AN ABSTRACT OF THE DISSERTATION OF

Valory Rae Anna Thatcher for the degree of Doctor of Philosophy in Education presented on February 23, 2014.

Title: Issues Experienced by Community College STEM Faculty Implementing and Using Pedagogies of Engagement

Abstract approved:____

Darlene F. Russ-Eft

The purpose of this study was to explore the issues involved with implementing and using pedagogies of engagement in community college STEM courses. The rationale for this study was based on current and emerging STEM education policy directives calling for an updated approach to teaching undergraduates, focused on student engagement, and also the need to include the perspectives of community college faculty in guiding the refinement of these policies.

Pedagogies of engagement are classroom techniques intended to stimulate deeper and more student-centered learning experiences and include such activities as calibrated peer review, cooperative learning, interactive lectures, case-based studies, and peer-led learning. Numerous studies have indicated that pedagogy intending to better engage students can improve learning as well as retain and even recruit students into STEM fields. Therefore, engagement has been a central theme in recent education policy. Given the relatively-new policy encouraging the use of pedagogies of engagement in undergraduate STEM courses, research that contributes to this topic is significant, especially in the community college setting, a focus that is rarely highlighted in the literature.

This study was designed to contribute to the growing body of research about how pedagogies of engagement can improve community college STEM

programs by investigating issues that full-time faculty experience when implementing and using these pedagogical strategies. This study was guided by the following foundational questions: (1) What are the issues involving pedagogies of engagement in community college STEM programs? (2) How can the identified issues be resolved? (3) What strategies can be used for implementing and using pedagogies of engagement?

This study employed a qualitative research approach focusing on six individual community college full-time faculty members who were experienced with these instructional styles. These individuals were recruited via a preliminary screening survey that determined their experience with the techniques and willingness to be interviewed. The data gathered in this study consisted of in-person interviews, analysis of supportive documentation provided by or referred to by the participants, and participant feedback of the results.

The issues experienced by full-time community college STEM faculty when implementing and using pedagogies of engagement were broadly organized into the following themes: student issues, faculty issues, and external issues. Student issues involved student resistance and the perception of engaged pedagogy being of lesser value than traditional lecture-based instructional approaches. Faculty issues included skepticism of the efficacy of the pedagogy, the need for curriculum planning time, cost of facility and equipment upgrades, and the lack of assessment tools to measure student engagement. External issues included insufficient access to professional development opportunities with an engagement focus and also the need for faculty evaluation systems with student engagement as a key outcome. The study findings revealed that those issues could be resolved through collaborative team problem-solving approaches and through participation in high-quality professional development programs. Finally, in regard to the final research question involving strategies for implementing and using pedagogies of engagement, questions for practice were developed that community college educators might consider when implementing these instructional strategies.

Issues Experienced by Community College STEM Faculty Implementing and Using Pedagogies of Engagement

by

Valory Rae Anna Thatcher

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Chapter 1 - Introduction

Improving education in math and science is about producing engineers and researchers and scientists and innovators who are going to help transform our economy and our lives for the better.

President Barack Obama, November 23, 2009

Leadership in science, technology, engineering, and mathematics has been a national priority since this country's inception because scientific and technological innovations are fundamental engines of modern society. STEM professionals are vital to every aspect of our lives. They discover our medicines, invent technology to connect us, and build the structures on which our civilization depends. Therefore, student success in STEM fields is an ongoing and significant issue. Recent trends have alarmed policy makers and industry leaders with statistics such as a 5% decrease in undergraduates in science and engineering compared to the 1980s, despite persistently-high STEM employee compensation and robust demand for workers (Carnevale, Smith, & Melton, 2011; Galama & Hosek, 2008).

Given the necessity for continued innovation in the STEM fields, a multitude of reports in recent years have called for enhancing American competitiveness in science, technology, mathematics, and engineering, including those from the American Association for the Advancement of Science (2011), the National Research Council (2007, 2012), the National Science Board (2012), the National Science Foundation (2005) and Project Kaleidoscope (2006, 2007). The common themes of these reports were: that the number of STEM graduates in the U.S. has not kept pace with comparable foreign STEM graduates and that the U.S. has fallen far behind in innovation, research, and production (Maloney, 2007; U.S. Congress Joint Economic Committee, 2012). As stated by House Science Committee Chairman Boehlert (2005), "If the United States rests on its withering laurels in this competitive world, we will witness the slow erosion of our pre-eminence, our security, and our standard of living" (para. 2). The Business

Roundtable (2005) warned that, if current trends continue, the vast majority of all scientists and engineers in the world will live in Asia. Wells, Sanchez, and Attridge (2009) went further in their conclusion that increased global competition, lackluster performances in mathematics and science education, and a lack of national focus on renewing science and technology infrastructure have created a new economic and technological vulnerability as serious as any military or terrorist threat. The U.S. Census Bureau (2010) projects that in the year 2020, the economy will need triple the number of STEM graduates. These projections have alarmed key leaders in industry, government, and academia who are therefore urging innovative approaches to increasing the capacity and quality of the STEM education pipeline so that Americans can retain leadership in the increasingly-competitive global economy. These concerns are also integrated into current national science policy and science education policy.

Higher education has been identified to have a particularly important role in addressing the STEM challenge. In the opening statement for the congressional hearing *Building America's competitiveness: Examining what is needed to compete in a global economy* (2006) Chairman Howard McKeon's opening remarks cited the need to "better coordinate and implement reforms that improve math and science education" (p. 4). The Higher Education Opportunity Act (HEOA) reauthorization of 2008 addressed the mandates set forward in current national education policy and further articulated the need for STEM reform and promotion to develop truly relevant 21st-century education.

Capable students that divert from the STEM educational pathway represent a complex puzzle that concerns higher education and industry. Carnevale, Smith, and Melton (2011) found that: less than 20% of students initially intending to obtain a STEM degree graduate with a STEM degree, and only 10 out of 19 STEM graduates work in that respective STEM field. Enrollment data from the National Science Board (2004; 2012) indicates that the greatest attrition from STEM majors occurs within the first two years of college and that the losses are highest for minority students and women. Research suggests that these trends are not due to students' performance or attitudes (Seymour & Hewitt, 1997). Instead, these trends are correlated to loss of interest, perceptions of poor pedagogy, and feelings of being overwhelmed by the curriculum.

One promising higher education reform strategy advocated by the National Science Foundation's Project Kaleidoscope (2007) is the use of pedagogies that increase student engagement in undergraduate STEM courses as a means to address the issue of disinterested students who exit the STEM pipeline. Pedagogies of engagement, a term originally coined by Edgerton (2001), are those teaching methods that focus on student-faculty interaction, collaboration among students, and the active involvement of students in the learning process. Some common pedagogies of engagement in the STEM fields include investigative case-based learning, process-oriented guided inquiry learning (POGIL), cooperative learning, and calibrated peer review, to name a few (Project Kaleidoscope, 2007).

Emerging research in regard to the effectiveness of specific pedagogies of engagement at four-year institutions shows positive impacts on student learning outcomes and retention (Alarcon, Edwards, & Menke, 2011; Minderhout & Loertscher, 2007; Papinczak, 2007; Redish & McDermott, 1999; Sendag & Odabasi, 2008; Zepke, 2013). How community colleges implement and use these pedagogies effectively, however, is research yet to be done. Because research has indicated that STEM attrition is greatest in the first and second years of college (Seymour & Hewitt, 1997), and community colleges primarily serve students in these levels, community colleges are particularly important to include in the reform of American STEM education. That was also the rationale for this study. The purpose of this research was to explore the issues regarding the use and implementation of pedagogies of engagement in community college STEM programs. This study also examined issue resolution strategies that faculty used while implementing the strategies. Finally, from the findings of this study, questions for practice or practitioners were developed.

Research Purpose and Questions

The national calling to reform pedagogy in higher education STEM programs is the rationale for this study. Specifically, this research addresses the topic in regard to the community college from a faculty perspective. The intended outcome of this research was to identify strategies for implementation of pedagogies of engagement to the mainstream by answering the following research questions:

1. What are the issues involving pedagogies of engagement in community college STEM programs? Research into pedagogies of engagement in the community college is rarely considered. Given the large number of students who enter higher education via community colleges, research that helps to address this gap in the literature is valuable.
2. How were the identified issues resolved? Anticipating and resolving the issues involved with the adoption of these pedagogies will have practical significance to educators as they reform their STEM programs. How can community college programs determine the success of these pedagogies? How can they assessed? How expensive are they to implement? How can pedagogies of engagement work with existing laboratory facilities? This study sought to answer questions regarding issues such as these. I hope that the findings from this study will assist college educators as they plan STEM education improvement efforts.
3. What strategies can be used for implementing and using pedagogies of engagement? Ultimately, from this research, I produced questions based on the recommendations from the study participants. This research will, in addition to informing practice, ideally promote the implementation of these pedagogies.

