 1 2 3 4 5 DK NA
   Evidence:

2 The lesson was designed to engage students as members of a learning community... 1 2 3 4 5 DK NA
Evidence:

3 The lesson encouraged students to seek and value alternative modes of investigation or problem solving.................................. 1 2 3 4 5 DK NA
Evidence:

4 Faculty used a variety of methods to engage students.................1 2 3 4 5 DK NA
Evidence:

5 Appropriate connections were made to other areas of mathematics/science and/or other disciplines................................ 1 2 3 4 5 DK NA
Evidence:

6 Appropriate connections were made to real-world contexts, social issues, and global concerns... 1 2 3 4 5 DK NA
Evidence:

7 Interactions reflected collaborative working relationships among students and between teacher and students................. 1 2 3 4 5 DK NA
Evidence:

8 Faculty used a variety of means to instruct (lecture, discussion, demonstration).. 1 2 3 4 5 DK NA
Evidence:

9 Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives) to represent phenomena........... 1 2 3 4 5 DK NA
Evidence:

10 The teacher's questions triggered divergent means of thinking.. 1 2 3 4 5 DK NA
Evidence:

11 Active participation of students was encouraged ....1 2 3 4 5 DK NA
Evidence:

12 Material (print and electronic) was presented in a manner that would be accessible to all students.. 1 2 3 4 5 DK NA
Evidence:

13 Outlines and cues were used to support different learner backgrounds.. 1 2 3 4 5 DK NA
Evidence:

14 Students demonstrated their knowledge through a variety of means (projects, portfolios, discussion, presentations................ 1 2 3 4 5 DK NA
Evidence:

15 Faculty demonstrated flexibility in presenting the same material in multiple ways ((images, activities, video, demonstration, etc.) 1 2 3 4 5 DK NA
Evidence:

Adapted from the Reformed Teaching Observation Protocol (RTOP) (Piburn, Sawada, Falconer, Turley, Benford, & Bloom, 2000) and the Classroom Observation Protocol (Sireci, Zanetti, Cadman Slater & Berger, 2001). Addition items were added to reflect Universal Design.

ADDITIONAL COMMENTS

BIBLIOGRAPHY

Anfara, V.A., Brown, K.M., Mangione, T.L. (2002). Qualitative analysis on stage: Making the research process more public. *Educational Researcher,* 31 (7), 28-38.

Altman, B. A. (2001). Disability definitions, models, classification schemes, and application. In G. L. Albright, K. D. Seelman & M. Bury (Eds.), *Handbook of disability studies* (pp. 164-173). Thousand Oaks, CA: Sage.

American Association for the Advancement of Science. (1990). *Science for all Americans.* New York: Oxford University Press.

American Association for the Advancement of Science. (1993). *Benchmarks for Scientific Literacy.* New York: Oxford University Press.

American Association for the Advancement of Science. (1998). *Blueprints for reform.* New York: Oxford University Press.

American Association of Community Colleges. (2003). *Community College Tuition Survey.* Washington, DC.

American Psychological Association. (2002*). Understanding psychology learning goals and outcomes*. Retrieved November 11, 2004, from http://www.apa.org/ed/pcue/taskforcereport.pdf

Americans with Disabilities Act of 1990, P.L. 101-336, 104 Stat. 327, 42 U.S.C. 12102 et seq.

Bangert-Drowns, R. L., & Rudner, L. M. (1991). Meta-Analysis in educational research. *Practical assessment, research & evaluation, 2*(8), 24-29.

Bell, D. & Johnson, P. (1992). Support for the authors of multimedia tutorials. In L. Kjelldahl (Ed.), Multim*edia systems, interaction and implications* (26-34). New York: Springer-Verlog.

Berger, J. B., & Van Thanh, D. (2004). Leading organizations for universal design. *Equity & Excellence in Education, 37*(2), 124-134.

Bianchini, J. A., Whitney, D. J., Breton, T. D., & Hilton-Brown, B. A. (1999, March). *Inclusive science education: Scientists' views and instructional practices.* Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Boston, MA.

Blackburn, R. T., & J.H., L. (1995). *Faculty at work: Motivation, expectation, satisfaction*. Baltimore: Johns Hopkins University Press.

Bleicher, R. E., Romance, N., & Haky, J. (2002, Jan.). *Curriculum by design: Improving student learning in college chemistry and biology.* Paper presented at the Annual International Conference of the Association for Educational Teachers in Science, Charlotte, NC.