Significance of the Study

Numerous agencies, including the American Association for the Advancement of Science (2011) and the Association of American Universities (2011), are urging reforms for STEM education in response to decreasing numbers of undergraduates pursuing STEM degrees. In addition to these reports calling for reform, key leaders in industry, government, and academia continue to emphasize the need for a highly-skilled and creative workforce in order to keep America competitive in an increasingly global and high-tech world (Project Kaleidoscope, 2007). Input from the National Research Council's (2007) report *Rising Above the Gathering Storm* compiled recommendations that have been largely incorporated into current national science education policy language found in the 2008 re-authorization of the Higher Education Opportunity Act (HEOA). This latest re-authorization of the HEOA not only recognized the need for STEM progress but also highlighted the need to improve STEM education efforts, particularly in higher education settings.

According to Weiman (2007), traditional teaching methods are inferior to methods that actively engage the student in the learning process. Pedagogies of engagement are a variety of instructional techniques that increase student engagement. Pedagogies of engagement have been shown to improve student learning and success (Crouch & Mazur, 2001; Hake, 1998; Kozhevnikov & Thornton, 2006; Redish, Saul, & Steinberg, 1998). However, despite research that documents pedagogies of engagement positively affecting student learning outcomes, adoption of these pedagogies is not widespread (Weiman, 2007).

This research intended to investigate the issues involving the implementation and use of pedagogies of engagement in community colleges. By contributing to the understanding of the issues in regard to this topic, this research will inform practitioners on how to successfully and efficiently implement these strategies. In addition to having practical significance for community college educators, due to the lack of research conducted on this topic in the community college setting, this research will also have scholarly significance by addressing the gap in the literature.

According to the U.S. Census Bureau (2012), approximately 40% of all college students begin their experience in higher education at a community college. For students pursuing STEM fields, about half of all college students begin their studies at a community college (Starobin & Lanaan, 2010). Considering this significant population of students, it is vital that community colleges be included in the national conversation about reforming STEM education as mandated by national science policy (Hagedorn & Purnamasari, 2012). While the greatest impact from this research will be to inform community college practitioners, this research also seeks to inform policy makers as they craft future science education policy.

This topic is also one of deep personal significance to this researcher. As a scientist and community college science teacher, I am passionate about STEM education and its improvement. This topic encapsulates both my teaching philosophy and the focus of my present and future professional practice. Having experienced the success of many of these pedagogies first-hand, I am intrigued by the challenge of promoting their mainstream adoption within my own institution and beyond. My background also supports my approach to study this topic from a faculty-perspective. While this is discussed as a limitation of this study in the concluding chapter, talking to fellow teachers about the challenges they have faced and addressed is, to me, a logical approach.

According to Weiman (2007), "it remains a challenge to insert into every college and university classroom these pedagogical approaches and a mindset that teaching should be pursued with the same rigorous standards of scholarship as scientific research" (p. 15). The notion that this research process could sharpen my personal practice as an educator was certainly an incentive to choose this topic.

It was a fascinating and fulfilling experience. This research experience resulted in a critical self-evaluation of my epistemology, my teaching philosophy, my style of leadership, and my relationship to high-level research and scholarship.

Summary

Scientific and technological progress is a fundamental necessity in a dynamic and thriving society. Without responsible and forward-focused research and discovery in the STEM fields, the health, prosperity, and security of the modern world is at stake. Recently, many key stakeholders have called for a reformed approach to STEM education. One promising reform strategy involves numerous pedagogical methods collectively known as pedagogies of engagement. While pedagogies of engagement show consistent efficacy in improving student learning outcomes, little research exists concerning the issues involving their adoption and implementation, especially in community colleges. Given that community colleges serve large populations of students, and given that most students exit STEM early in their first two years of college, it is vital that community colleges be included in STEM education reform conversation. The research indicates a need in the research literature articulating the voice of the community college with its unique issues. This study attempted to address the absence of research examining community college STEM program use and implementation of pedagogies of engagement, learning strategies that research indicates stimulate deeper learning and excitement for the subjects.

Chapter 2 – Literature Review

The purpose of this literature review is to create the context and rationale for a research study exploring the issues involving pedagogies of engagement in community colleges science, technology, engineering, and mathematics (STEM) programs as well as to identify effective resolution strategies for those issues. The goals of this review were to explore the foundational questions guiding this study and provide insights on its design.

In order to provide a thorough background for this research, multiple academic databases available through the Oregon State University library were used as a primary means of collecting literature sources; these databases included Academic Search Premier, ERIC, EBSCOhost, and Dissertation Abstracts, using the following key words: STEM education, science education, science policy, STEM policy, STEM reform, engaged learning, engaged learners, pedagogies of engagement, and community college. Books, peer-reviewed journals, dissertations, and national reports were the primary reference sources used. Bibliographies from those primary sources were examined for additional resources.

National science policy involving the STEM fields is significant both historically as well as on an ongoing basis. It is reflected in many of this nation's developmental milestones from as far back as the framing of the U.S. Constitution, and it continues to play a vital role in STEM education today. Because science policy is intended to ensure STEM progress, it is important to understand the role of science policy in education. In order to provide a brief historical overview of science policy, documents from the United States Congress and national agencies including the National Science Foundation, National Science Board, and the National Academies of Science were used. Current science education policy for higher education is an aspect of the Higher Education Opportunity Act (HEOA). The current HEOA, 2008 reauthorization, was carefully analyzed in relation to

STEM. Congressional testimony and reports that guided the policy language of the HEOA were also examined.

In addition to pedagogy, STEM education reform has multiple components, including teacher professional development, facility upgrades, and curricula, to name a few. In order to narrow the scope of STEM education reform, pedagogies of engagement became the focus of this research. Pedagogies of engagement were chosen, because their implementation and use is advocated by the NSF-funded organization Project Kaleidoscope (an informal network of STEM education advocates and reformers). Pedagogies of engagement are not necessarily new to K-12 education systems, but their usage in higher education STEM fields is relatively new. While research involving community college settings were emphasized, to better understand the topic of student engagement, research studies examining pedagogies of engagement in K-12 were included.

Organization

During the course of this literature search and review, four major themes became apparent, and this literature review is organized to reflect those themes in four sections.

1. The first theme reviews the historical development of national science policy and its influential role in shaping current national science education standards and outcomes. After a brief historical overview of science policy and its function, this section reviews current science education policy as outlined in the Higher Education Opportunity Act (HEOA), which was re-authorized in 2008. Given the breadth of the HEOA, this section is particularly focused on policy specific to STEM.
2. The second theme focuses specifically on the influence of science policy on undergraduate STEM educational practice. This section will provide additional context for understanding the connection between science policy and pedagogical reform initiatives. Since the 1950's, science policy has periodically directed educators to reform their approaches. Those efforts

have been evident in the classroom from changes in curricula and learning outcomes to teacher professional development.

3. The third theme explores the topic of student engagement. This section examines how student engagement has been a focus for increasing achievement by stimulating deeper learning. This theme also focuses on research involving pedagogies of engagement as one promising method for improving STEM in undergraduate education. Policy-directing agencies, such as the National Science Foundation and Project Kaleidoscope, have advocated the use of pedagogies of engagement to improve student learning and interest in the STEM fields and to comply with science policy mandates calling for improvement to STEM education. This theme examines pedagogies of engagement from an efficacy perspective, since research exploring the issues involved with implementing them has yet to be done.
4. The final theme involves the critical role of community colleges in preparing students for STEM-related careers. Because community colleges are generally omitted from the research involving pedagogies of engagement, this section identifies the gap in the literature. Given the significant number of students who enter higher education via a community college, this section also emphasizes the significant need for research involving these institutions.

Key Definitions and Clarifications

Before this literature review addresses the larger themes and creates a context for the present research, it is beneficial to clarify the following key terms: science, technology, engineering, mathematics, STEM, and science policy. According to the dictionary (Merriam-Webster, 1993), the word science itself is derived from the Latin word *scientia* meaning knowledge. Science describes both a process and an outcome – it is the process of obtaining knowledge, and it is the knowledge that is obtained via that scientific process. The terms science and technology can be understandably confused because the terms are frequently used synonymously. Technology, however, is contrasted from science in that technology "derives from a conscious attempt to draw upon existing scientific or engineering knowledge for the purpose of achieving a specific material result" (Homer, Tobin, & McCormick, 2008, p. 6). A similar confusion can occur between the terms science and engineering, which are summarily regulated under the umbrella term of "science " despite the fact that today engineering and science are understood to be distinct disciplines. Engineering, according to the *New Merriam-Webster Dictionary* (1993), is defined as the "branch of science and technology pertaining to the design, construction, and use of structures" (p. 303). Mathematics is a similar term that encompasses the language in which scientific principles are codified and explored. Mathematical fluency is thus a necessity and is included in the construction of policy regulating science, technology, and engineering. Given the close association that these fields share, it is common to refer to them simultaneously. The term STEM is a popular acronym originally coined by Judith Ramaley, the former Assistant Director of the Education and Human Resources Directorate at the National Science Foundation (Chute, 2010). Finally, the term science policy requires clarification. Science policy is STEM policy. For the purpose of this literature review, science policy refers to the "federal rules, regulations, methods, practices, and guidelines under which scientific research is conducted" (Homer, Tobin, & McCormick, 2008, p. 9).

Overview of American Science Policy

This section of the literature review is intended to provide historical context for this study. It begins by describing the development of America's national science policy followed by examination of current science education policy as specified in the Higher Education Opportunity Act (HEOA). It is important to initially approach this study from a policy perspective, because national science policy is a driver of STEM education and its reform. Because science education policy is calling for improved approaches to STEM teaching, an understanding of national science policy is directly related to the rationale for the study.

Historical context for a national science policy. Scientific and technological progress is not inevitable. It is the consequence of significant personal, institutional, and national commitment. According to Dupree (1996), the United States has prospered from its long history of leading the world in scientific research and technological innovation, because it has long emphasized the importance of those pursuits. Among the framers of the U.S. Constitution were some of the premier scientific thinkers of the time. Indeed, science was such an important philosophical perspective that the topic of science itself was an integral aspect of the debates leading to the document ratified by the Constitutional Convention (Farrand, 1911).

The Constitutional Convention is the earliest record of the American government's attempt to synthesize a national policy to ensure scientific progress. The first mention came from James Madison, who produced a recommendation that the General Legislature "establish a university" (Farrand, 1911, p. 325). This proposition was referred to the Committee of Detail and unanimously moved forward for debate by Charles Pinckney. Pinckney's final report called for the establishment of "seminaries for the promotion of literature and the arts and sciences" and went as far as to recommend an established "public institution" to promote these ambitions (p. 325). While this plan was eventually dismissed out of concern about the magnitude of general powers inherent in the national government, it remains an important realization that a national dedication to science was an impetus of the founding fathers (Dupree, 1986; Farrand, 1911). The ultimate compromise language in the U.S. Constitution became: "To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoverie" (U.S. Const. art. I, §8 cl 8., 1787).

Although a national science policy would not exist until the middle of the twentieth century, standardized science education gradually developed from the driving influences of the agricultural and manufacturing industries. These industries directed workforce development in the directions of complexity and specialization (Dupree, 1986). This paradigm shift eventually created citizens who were increasingly "specialized, more professional in their attitude, and more willing to cut the time lag on information disseminated from Europe," which was still widely considered the center of the world's knowledge (p. 45-46). The shift towards mechanized industrialization was an important and intransient fact about science education and policy until the era of World War II. It was at that point in American history that national science policy finally became a reality, and its role in education became a prominent influence.

World War II era science policy. In 1939, policy scholar Robert Lynd published *Knowledge for What?* In this book, Lynd expressed the view that science and technology should be addressed in terms of a national policy and that education would be a key factor in the endeavor. Lynd recognized the tremendous industrial focus toward technology coupled with a new awareness of the inter-dependence of science education and national policymaking. This was an important paradigm shift in thinking strategically about science on a national level; however, World War II dominated the activities of the President and the Congress for the next several years. It was not until this war came to a resolution that Lynd's ambitions were considered.

President Franklin D. Roosevelt wrote a letter on November 17, 1944 to Vannevar Bush, the director of the Wartime Office of Scientific Research and Development at the time, to solicit advice on how to transition the American war machine into days of peace. It was clear in Roosevelt's letter that he saw a vision for science as a critical and central tenet for America to achieve the highest quality of life when he remarked that:

> New frontiers of the mind are before us, and if they are pioneered with the same vision, boldness, and drive with which we have waged this war we

> can create a fuller and more fruitful employment and a fuller and more fruitful life. (p. 1)

Bush's report, which synthesized the wisdom from four committees of distinguished scholars and scientists, was eventually published in 1945. The salient point of this report to the President was that a "National Science Foundation" should be established by the Congress to support and encourage basic research and education in the sciences and for the development of national science policy (Bush, 1945).

The transition into the Truman administration caused a significant delay in the founding of Bush's visionary National Science Foundation. After President Truman vetoed the initial legislation, he called for an expanded version of Bush's report (Mazuzan, 1988). This expanded report was produced by John Steelman, the chairman of the Scientific Research Board. This report was an epic treatise in five volumes. The first three volumes dealt with the federal government's special role in supporting the nation's total scientific effort, the fourth volume dealt with the problem of scientific and technical manpower, and the fifth volume dealt with research in the medical fields both in the government and in the nation at large (Steelman, 1947). Eventually, House Resolution 4846 and Senate Bill 247 passed, and President Harry S. Truman, from the caboose of a train in Pocatello, Idaho, signed Public Law 81-507, creating the National Science Foundation (Mazuzan, 1988).

The original National Science Foundation Act created the structural organization of the National Science Foundation (NSF) and its governing body, the National Science Board, with the mission to promote the scientific progress and to advance the national health, prosperity, and welfare (NSF Act, 42 U.S.C. § 1861-75, 1950). The Act made the National Science Board responsible for establishing the policies of the NSF and established its authority as the board of governors. The Act also directed the Board to advise the President and Congress, at their request or on its own initiative, regarding policy matters related to science and engineering and education in science and engineering (Mazuzan, 1988).

The newly-created NSF continued to support its ambitious mission at a relatively conservative pace until October 5, 1957. On that day, the Soviets successfully launched the world's first orbital satellite, Sputnik 1. That same year, the annual operational budget of the NSF went from $3.5 million to $134 million (Homer, Tobin, & McCormick, 2008). This expansion galvanized the important role of the NSF in guiding research agendas and science education policy.

Current science education policy. In addition to establishing and prioritizing research endeavors, national science policy directs science education policy. For higher education, science education policy is component legislation included within the comprehensive Higher Education Opportunity Act (HEOA). The original purpose of the HEOA was "to strengthen the educational resources of our colleges and universities and to provide financial assistance for students in postsecondary and higher education" (Higher Education Act, House Bill 621, 1965). It arose during a time of a new focus on civil rights and poverty issues under President Johnson, and according to Yager (2000), it expanded access to higher education for more lower and middle income families, assisted small and less developed colleges, improved libraries, and utilized college and university resources as vehicles of community economic development.

The HEOA is typically scheduled for reauthorization every four years and was most recently reauthorized in 2008. The next authorization of the HEOA is expected in early 2014 (Harkin, 2013). The HEOA is used as a vehicle for shaping educational policy via federal funding initiatives. Because its origin is intertwined with the era of civil rights, the HEOA has changed the landscape of who goes to college. Aside from legislation like the GI bill, which allowed many lower-income veterans to attend college, the HEOA has been the primary means for lower-income and minority Americans to access higher education. The HEOA also has driven initiatives related to a wide range of related issues such as teacher education, student retention, educational research and databases, and workplace and community training (Higher Education Opportunity Act, House Bill 4137, 2008).

In leading up the most recent 2008 reauthorization of the current Higher Education Opportunity Act, Howard P. McKeon (2006), then chairman of the congressional Education and Workforce Committee, cited a new global reality that "requires technology, innovation and new ideas as engines of growth. In many ways, we have left the age of muscle and the machine and have definitively entered the age of the mind" (p. 2). A key feature of this hearing was an understanding of the need to "better coordinate and implement reforms that improve math and science education" (p. 4). In a letter to this House committee, a coalition of business and education leaders noted, "Throughout our nation's history, American economic and technological strength has been built upon a large and highly skilled domestic workforce of scientists, technologists, engineers, and mathematicians – the STEM workforce" (STEM Education Coalition, 2007, p. 1).