Bosco, J. (1986). An analysis of evaluations of interactive video. *Educational Technology, 25*, 7-16.

Bransford, J. D., Brown, A. L., & Cockning, R. (Eds.). (1999). *How people learn: Brain, mind, experience and school*: Committee on Developments in the Science of Learning, National Research Council.

Brothen, T., & Wambash, C. (2003). Universal instructional design in a computer-based psychology class. In J. L. Higbee (Ed.), *Curriculum transformation and disability: Implementing universal design in higher education* (pp. 127-147. Minneapolis, MN: Center for Research on Developmental Education, University of Minnesota.

Brown, K. (1999). Creating community in middle schools: Interdisciplinary teaming and advisory programs. Unpublished doctoral dissertation, Temple University, Philadelphia.

Bruner, J. (1990). *Acts of meaning*. Cambridge, MA: Harvard University Press.

Bryant, A. N. (2001). Eric review: Community college students: Recent findings and trends. *Community College Review, 29*(3), 1-14.

Burgstahler, S. (1994). Increasing the representation of people with disabilities in science, engineering and mathematics. *ITD Journal, 4* (9) 1-8.

Burgstahler, S. (2001). *Universal design of instruction.* Arlington, VA: National Science Foundation.

Business-Higher Education Forum. (2003). *Building a nation of learners*. Washington, DC: Author.

Cambell, G. (2002). Changing assumptions about who can learn. In J. Narum & K. Conover (Eds.), *New directions for higher education: Building robust learning environments in undergraduate science, technology, engineering, and mathematics* (pp. 23-28). San Francisco: Jossey Bass.

Center for Applied Special Technology (CAST), Woburn, Massachusetts. Retrieved November 10.2004, from www.cast.org

Chow, S. L. (1987). Meta-Analysis of pragmatic and theoretical research: A critique. *The Journal of Psychology, 121*(3), 259-271.

Colburn, A. (2000). An inquiry primer. *Science Scope, 23*(6), 42-44.

College Board. (2003). *Trends in College Pricing*. Retrieved January 15, 2005, from http://www.collegeboard.com/press/article/0,38993,00.html

Constas, M.A. (1992, Summer). Qualitative analysis as a public event: The documentation of category development procedures. *American Educational Research Journal. 29* (2), 253-266.

Cougnlin, D. (1997). The person with a learning disability as a minority group member. *Journal of Learning Disabilities, 30*(5), 22-27.

Creswell, J. W. (2003). *Research design: Qualitative, quantitative and mixed methods approaches*. Thousand Oaks, CA: Sage.

Davis, K. S., & Irwin, C. (2001). *Building a bridge for females to equitable, inclusive, and participatory science activities.* Paper presented at the Annual meeting of the National Association for Research in Science Teaching, St. Louis, MO.

Diamond, M., & Hopson, J. (1998). *Magic trees of the mind.* New York: Dutton.

Dunn, R. & Waggoner, B. (1995). Comparing three innovative instructional systems. *Emergency Librarian, 23* (1), 9-16.

Dunn, R., Griggs, S.A., Olson, J., Beasley, M. & Gorman (2001). A meta-analytic validation of the Dunn and Dunn model of learning preferences. *The Journal of Educational Research, 88*(6), 353-362.

EASI. (1995). *EASI street to science, engineering and mathematics access for people with disabilities*. Retrieved on September 10, 2004 from http://www.rit.edu/%7Eeasi/easisem/semintro.htm

Ehlers, V. T. (1997). Science literacy and the U.S. Congress. *Journal of College Science Teaching, 26* (11), 85-86.

Fensham, P., 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* (pp: 64 –72). Washington, D.C.: Falmer Press.

Fletcher, D. (1990). The effectiveness of videodisc instruction. *Machine Mediated Learning, 3,* 361-385.

Fox, M. (1998). Improving undergraduate science education: National initiatives, local implications. *Journal of College Science Teaching, 27*(5), 373-375.

Freire, P. (1970). *Pedagogy of the oppressed.* (M. Bergman Ramos, Trans.). New York: Herder and Herder.

Gamble, D. (2000). *An analysis of disability support services in higher education* (p. 9). Washington, DC: (ERIC Document Reproduction Service No. ED445445).

Gardner, H. (1999). *Intelligence reframed: Multiple intelligences for the 21st century.* NY: Basic Books.