Workforce gap analyses, from a number of states for STEM jobs, found that across the board, the number of STEM jobs continued to outpace the numbers of graduates prepared for those jobs. For instance, the Massachusetts Department of Education found that: four of the state's STEM occupational groups were experiencing job vacancy rates at or above the statewide vacancy rate average of 3.0%. Life, physical, and social sciences were particularly heavily affected, with vacancy rates of 5.9%, or nearly double the state average; similarly, 4.4% of healthcare occupations were vacant. (Conaway, 2007, p. 2) These findings influenced the Higher Education Opportunity Act (HEOA) reauthorization of 2008 with its strong emphasis on the need for STEM education reform and promotion.

STEM education in general received a boost from the 2008 reauthorization of the HEOA, especially under Title III but also significantly under Title I, Title II, and Title VI. In fact, the term "STEM" occurs 37 times in the 2008 amendments. Title I amendments include a call for a STEM database which lists "scholarships, fellowships, and other programs of federal, state, local, and, to the maximum extent practicable, private financial assistance available for the study of science, technology, engineering, or mathematics at the postsecondary and post-baccalaureate levels" (p. 3096). Title II promotes teacher training in science and math (p. 3164) while Title VI promotes "projects that support students in the science, technology, engineering, and mathematics fields to achieve foreign language proficiency" (p. 3334).

Because Title III focuses on institutional aid, Congress has used this title in particular to promote STEM via higher education institutions such as community colleges. The 2008 Title III amendments, in recognizing the importance of STEM education to the economic prosperity of the country as a whole, call for an increased focus on STEM promotion. Title III involves grants and partnerships for institutions of higher education that work to promote programs in STEM fields. Subpart 2 of Section 315 is labeled "Programs in STEM Fields," and section 355 of this subpart calls for "Grants to Eligible Partnerships" (p. 3182) specifically to encourage minority and underrepresented populations to pursue education and careers in STEM fields. Such partnerships include programs that promote "hands-on" science experiences that would draw young minority and low-income K-12 students into STEM paths. Section 356 focuses on "promotion of entry into STEM fields" and describes a campaign which includes "monitoring trends in youths' attitudes towards pursuing education and professions in the STEM fields," as well as finding out what factors are preventing students, especially those from underrepresented demographics, from entering STEM fields (p. 3183). Consistent with the original mission and vision of the HEOA, Title III promotion of STEM mentions as a priority "making specific appeals to Hispanic Americans, African Americans, Native Americans, students with disabilities and women, who are currently underrepresented in the STEM fields" (pp. 3183-3184).

The efforts of Congress to widen the scope of Title III to include STEM, as well as inclusion of STEM education promotion in other sections of the HEOA reauthorization, has been praised by educators and industry partners. In a letter to Congress, a coalition of STEM organizations commended Congress for recognizing “the vital role that strong science, technology, engineering, and mathematics (STEM) education programs play in ensuring our nation’s competitiveness in the global economy” (STEM Education Coalition, 2007, p. 1). This coalition, which also issued recommendations for STEM education inclusion in the HEOA reauthorization, includes education groups such as the Association for Science Teacher Education and the American Society for Engineering Education, as well as industry partners such as the Institute of Food Technologists and business networks such as the U.S. Chamber of Commerce.

Summary: Connections to this study. Leadership in science, technology, engineering, and mathematics has been a national priority since this country’s inception and continues to be a priority today. While the early attempts to create a national science policy were sporadic, eventually the American government embraced the ideal and formed the NSF. It is the ongoing mission of the NSF to direct and advocate for STEM education and science policy priorities. Understanding this historical context is important in understanding how political stakeholders, through the NSF, have influenced and continue to influence the current educational system.

The NSF is not the only agency advocating for STEM education reform. Key leaders in industry, government, and academia also recognize the need for innovative approaches to teaching and learning (American Association for the Advancement of Science, 2011; Project Kaleidoscope, 2007).

The most recent HEOA reauthorization recognizes the ongoing need for STEM education reform and promotion to develop truly relevant vocational education and better prepare students for the challenges they will face. In response to the alarming trend involving low numbers of undergraduates pursuing STEM careers despite record enrollments, national science policy and science education policy are urging reform. In particular, institutions of higher education are being urged to change their approach to teaching and supporting STEM courses.

Despite strong language in the HEOA indicating the importance of STEM in society and the need to improve upon STEM educational efforts, the act itself is massive (over 1,100 pages) and includes somewhat general descriptions of its mandates. This leaves practitioners with the daunting task of HEOA interpretation and implementation. The HEOA does make clear, however, that STEM educators must improve their efforts.

This literature review section reviewed science policy from a historical perspective to provide context for understanding current science education policy reform initiatives. This section also analyzed the HEOA in regard to STEM education. This analysis further articulates the significance, rationale, timeliness, and need for research involving STEM education improvement efforts that comply with science education policy mandates.

Linking Policy and Practice

Educators commonly ignore the influence and role of education policy, particularly science education policy, on their practice, i.e., pedagogy. According to Fensham (2009), "science education has a rather spectacular record of naiveté about educational policy and politics, and even about the politics of science education itself" (p. 1078). However, often unbeknownst to classroom educators and even educational administrators, policy does indeed have a significant impact on classroom practice. Fensham (2009) goes on to argue that science policy should directly influence student learning outcomes and thus shape the process of learning itself in a feedback cycle. Given the interplay between science policy and classroom pedagogy, it is important that this link be examined and appreciated by practitioners. This section of the literature review examines the link between science policy and science pedagogy. Following a brief history of how science policy has guided educational practices in the past, emphasis will be focused on current policy mandates calling for reform to STEM pedagogy.

According to Yager (2000), "In the late 1950s, Soviet space exploits resulted in massive reforms . . . that were drastically different from past reforms" (p. 51). This new appreciation of the global competition for scientific and technological supremacy created a new urgency and purpose for the NSF in regard to advocating for stronger STEM education initiatives. The NSF, according to Homer, Smith, and McCormick (2008), did not come to the decision to enter the curriculum development field lightly. Moving into the territory of *what* to teach was a difficult matter politically. As a result of this NSF movement, STEM curricula in the 1950s and 1960s became standardized, and content knowledge from textbooks was heavily emphasized (Yager, 2000).

This era dominated by the factual content in a textbook and the notion of "teacher-proof" curricula faded by the mid 1970's, and in 1978, the comprehensive study called Project Synthesis, commissioned by the NSF, released its results (Yager, 2000). Surprisingly, Yager's (2000) study indicated that even the "most interested and successful students had not learned" the fact-based curriculum (p. x). Harms and Yager (1981) described the need to understand the way science and technology affected individuals and impacted society. They articulated the need to shift away from academic preparation for science careers for a few students to academic preparation for all students with knowledge of science and technology for their own, everyday lives.

The educational curriculum phenomenon that emerged from Project Synthesis was called Science, Technology, and Society (STS). According to Yager and Roy (1993), the intent of the STS movement was to "integrate science and technology, the quintessential and pervasive characteristics of our culture, into all the traditional learning of society" (p. 7). STS can be a confusing term because it has evolved to include multiple curricula including: science-technology-citizenship, nature-technology-society, science for public understanding, citizen science, and functional scientific literacy (Solomon & Thomas, 1999). These STS curricula were often seen as vehicles for achieving such goals as science for all, scientific literacy, and for improving the participation of marginalized students in science education.

Gradually, a variety of assessment instruments and techniques (both qualitative and quantitative) were developed, showing unambiguously positive results as to the efficacy of STS curricula. Ratcliffe (1999), for instance, documented improvement in analyzing scientific journal articles in students from three groups: middle-school students, college science students, and science baccalaureate graduates. Although the abilities also increased with level of education, years of experience, and self-selection into science, Ratcliffe also discovered research analysis skills were improved across all three populations. In another 18-month action research project, Solomon and Thomas (1999) showed that students developed a more realistic understanding of science and the abilities of scientists. While these quasi-experimental studies showed that STS is a valid philosophy in terms of new curricula, they did not address actual classroom pedagogy. Indeed, the next (and current) phase of educational reform direction from the NSF addressed pedagogy. Specifically, the NSF has made recommendations on implementing pedagogy designed to increase student engagement (Project Kaleidoscope, 2007). Today, the NSF endorses student-centered STS curricula facilitated via pedagogies of engagement (Project Kaleidoscope, 2007).

As articulated in this review, the NSF has evolved its position over time. While it is possible that future educational efforts will involve other strategies, the educational efforts of today involve pedagogies of engagement and the ways in which they are improving STEM education. This policy perspective underlies the rationale for this research exploring the issues involved with pedagogies of engagement.