Giroux, H. (1983). *Theory & resistance in education: pedagogy for the opposition.* South Hadley, MA: Bergin & Garvey.

Girourx. H. (1997) *Pedagogy and the politics of hope: theory, culture, and schooling: A critical reader.* Boulder, CO: Westview Press.

Glasser, B. & Strauss, A. (1967). *Discovery of grounded theory: Strategies for qualitative research.* Chicago: Aldine de Gruyter.

Gordon, M., & Keiser, S. (1998). *Accommodations in higher education under the Americans with Disabilities Act (ADA): A no-nonsense guide for clinicians, educators, administrators, and lawyers.* New York: Disabilities and Gifted Education.

Grubb, W. N. (1999). *Honored but invisible: An inside look at teaching in a community college.* New York: Routledge.

Hahn, H. (1999). The political implications of disability definitions and data. In R. P. Martinelli & A.E. Dell Orto (Eds.), *The psychological and social impact of disability* (4th ed., pp. 3-11). New York: Springer.

Hall, L. M., & Belch, H. A. (2000). Setting the context: Reconsidering the principles of full participation and meaningful access for students with disabilities. *New Directions for Student Services, 91*, 5-17.

Henderson, C. (2001). *College freshman with disabilities: A biennial statistical report.* Washington, DC: American Council on Education.

Higbee, J. L. (2001). Implications of universal instructional design for developmental education. *Research and Teaching in Developmental Education, 17*(2), 67-70.

Hitchcock, C., Meyer, A. Rose, D. & Jackson, R. (2002). Providing new access to the general curriculum: Universal design for learning. *Council for Exceptional Children,* 8-16.

Horn, J., & Bobbitt, L. (1999). *Students with disabilities in postsecondary education: A profile of preparation, participation, and outcomes.* Washington, DC: National Center for Educational Statistics.

Jarrett, D. (1997). *Inquiry strategies for science and mathematics learning.* Portland, Oregon: Northwest Regional Educational Laboratory.

Jensen, J. M., McCrary, N., Krampe, K., & Cooper, J. (2004). Trying to do the right thing: Faculty attitudes toward accommodating students with learning disabilities. *Journal of Postsecondary Education and Disability, 17*(2), 81-90.

Johnson, B., & Christenson, L. (2004). *Educational research: Quantitative, qualitative and mixed approaches* (2nd ed.). Boston: Pearson.

Kardash, C. M., & Wallace, M. L. (2001). The perceptions of science classes survey: What undergraduate science reform efforts really need to address. *Journal of Educational Psychology, 93*(1), 199-210.

Kenyon, L. O. (2003). *The effect of explicit, inquiry instruction on freshman college science majors' understanding of the nature of science.* Unpublished doctoral dissertation, University of Houston, Houston.

Kim, J. & Mueller, C. (1978). *Introduction to factor analysis, What it is and how to do it.* Beverly Hills: Sage.

Kolb, D. A. (1984). *Experiential learning*, Englewood Cliffs, NJ: Prentice Hall.

Kumar, D., Ramasamy, R., & Stefanich, G. P. (2001). Science for students with visual impairments: Teaching suggestions and policy implications for secondary educators. *Electronic Journal of Science Education, 5*(3), 1-9.

Lawson, A. E. (2002). Using the RTOP to evaluate reformed science and mathematics instruction. In N. R. Council (Ed.), *Improving undergraduate instruction in science, technology, engineering and mathematics* (pp. 89-100).Washington, D.C.: The National Academy Press.

Leyser, Y., Vogel, S., & Wyland, S. (1998). Faculty attitudes and practices regarding students with disabilities: Two decades after implementation of section 504. *Journal on Postsecondary Education and Disability, 13*(3).

Longmore, P.K. & Umansky, L. (2001). Disability history: From the margins to the mainstream. In P.K. Longmore and L. Umansky (Eds.), *The new disability history: American perspectives* (pp. 1-29). New York: University Press.

Mace, R. (1997). Center for Universal Design. North Carolina State University. School of Design. Retrieved December 2, 2004 from http://www.design.ncsu.edu:8120/cud/univ_design/ud.htm

Marinelli, R. P., & Dell Orto, A. E. (Eds.). (1999). *The psychological & social impact of disability* (4th ed.). New York: Springer.

Martino, G., & Marks, L.E. (2000). Cross-modal interaction between vision and touch: The role of synesthetic correspondence. *Perception, 29*(6), 745-754.

Mayer, R.E. & Anderson, R.B. (1992). The instructive animation: Helping students build connections between words and pictures in multimedia learning. *Journal of Educational Psychology*, 82 (2), 715-726.

McAlexander, P. J. (2003). Using principles of universal design in college composition courses. In J. L. Higbee (Ed.), *Curriculum transformation and disability: Implementing universal design in higher education* (pp. 105-114). Minneapolis, MN: Center for Research on Developmental Education, University of Minnesota.

McCormick, B. (2004). Science education reform and higher education: A historical perspective. In D. W. Sunal, E. L. Wright & J. Bland Day (Eds.), *Reform in undergraduate science teaching for the 21st century*. Greenwich, CT: Information Age Publishing.

McLaren, P. (1994). *Life in schools: An introduction to critical pedagogy in the foundations of education* (2nd ed). New York: Longman.

McLaren, P. (1995). *Critical Pedagogy and Predatory Culture*. New York: Routledge.

Mellow, G. O. (2000). *The history and development of community colleges in the United States.* Paper presented at the Combined Seminar of the Inter-American Development Bank and the Harvard Graduate School of Education, Cambridge, MA.

Merriam, S. (1998). *Qualitative Research and case study applications in education.* San Francisco: Jossey-Bass.

Meyer, A., O'Neil, L. (2000, March). Beyond access: universal design for learning. *The Exceptional Parent*, 30 (3), 59-61.

Miksch, K. L. (2003). Universal instructional design in a legal studies class. In J. L. Higbee (Ed.), *Curriculum transformation and disability: Implementing universal design in higher education* (pp.163-169). Minneapolis, MN: University of Minnesota, Center for Research on Developmental Education.

Miglietti, C. Strange, C.C. (1998). Learning styles, classroom environment preferences, teaching styles, and remedial course outcomes for underprepared adults at a two-year college. *Community College Review, 26* (1), 1-19.

Moran, A. (1991). What can learning styles research learn from cognitive psychology. *Educational Psychology, 11*(3/4), 239-245.

Najjar, L.I. (1996). Multimedia information and learning. *Journal of Educational Multimedia and Hypermedi*a, *5* (2), 129-150.

National Center for Educational Statistics. (1996a). *National Education Longitudinal Transition Study, Methodology Report.* Washington, DC: Author.

National Center for Educational Statistics. (1996b). *National Postsecondary Student Aid Survey: 1996.* Washington, DC: Author.

National Center for Educational Statistics. (1999). *National Education Longitudinal Transition Study.* Washington, DC: Author.

National Center for Educational Statistics. (2000). *National Postsecondary Student Aid Survey: 2000.* Washington, DC: Author.

National Center for Educational Statistics. (2002a). *Digest of education statistics.* Washington. DC.

National Center for Educational Statistics (2002b). *National study of postsecondary faculty.* Washington, DC: Author.

National Center for the Study of Postsecondary Educational Supports. (2000). *National survey of educational support provision to students with disabilities in postsecondary education settings: Technical report.* University of Hawaii.

National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for educational reform.* Washington, D.C.: U.S. Government Printing Office.

National Research Council. (2001). *Educating teachers of science, mathematics, and technology for the new millennium.* Washington, DC: National Academy of Sciences.

National Research Council. (2001). *Evaluating and improving undergraduate teaching in science, technology, engineering and mathematics.* Washington, DC: The National Academy Press.

National Research Council. (2003a). *Evaluating and improving undergraduate teaching in science, technology, engineering and mathematics*. Washington, DC: The National Academy Press.

National Research Council. *(2003b). National science education standards*. (9th ed.). Washington, DC: National Academy Press.

National Science Foundation. (1989). Task Force on Women, Minorities and Handicapped in Science and Technology. *Changing America: The new face of science and engineering.* Arlington, VA: Author.

National Science Foundation. (1986). National Science Board, Task Committee on Undergraduate Science and Engineering Education. *Undergraduate science, mathematics and engineering education; Role for the National Science Foundation and recommendations for action by other sectors to strengthen collegiate education and pursue excellence in the next generation of U.S. leadership in science and technology,* Arlington, VA: Author.

National Science Foundation. (1996) *Shaping the Future: New expectations for Undergraduate education.* Arlington, VA: Author.