Summary: Connections to this study. Every generation has struggled with the prospect of scientific and technological progress; the need for improvement to our system of STEM education is certainly not new. These notions are integrated into both national science policy and national science education policy. Indeed, policy directly drives educational practices, as seen in the standardization and content-heavy era in science education resulting from post-Sputnik science policy. Similarly, new understanding about how humans learn, paired with the need to better recruit and retain students into STEM fields, drive current policy initiatives and educational reforms.

The STEM workforce is a critical aspect of the American economy. Moreover, STEM jobs are some of the fastest-growing and best-paying jobs available (Evans, McKenna, & Schulte, 2013). The U.S. Department of Commerce's Economics and Statistics Administration (ESA) issued a report in 2011 that found STEM job growth was three times greater than non-STEM job growth, and that STEM jobs were expected to continue to grow at a faster rate than other jobs in the coming decade. The report also found that STEM workers were less likely to experience joblessness during the economic recession. Future employment forecasts indicate that there will be 2.4 million STEM occupational vacancies in 2018 (Woods, 2009). Given the importance of STEM occupations, and the anticipation that demand for highly-skilled STEM workers will only increase in the near future, concern has been growing that the United States must increase and improve the STEM education pipeline.

This section of the literature review sought to frame the ongoing need for science education research with respect to national science policy and science education policy mandates. The national science agenda is focused on the importance of continuous progress in the STEM fields. Given the national science policy agenda, the STEM education agenda directs continuous progress in educating STEM students, and, specifically, the need to reform educational practices to recruit and retain better-prepared students in STEM fields. This also points out the need for not only additional research but for ongoing research. This supports the underlying premise of this research from both a policy and practical perspective.

A Focus on Engagement

Student engagement is an important and well-researched phenomenon. It has been directly linked to improved attendance, higher graduation rates, and a lessening of achievement gaps (Corso, Bundick, Quaglia, & Haywood, 2013). Pedagogy that engages students is also listed as the first educational practice priority in the Association of American Universities' Undergraduate STEM Initiative (2011). While its value is generally undisputed, the definition of student engagement can vary amongst researchers to involve academic, behavioral, emotional, social, as well as psychological transformations (Willms, Friesen, & Milton, 2009). Such complexity makes it difficult to pin down a simple understanding of the phenomenon. Yet, regardless of how it is defined, engagement is considered to be an important issue in education. Indeed, some educators consider student engagement to be *the* biggest challenge (Cothran & Ennis, 2000).

Despite the consensus that student engagement leads ultimately to academic success, the literature indicates that large numbers of students are chronically disengaged. In a recent study of American middle and high school students conducted by the Quaglia Institute for Student Aspirations (2012), results indicated that more than half of students were uninterested in school curriculum and did not enjoy being there. Alarmingly, disengagement has been shown to increase as students progress through grade levels, making remediation of those students more and more difficult (Eccles, Wigfield, & Schiefele, 1998).

Defining student engagement. The term engagement is certainly complex. However, the literature indicates that it can be generalized in different ways. Fredericks, Blumenfield and Paris (2004) suggested that engagement is comprised of three interdependent but distinct modes: thought, feeling, and action. Engagement in thought involves the psychological aspects of subject mastery as well as the desire to learn. Engagement in feeling involves a student's emotions regarding relationships between peers and teachers as well as the general senses of well-being in the academic setting and passion for the subject topics. Engagement in action involves attendance, in-class participation, compliance with school regulations, and completion of academic assignments.

Windham (2005) goes further in saying that engagement specifically involves (a) interaction, (b) exploration, (c) relevancy, (d) multimedia, (e) instruction, and (f) assessment. These themes echo throughout the research literature in studies by Willms, Friesen, and Milton (2009), Claxton (2007), and Hay (2000), to name a few. The desire for engaged learning comes not only from the instructional sphere. The majority of studies indicate that students themselves express a desire for challenge and engagement (Connell & Klem, 2006; Hay, 2000; Thiessen, 2006; Willms, Friesen, & Milton, 2009).

Pedagogies of engagement as an education reform strategy. In the last decade, the National Science Foundation has supported the genesis, evaluation, and adoption of pedagogies of engagement. Pedagogies of engagement, a term originally coined by Edgerton (2001), are defined as those with methods of learning that focus on student-faculty interaction, collaboration among students, and active engagement of students in the learning process. While Edgerton made many excellent general justifications for implementing pedagogies of engagement, his research did not involve the institutional issues involved with implementing these pedagogies or using them on an ongoing basis.

Prior to Edgerton's paper, Chickering and Gamson (1987) stressed the same general concepts: student-faculty relationships, collaboration among students, and active learning. The National Survey of Student Engagement (2012) further emphasized the need for institutions to promote student engagement, especially in the area of science.

Many quantitative studies have documented how pedagogies of engagement can positively impact learning in a variety of STEM classroom settings. For example, Redish and McDermott (1999) documented statistically-significant improvement in concept mastery by students in large-size physics classes due to the use of cooperative learning tutorial sessions. These results were based on pre- and post-test scores from 68 students. While sole reliance on pre- and post- testing scores leaves little to interpret about the pedagogy, the results do positively support the teaching method. Minderhout and Loertscher (2007) documented positive student perspectives of Process-Oriented Guided Inquiry Learning (POGIL) in a lecture-free biochemistry course, using an attitude survey with a 5-point Likert scale questionnaire. These data supported the specific pedagogical method (POGIL) being evaluated, although direct comparisons between the POGIL and traditional formats are problematic due to their dramatically different learning environments. In a mixed-methods study conducted on first-year medical students regarding their experience with one specific pedagogical method (problem-based learning), analysis of demographic and self-reported survey responses allowed researchers to categorize students into discrete subgroups and predict learning preferences among those groups (Papinczak, 2007). This research reported positive results with the pedagogy, despite using methods that addressed the learning styles of a very isolated student population (medical students). Online tools have also been shown to increase student engagement. In a comparison of 20 online problem-based learning (PBL) students and 20 traditional online students enrolled in a computer course, two-way ANOVA analysis of test scores revealed that content mastery was not significantly different, but the PBL group experienced a significantly positive effect on their critical thinking skills (Sendag & Odabasi, 2008).

The success of STEM programs is impacted not only by student learning issues but also by student retention problems. Enrollment data from the National Science Board (2004) indicated that the greatest attrition from STEM majors occurs within the first two years of college. Furthermore, the losses were highest for minority students and women. Research suggested that these trends are not due to students' performance. Instead, these trends were correlated to loss of interest, perceptions of poor pedagogy, and feelings of being overwhelmed by the curriculum (Seymour & Hewitt, 1997). Pedagogies of engagement were developed in part to confront these issues. According to Weiman (2007), traditional teaching methods are simply inferior to methods that actively engage the student in the learning process (Weiman, 2007). In addition, pedagogies of engagement involve a diverse set of instructional techniques that have been shown to improve student success (Crouch & Mazur, 2001; Hake, 1998; Kozhevnikov & Thornton, 2006; Redish, Saul, & Steinberg, 1998). Despite these findings, however, adoption of these pedagogies has not been widespread in STEM education programs (Weiman, 2007).

Findings from these studies on pedagogies of engagement in college STEM courses suggest that pedagogies of engagement can improve student learning and retention in STEM courses. This supports the ambition among some educators to implement them as a reform strategy to improve STEM education. However, due to the quantitative methodology employed in these studies, they fail to provide deep and personal insight into how these pedagogies can be successfully integrated into mainstream adoption. The barriers or issues involved are critical missing pieces of information that practitioners need before adoption is feasible. In order to understand those issues, further research directed at examining the issues is needed.

According to Mestre (2005), myths have persisted regarding pedagogies of engagement which prevent them from being the norm in college STEM programs. The most significant barrier is the notion that "pedagogies of engagement result in less content being covered and [that] this was a disservice to students" (p. 26). Mestre (2005) countered this argument by articulating that traditional lecture-based pedagogy covering more content material is not necessarily correlated to increased student understanding of that material.

Constructivist views of learning have been based on research that suggested learners "not only construct knowledge, but the knowledge they already possess filters any new knowledge that they are trying to learn" (Mestre, 2005, p.

24). An important and relevant implication of constructivist epistemology has been that pedagogies should facilitate construction of knowledge in ways that integrate the natural learning process. Many pedagogies of engagement were developed for that specific purpose, including cooperative learning, case-based studies, and hands-on experimentation. Commonly, pedagogies of engagement have included aspects of active learning as well. According to Mestre (2005), pedagogies of engagement: (a) actively engage students in constructing knowledge, (b) facilitate students expressing the reasoning behind their answers for evaluation, (c) focus class time on concept refinement, exploration, and application of conceptual knowledge, and (d) permit students to become more self-sufficient and less reliant on the teacher.

Pedagogies of engagement in the literature were generally approached from a classroom perspective intending to measure their efficacy at improving student learning. This research is valuable for the purpose of evaluation, but these studies do little to prepare practitioners for the issues involved regarding their implementation and use. This gap in the literature further emphasizes the need for research that addresses those questions.

Summary: Connections to this study. Despite the difficulty in agreeing on a standard definition of engagement, the act of being actively involved and interested in curriculum is an important aspect to learning and academic success. The literature stresses the need to engage students at all levels of their development.

The notion that education must change is also endorsed in the literature. Education must change to become more engaging through new curriculum and pedagogy that embraces greater collaboration, an emphasis on exploration, and technology in the classroom at every level in the educational process. Clearly, this challenge falls to educators throughout the educational system, but the benefits to the success and well-being of the student are clear. Engaged students succeed when compared to disengaged peers.

For undergraduates, the NSF is advocating for the reform of higher education STEM pedagogy. This reform strategy emphasizes a variety of teaching methods, collectively termed pedagogies of engagement. The literature reviewed in this section indicated that these pedagogical methods improved student learning, as examined using quantitative survey and exam analysis. Assessment of knowledge in STEM courses is an important aspect of instruction. In general, these studies inform practitioners that these teaching methods have been positively assessed.

Practitioners, in addition to needing evidence supporting the usefulness of new teaching methods, require information on *how* to implement them. The studies found in the literature do not address this problem. Research from a qualitative perspective is often employed to explore the issues of how. This present study will help address this problem by examining the issues involved with the implementation and use of pedagogies of engagement. In particular, this research is focused on how programs resolved the issues so that other community colleges can benefit from their wisdom and experience. In this capacity, this research will not only help close a literature gap, it will contribute useful information to practitioners who are working to improve their STEM programs by better preparing and retaining students.

The Critical Role of Community Colleges

This section of the literature review will provide an overview for the important role that community colleges play in higher education, particularly in STEM education. This overview will provide context and also illuminate the gap in the scholarly literature involving the role of community colleges in STEM education.

According to Cohen and Brawer (2008), the emergence of the massive industrial complex leading into the 20th century and its demand for a workforce with higher skill sets brought about the expansion of higher education to include community colleges. The inclusion of the two-year or junior college institutions was an important bifurcation point in education, because it dramatically increased access for potential students.

In terms of the STEM education pathway, community colleges play an especially prominent role. The National Center for Education Statistics (2004) reported that more than 44% of STEM graduates attended community college at some point in their education. In addition, many of these STEM graduates came from underrepresented groups. In analyzing this report, Tsapogas (2004) found that Hispanic graduates were more likely to have attended a community college than any other group. Additionally, for Hispanic, American Indian, and Alaskan Native doctorate holders, community college attendance at some point in their educational path was much higher than for Asian, Pacific Islander, Black, or White doctorate holders. Women science and engineering graduates were also found to have attended community college in higher proportions than their male counterparts (Tsapogas, 2004).

According to the National Science Board (NSB), enrollment data from 2004 indicated that the greatest attrition from STEM majors occurred within the first two years of college. These findings were, in large part, the major focus of the National Research Council's seminal report (2007) *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. This report, requested by Congress, recommended 20 implementation actions including a call for educators to emphasize student engagement.

Research involving community colleges in relation to STEM education is particularly important given the large numbers of students that these institutions serve. According to Seymour and Hewitt (1997), a student's initial experience in STEM courses can be the most critical. Because community colleges serve such large populations of students who are entering higher education, and especially minority and women students who are generally underrepresented in STEM fields, it is vital that community colleges not only maximize learning but also maximize the successful transition of talented prospects into the STEM pipeline toward STEM careers and advanced degrees.

Extensive analysis of solicited input from community college STEM educators led to the conclusion that barriers to participation of community colleges in improving STEM education still exist for many if not most community colleges (National Research Council, 2012; Project Kaleidoscope, 2006). This finding demonstrated the need for further research intending to explore the issues involved with successful STEM programming in the community college setting.

Summary: Connections to this study. Community colleges have a significant role in the education of recent STEM graduates. Despite their important role, community colleges have not been represented in the literature, despite serving a majority of this nation's students at some point in their higher education experience. These statistics demonstrate the need for community colleges to be included in the strategic reform of STEM education. This study sought to explore the issues pertaining to reforming STEM pedagogy in community colleges in order to inform practitioners intending to improve their STEM education programming.

Summary of Reviewed Literature

Success in STEM continues to be an important issue of national significance. Progress in STEM is intermingled with America's ability to solve some of its most complex problems. America's founders recognized that progress as a society requires continued leadership in the areas of STEM, and American science policy has evolved to emphasize continued progress.

A consensus from national agencies, including the NSF and non-governmental organizations, is currently calling for a better approach to STEM education. That calling has materialized in the HEOA's most recent reauthorization. This literature review briefly summarized the history of American science policy so that it could be understood from a historical context. The current

HEOA was also analyzed to provide insight on how this policy is influencing STEM education.

In terms of classroom practice, educators and researchers have advocated for pedagogy designed to increase student engagement in STEM courses as an important aspect of meaningful learning. As described in this literature review, these so-called pedagogies of engagement show consistently positive outcomes in a variety of STEM classroom settings and provide a convincing means for reforming STEM education. From this literature review, I found that the majority of research was done from a primarily quantitative perspective to show that these pedagogies improve learning. As an educator, these studies were the evidence that I needed to support these teaching strategies from a practical perspective. My next question as an educational leader was how to implement them into practice. In this way, these studies informed my current study by framing what was not in the literature. Finally, a critical gap in the literature exists pertaining to the experience of community colleges. In order to truly maximize STEM education, recruit greater numbers of talented students into the STEM pipeline, and improve the science literacy of the citizenry, community colleges must be included.

Overall, this literature review supports the purpose, significance, and rationale of this study, which is to explore the issues involving pedagogies of engagement in community college STEM programs. This study has the potential to close the literature gap on how pedagogies of engagement are being used in community colleges and inform practitioners on issues regarding their implementation by contributing findings from a qualitative perspective.

Chapter 3 – Design of Study

The purpose of this study was to explore the issues experienced by full-time community college STEM faculty as they implemented and used pedagogies of engagement in their programs. This study also sought to explore the ways in which those issues were successfully resolved. Lastly, the final research question was intended to produce questions for practice that might be useful to community college STEM programs based on the recommendations of the participants.

This study was designed from an interpretive social science (ISS) perspective and used a qualitative research approach. While this study did not involve the in-depth fieldwork and observation of participants in their natural settings, and thus was not considered a case study, many methods employed in this qualitative study were case study methods.

This chapter begins by defining key terms and articulating the philosophical approach and personal disclosure of the researcher. The subsequent section describes how this qualitative research approach was consistent with the goals of this study. Ultimately, this chapter concludes with discussion of specific data collection and analysis procedures employed throughout the research process including strategies taken to ensure trustworthiness.

Key Definitions

The following provide definitions of key terms. These will aid the reader in examining the methods used in this study.

Interpretive social theory. A research perspective that seeks to develop an understanding of social phenomena by exploring their meaning in natural settings (Newman, 2003).

Qualitative research. Inquiry when "complex detailed understanding of the issue" is needed involving the empowerment of people to "share their stories, hear their voices, and minimize the power of relationships that often exist between a researcher and the participants of the study" (Creswell, 2007, p. 40).

Trustworthiness. Qualitative term equivalent to the quantitative approaches to validation (Creswell, 2007).

Philosophical Approach & Personal Disclosure

My approach to educational research has been greatly influenced by my experiences over the past 15 years as a biologist, biomedical researcher, and life science instructor. As a science instructor at a community college, I have been passionate about making the educational experience for my students as transforming as possible. I view engaged pedagogy as a key for students to relate to scientific thinking in real and meaningful ways. I am also deeply committed to STEM education reform. Most of my years as an instructor have involved experimenting with and assessment of pedagogies of engagement. These experiences have shaped both my interest in this research topic and my epistemology.