National Science Foundation. (1999). National Science Board. *Report on mathematics and science achievement.* Retrieved on November 10, 2004 from http://nsf.gov/nsb/documents/1999/nsb9931/nsb9931.txt

National Science Foundation. (2000). *Land of plenty: diversity as America's competitive edge in science, engineering and technology.* Arlington, VA: Author.

National Science Foundation. (2002). *Women, minorities and persons with disabilities in* science *and engineering.* Arlington, VA: Author.

National Science Foundation. (2004). *Women, minorities and persons with disabilities in science and engineering*. Arlington, VA: Author.

Okwis, R. (1999). Universal design: Ensuring access to the general education curriculum. *Research Connection in Special Education*, 5_2 2-7.

Orkwis, R. McLane, K. (1998). *A curriculum every student can use design principles for student access.* ERIC/OSEP Topical Brief ED423654.

Oliver-Hoyo, M., Allen, D., & Anderson, M. (2004). Inquiry-guided instruction. *Journal of College Science Instruction, 33*(6), 20-24.

Olkin, R. (2002). Could you hold the door open for me? Including disability in diversity. *Cultural Diversity and Ethnic Minority Psychology, 8*(2), 130-137.

Patten, M. (2001). *Questionnaire research: A practical guide* (2nd ed.). Los Angeles: Pyrczak.

Peterson, P. E. (2003). Ticket to nowhere: in the wake of A Nation at Risk, educators pledged to focus anew on student achievement. Two decades later, little progress has been made. *Education Next, 3*(2), 39-46.

Piburn, M., Sawada, D., Falconer, K., Turley, J. Benford, R., Bloom, I. (2000). Reformed Teaching Observation Protocol (RTOP). ACEPT IN-003. Temple, AZ: Arizona Collaborative for Excellence in the Preparation of Teachers. Retrieved on February 21, 2004 from http://cresmet.asu.edu/prods/rtop.shtml

Pisha, B., Coyne, P. (2001 July/August). Smart from the start: the promise of universal design for learning. *Remedial and Special Education, 22* (4), 197-203.

Quick, D., Lehmann, J., & Deniston, T. (2003). Opening doors for students with disabilities on community college campuses: What have we learned? What do we need to know? *Community College Journal of Research and Practice, 27*, 815-827.

Reeve, S., Hammond, W., & Bradshaw, W. (2004). Inquiry in the large-enrollment science classroom. *Journal of College Science Teaching, 34*(1), 44-48.

Rehabilitation Act of 1973, (1973) Pub. L. No. 93-112, 87 Stat.355, 29 U.S.C. 701 et seq.

Reitz, C. (2002). Elements of education: Critical pedagogy and the community college. In J. J. Slater, S. M. Fain & C. A. Rossatto (Eds.), *The Freirean Legacy: Education for social justice* (pp. 198-206). New York: Peter Lang.

Reiter, S., & Asgad, B. (1992). Theoretical analysis and comparison of current attitudes in special education and rehabilitation: an outline of three models. *Issues in Special Education and Rehabilitation, 7*(1), 113-126.

Rioux, M. H. (1997). Disability: the place of judgment in a world of fact. *Journal of Intellectual Disability Research, 41*, 102-111.

Rose, D. (2000, Winter). Universal design for learning. *Journal of Special Education Technology, 15* (1), 67-70.

Rose, D.H. & Meyer A. (2002). *Teaching every student in the digital age: Universal design for learning.* Alexandria, VA: Association for Supervision and Curriculum Development.

Rossman, G. B., & Rallis, S. F. (2003). *Learning in the field: An introduction to qualitative research* (2nd ed.). Thousand Oaks, CA: Sage.

Sandue, J.S. (2000). Citizenship and universal design. *Aging International, 25* (4), 80-81.

Sarrison, L.C. (1999). *Learning style perspective: impact in the classroom.* Madison, WI: Atwood.

Scott, S. S., McGuire, J. M., & Shaw, S. F. (2003). Universal design for instruction: A new paradigm for adult instruction in postsecondary education. *Remedial and Special Education, 24*(6), 369-379.

Seymour, E., & Hewitt, N. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder, Colorado: Westview Press.

Seymour, J., & Hunter, A.B. (1998). *Talking about disability: The education and work experiences of graduates and undergraduates with disabilities in science, mathematics, and engineering majors* (AAAS No. 98-02S). Washington, DC: American Association for the Advancement of Science.