My professional life began as a research scientist. Because the natural sciences and scientific research are historically and fundamentally based on positivist philosophy (Neuman, 2003), I have been heavily influenced by its ideology and paradigms. The positivist approach, with its inhering principles of mathematics and systematic rules of the scientific method, has been, and continues to be, very much aligned with how I approach problem solving. However, the rigid positivist dogma does not consistently satisfy my ontology, natural skepticism, and critical sense of reality. Thus, I admit that my awareness of flaws and gaps that can arise in any researcher's pursuit of truth is also influenced by what is best described as postpositivist philosophy.

While positivism and postpositivism have been and continue to be influential to my understanding of scientific research and describe my general desire to produce valid, reliable, and replicable findings, it is interpretive social theory that best describes my philosophy as an educational researcher. Interpretive social theory, according to Yin (2003), is an intensive, holistic process used to describe contemporary phenomenon. Researchers using the interpretive social science approach thus assume that we cannot understand human behavior unless we explore the relevant meanings that shape actions. In the subsequent subsections, after brief mentions of positivist and postpositivist philosophies, interpretive social science will be described in depth in an attempt to divest researcher bias and explain how their influences guided the design of this research.

Purpose of this approach to research. The ultimate purpose of positivist research, according to Neuman (2003), "is to discover and document universal laws of human behavior" (p. 71). In the scientific exploration of physical phenomena, the research intent is to predict and control for verifiable relationships and propositions. This approach has great utility and credibility when the phenomena being researched are physical and observable. Social phenomena, however, are different in that they do not exist independently from our knowledge of them (Colomy, 1991). It is in the social sciences that the positivist approach, with its putative predictions, isolated variables, controls, and randomizations, requires reconsideration. This reconsideration of social phenomena, viewed through a lens of natural skepticism, is a central tenet of postpositivism (Trochim, 2006). The aim of postpositivism is similar to positivism in that it also seeks explanation of phenomena but from the perspective that the findings are not universally unchallengeable. It is not an expected outcome that this approach will produce absolute truth but rather conjectural explanations of human behavior. It seeks to investigate sociological phenomena, recognizing that there are often no universal truths in human behavior (Trochim, 2006). While postpositivism influences my perspective and continues to predominate my understanding of the natural sciences, it does not adequately describe my research philosophy in the sociological arena. Positivism and postpositivism do, however, influence my approach to data collection, verification, and analysis. In regard to those particular aspects of research, my perspective could perhaps be best described as scientifically-based.

According to the National Institute for Literacy (2006), scientifically-based research:

> employs systematic, empirical methods that draw on observation . . . involves rigorous data analyses . . . [and] provides valid data across multiple measurements and observations. (p. 1)

The predominant philosophical approach that was used in this study is scientifically-based interpretive social theory. While the roots of interpretive social science are probably ancient, modern study of them can be largely attributed to an era in the 19th century and the seminal works of Emile Durkheim, Wilhelm Dilthey, Karl Marx, and Max Weber (Carr & Kemmis, 1997; Mottier, 2005; Neuman, 2003). From the works of these influential authors, the interpretive philosophy became an approach to understanding social practices and artifacts within a system where the researcher is embedded (Mottier, 2005).

The purpose of interpretive social science research is to understand social life and discover meaning (Neuman, 2003). The interpretive approach, as described by Rabinow and Sullivan (1977), “emphatically refutes the claim that one can somehow reduce the complex world of signification to the products of a self-consciousness in the traditional philosophical sense” (p. 5). In comparison to the previously-described philosophical influences, interpretive social theory might be viewed as more ambiguous, but to interpret meaning from the rich, detailed web of inter-related systems can be a valid theoretical approach to social science research. It can also be viewed as an ideal approach for exploring the experiences of subjects in regard to a specific phenomenon.

Major assumptions this approach makes about the nature of reality and truth. The interpretive social science aim is not to elucidate universal social realities. Instead, “for interpretive social science, the only aim is enlightenment, and through enlightenment, rationality in a critical, moral and reflective sense” (Carr & Kemmis, 1997, p. 94). Reality, therefore, is what we interpret it to be, and multiple interpretations may be possible and valid. As a result of this ontological assumption, I accept that participants can have different subjective realities. Given that interpretive social theory allows for multiple valid realities, generalizations were cultivated from a circular process of understanding. A circular process of understanding allows for many relationships and directions to be included in the overall understanding of the phenomenon.

How this approach relates to the proposed research. Interpretive researchers "study things in their natural settings" (Denzin & Lincoln, 1998, p. 3). This approach yields descriptive data in an attempt to comprehensively understand what is being studied. "Everything has the potential of being a clue" (Bogdan & Biklen, 1996, p. 31). This endeavor required that I made conscious effort to reflect the participants' perspectives. As championed by Creswell (2007), I used quotes and themes from participants as evidence of their perspectives. These data effectively convey commonalities that existed amongst participants.

Findings from interpretive social science studies can be criticized for their lack of generalized applications or lack of objective standards in the reporting of their results (Creswell, 2007). This research perspective, however, can be an ideal one if the intended outcome is to uncover a deeper understanding of the study's participants and even influence their understanding of an issue (Carr & Kemmis, 1997; Creswell, 2007). The goal of this research was to produce a more thorough understanding of the issues involving pedagogies of engagement in community college STEM programs and provide insight on how STEM education can be improved via those methods. Interpretive social theory provided appropriate context and direction for this study.

Research methodology and tradition. Qualitative research is the preferred methodology when the intent is to explore broad, description problems and investigate meaning in the natural setting (Patten, 2009). Therefore, qualitative methodology was a suitable approach for this study. Within the context of qualitative methodology, I intended to explore the perceptions and experiences of participants to acquire a deeper understanding.

Qualitative studies are often used to exploring endeavors in higher education. According to Macpherson, Brooker, and Ainsworth (2000), “it is the richness of the detail provided by a well conducted case that develops insights that have resonance in other social sites, thereby, allowing theoretical connections to be explored and established” (p. 52). According to Yin (2009), qualitative research allows researchers to reveal the multiplicity of factors that have interacted to produce the unique character of the entity that is the subject of study. In this way, qualitative research allows researchers to analyze complex instances through description and contextual analysis. The results are ideally descriptive and theoretical in that questions are addressed about why the instance occurred and also what may be important to explore in similar situations. A qualitative study can thus be one appropriate strategy for answering *how* or *why*.

Qualitative research can be criticized for generally lacking rigor. According to Kyburz-Graber (2004), studies “seem to allow research to be conducted with a minimum of effort” (p. 53). This criticism that qualitative studies are weak can certainly be attenuated by data triangulation, non-participant observation, and review of related documentation.

Another criticism of the qualitative approach is that it can be limited to a relatively small set of participants. In some cases, this may cause generalizations to be problematic. This point is an important one with this study. The findings may not apply to all college settings. Despite this, however, this research will have value by adding to the limited literature on this topic.

This study also involved multiple investigation sites. Therefore, multiple case or multi-case study method was used. Stake (2006) articulated that the multi-case method allows for thematic analysis across individual cases. From multiple sites, my goal was to identify and explore the intrinsic issues that were shared.

Research Procedures

This section overviews how study participants were selected and interviewed, how data was collected and analyzed, and finally what strategies were used to ensure trustworthiness.

Case selection. This study emphasized the experience of faculty in order to better understand the topic and answer the research questions. It was my intent to explore the experience of diverse faculty.

Before data were collected, a brief survey was developed and sent to community college faculty with affiliation to a reputable network of faculty and administrators dedicated to the advancement of pedagogies of engagement. A copy of this survey can be found in Appendix A. This group of candidates was intentionally sampled, as advocated by Creswell (2009), to best inform on the research problem being examined. The purpose of this survey was to screen potential candidates with experience using pedagogies of engagement, influencing their implementation, and resolving issues that arose from their implementation at their respective institutions. The individuals who were selected as participants were those who indicated the greatest number of years working with pedagogies of engagement.

Study participants. At the outset of the study, a brief electronic survey (see Appendix A) was sent to all community college STEM faculty members of a nation-wide STEM reform network. Survey questions were intended to screen candidates for their experience using and implementing pedagogies of engagement at their institution. Surveys were sent to 36 individuals. A total of 17 surveys were completed and returned. All 17 respondents indicated at least two years of experience using pedagogies of engagement. After the selection process, six participants were scheduled to participate in interviews with two candidates serving as alternates. One of the original six was eventually excluded when a scheduling conflict could not be remedied, and this participant was replaced with an alternate candidate. All participants shared the following characteristics:

1. All were full-time faculty teaching in STEM programs in community colleges.
2. All had disclosed at least three years of experience working with pedagogies of engagement using a variety of instructional styles.
3. All expressed interest in participating in the interview process.