Shunit, R. (2000). Society and disability: A model of support in special education and rehabilitation. *Focus on Exceptional Children, 32*(8), 15-28.

Sims R.R. & Sims S.J. (1995). *The importance of learning styles: Understanding the implications for learning, course design and education.* Westport, CT: Greenwood Press.

Sireci, S. G., Zanetti, M. L., Cadman Slater, S., & Berger, J. B. (2001). *STEMTEC evaluation report for year 4*. Amherst, MA: University of Massachusetts.

Silver, P., Bourke, A. B., & Strehorn, K. C. (1998). Universal instructional design in higher education: An Approach for Inclusion. *Equity and Excellence in Education, 31*(2), 47-51.

Smith, D. (1997). Student diversity: Challenge and potential for faculty motivation. In J. L. Bess (Ed.), *Teaching well and liking it* (pp. 248-267). Baltimore: Johns Hopkins University Press.

Spradley, J. (1980). *Participant observation.* New York: Holt, Rhinehart & Winston.

Stafford, J. Y. (1990). *Effects of active learning with computer-assisted or interactive video instruction.* Unpublished Dissertation, Wayne State University, Detroit, Michigan.

Stahl, S., Branaman, J. (2000). Automatic accommodations: The potential of online learning for all students [18 paragraphs]. *Student Affairs Online, 1* (1). Retrieved September 10.2004, from http://www.studentaffairs.com/ejournal/ Spring_2000/article3.html.

Stefanich, G. P., & Norman, K. I. (1999). *Teaching science to students with disabilities: Experiences of classroom teachers and science educators.* Washington, DC: Association for the Education of Teachers in Science.

Sternberg, R.J. & Grigorenko, E.L. (2002). Applying the theory of successful intelligence as a basis for instruction in higher education. In D.E. Halpren & M.D. Hakel (Eds.), *Applying the science of learning to university teaching and beyond.* San Francisco, CA: Jossey-Bass.

Strauss, A. & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory*(2nd ed). Thousand Oaks, California: Sage.

Stodden, R. A. (2001). Postsecondary education supports for students with disabilities: A review and response. *Journal for Vocational Special Needs Educatoin, 23*(2), 4-11.

Sunal, D. W., Sunal, C. S., Whitaker, W., Freeman, L. M., Odell, M., Hodges, J., et al. (2001). Teaching science in higher education: Faculty professional development and barriers to change. *School Science and Mathematics, 10*(5).

Sylwester, R. (1995). *A celebration of neurons.* Alexandria, VA: Association for Supervision and Curriculum Development.

Szymanski, E. M., & Trueba, H. T. (1999). Castification of people with disabilities: Potential disempowering aspects of classification in disability services. In R.P. Martinelli & A.E. Dell Orto (Eds.), *The psychological and social impact of disability* (pp. 195-211). New York: Springer.

Talaga, T. (2000). Rethinking the brain. *The Brain in the News.* p. 3.

Taylor, P. C., Gilmer, P. J., & Tobin, K. (2002). Introducing transformations. In P. C. Taylor, P. J. Gilmer & K. Tobin (Eds.), *Transforming undergraduate science teaching: Social constructivist perspectives* (pp. 183-186). Washington, D.C.: Peter Lang.

Tuitt, F. (2003). Realizing a more inclusive pedagogy. In A. Howell & F. Tuitt (Eds.), *Race and higher education: Rethinking pedagogy in diverse college classroom.* Cambridge, MA: Harvard Education Press.

U.S. Census Bureau. (2003). *Disability Status: 2000..* Washington, DC: U.S. Department of Commerce.

U.S. Department of Justice (2002). *A guide to disability rights law.* Washington, DC: Author.

U. S. General Accounting Office Report (2003). *Special education: Federal actions can assist states in improving postsecondary outcomes for youth* (Publication No.GAO-03-773). Washington, DC: U.S. Government Printing Office.

Walczyk, J. J., & Ramsey, L. (2003). Use of learner-centered instruction in college science and mathematics classrooms. *Journal of Research in Science Teaching, 40*(6), 566-584.

Wolanin, T. R., & Steele, P. E. (2004). *Higher education opportunities for students with disabilities.* Washington, DC: The Institute for Higher Education Policy.

Yin, R. K. (2003). *Applications of case study research* (2nd, ed.). Thousand Oaks, CA: Sage.