Each participant in this study was a full-time faculty member. The experience of full-time faculty members was desired, given their involvement with curriculum design and planning processes at their respective programs. I did not gather input from adjunct faculty members. The role of adjunct faculty members, however, did arise as an issue of relevance.

Data collection. Several established protocols are available for qualitative research (Merriam, 1998; Stake, 1995; Yin, 2003). Each of these protocols, however, according to Creswell (2007), involves extensive data collection from multiples sources. Yin (2003) recommended six types of data sources, including documents, archival records, interviews, direct observations, participant-observations, and physical artifacts. Creswell (2007) categorized forms of data into four categories: observations, interviews, documents, and audiovisual materials.

Before conducting interviews, a pilot interview was used to evaluate the proposed interview questions with a non-participant who met the criteria of the desired applicants. Feedback form this process was positive and validated the nature of the interview instrument. A copy of the interview questions can be found in Appendix C. Once participants were selected and interviews were scheduled, I conducted in-person interviews with each research subject between the months of August, 2012 and January, 2013. The interviews were digitally recorded and transcribed by the researcher within 48 hours. Transcripts were made available to participants for review.

The duration of the interviews was approximately 35-45 minutes. At the end of the interview, I asked the participant to recommend any supporting evidence that might provide additional insight on the research questions. Follow-up e-mail communication was used to clarify or verify particular items. The final member checking of this data involved participant review of the findings about their specific interview. To the best of my ability, I involved participants in the analysis of their case information. The transcripts from interviews provided the foundation for the findings in this study. The other primary source of data consisted of documentation recommended or provided by participants and participant feedback of the results.

Data analysis. The audio recordings of all six interviews were transcribed verbatim with the exception of pauses and fillers such as *um*. Once the transcripts were verified for accuracy by the participants and corrected if need be, the transcripts were broken down into individual sections and analyzed. Analysis consisted of theme categorization in an effort to form patterns among the cases. Transcript sections were imported into a computer aided textual markup and analysis tool (http://www.CATME.de). Using the CATME tool, text was tagged for specific vocabulary words, major themes, and minor themes across the cases.

The goal of qualitative analysis, according to Lichtman (2010), is to take copious and even cumbersome data and distill it into something that makes sense. A narrative of each case was constructed, and then each case was cross-analyzed in an effort to capture patterns. Patterns that arose from the data were then ultimately organized into key themes. Yin (2009) recommended the use of ancillary databases as additional analytic support tools. The narratives and transcripts were input into a spreadsheet database to serve as this secondary source of validation.

Strategies to ensure trustworthiness. Trustworthiness in qualitative studies, according to Yin (2009), includes four criteria: (a) construct validity, (b) internal validity, (c) reliability, and (d) external validity.

Construct validity. To ensure construct validity, which Yin (2009) generally described as the operational procedures involved in a study, this research involved multiple sources of evidence, careful review of written and audio data files, provided participants with the ability to member-check their cases, and compared data between cases.

Internal validity. The internal validity of qualitative research is the credibility of the results in terms of how well the findings answer the research questions. Participants reviewed their interview transcripts to ensure that they were accurate and reflected what they meant to say. Participants also examined the results from the interview and document analysis so that key themes were not missed. The researcher documented procedures and research methods in an auditable trail so that any external observer could follow how the evidence was handled. Internal validity is generally used in studies that seek to identify causal relationships between concepts (Yin, 2009). Given that this study did not seek to describe and explore relationships between sites, external validity techniques were emphasized in the exploration of the themes that emerged across the cases.

External validity. External validity involves the concept of transferability, or how individuals with similar situations might find this information useful and trustworthy. This was an especially important consideration in this study. The first aspect to ensure external validity was the selection of participants – participants in this study had at least three years of experience with pedagogies of engagement. Another aspect of this study was the saturation point of information gathered from participants. In order to achieve saturation, I collected and analyzed data from enough participants until repetition in the themes became apparent. A common threat to external validity is a researcher's over-generalization. In order to prevent any invalid explanations or conclusions to be drawn, member-checking, feedback with participants, and comparisons to existing literature were key.

Reliability. Reliability was ensured by following established qualitative research protocol. Following the same data collection process should result in repeatable data collection. It is also important to consider before making the claim that any findings are reliable (Yin, 2009). Scripts were used during interviews to ensure that data collection was consistent. This study also included the use of a database in the form of a spreadsheet that minimized errors and assumptions. This study involved interviews and supporting documents focused on the following research questions:

1. What are the issues involving pedagogies of engagement in community college STEM programs? To answer this question, interviews were conducted in person with each participant.
2. How can the identified issues be resolved? This question naturally followed the first research question because community college educators need to know not only what the issues might be, they also need to know how to resolve them. This question was also addressed during the interview process with questions directed at how participants resolved the issues, such as: what were the options considered for implementing pedagogies of engagement, how did faculty decide which pedagogies were suitable for their classes, how did administrators and support staff assist in the process, what were the problems or barriers associated with implementing pedagogies of engagement, and how were those issues resolved successfully?
3. What strategies can be used for implementing and using pedagogies of engagement? The purpose of this question was to generate practical questions that community college STEM programs might find helpful to consider when implementing these strategies or working through issues involving the use of pedagogies of engagement. Merriam (1988) warned that a danger of qualitative research is to produce reports that are too long, detailed, and involved for practical use. With this concern in mind, I attempted to write questions that were straightforward and concise.

In order for this research to be valid, efforts were made to assure systematic data collection procedures were conducted, auditable records were secured, and appropriate engagement with participants was made. Participant selection was the first challenge. According to Creswell (2007), participants must be carefully chosen. Once willing participants were established, this research followed the procedures as outlined by Yin (2003), Stake (1995), and Creswell (2007).

Data for this research were primarily collected from semi-structured interviews. Interviews were digitally recorded, transcribed, member-checked, and audited. During the interview process, I wrote field notes that emphasized strong impressions and non-verbal communication observations such as body language. In addition, as suggested by Merriam (1998), I made journal notes while listening to the interview recordings to capture other insights.

In contrast to many forms of purely quantitative statistics, the analysis of qualitative data can be difficult (Yin, 2003). The data analysis process, as described by Creswell (2007), involved creating and organizing data, reading through text and forming initial codes, richly describing the case, using direct interpretation, developing naturalistic generalizations, and presenting an in-depth view of the case using detailed narrative, tables, and figures. As recommended by Creswell (2007), data comprised of direct quotes and key words from the multiple interviews were organized using a matrix. CATME software was used to tag text and organize results. Interview notes and journal notes were compared to the matrix. As themes developed from the matrix (pattern matching), they were organized into categories relating to each research question. Ultimately, thematic findings were submitted to study participants for review in the form of a site report. The site report for each case formed the basis for cross-case comparisons. Final results from the cross-case analysis was also submitted to and verified by each participant. Table 3.1 outlines the step-by-step data analysis procedures used.

Table 3.1

Data Analysis Procedures

Step	Process
Organized data	Data were transcribed verbatim by researcher and reviewed by participants to ensure accuracy.
Evaluated data	Evaluated interview transcripts and documents for key themes. Recordings were listened to multiple times while taking interview notes. Interview notes and journal notes were compared to transcript themes.
Coded data	Coded and categorized all text analysis using CATMA (http://www.catma.de) into themes. Once major themes were clear, minor themes were evaluated.
Performed lead coding	Grouped related themes across cases. This allowed for cross-case analysis.
Sought saturation	Determined saturation was met from findings.
Finalized	Determined accuracy of themes through participant feedback.
Analyzed data	Used triangulation to support trustworthiness. Tables were created to summarize key themes.

Efforts to ensure trustworthiness were made throughout this study. Creswell (2007) summarized procedures to assure trustworthiness as: prolonged participant engagement to build trust; triangulation of multiple participants and sources of evidence; peer review or external researcher checks; clarifying researcher bias; member checking; writing rich, thick description that allow readers to make decisions regarding transferability; and external audits. Yin (2003) emphasized several tests to establish quality assurance: construct validity, internal validity, external validity, and reliability. Not all these tests were established from the initial experimental design phase. Yin (2003) asserted that several of these research tactics "should be applied throughout the subsequent conduct" of a study rather than merely at its beginning (p. 41). Therefore, assurances of trustworthiness were ongoing throughout the research process (see Table 3.2).

Table 3.2
Tactics for Four Design Tests (Yin, 2003, p. 41).

Tests	Tactic Used
Construct Validity	• Used pilot interview with non-participant to validate and authenticate the interview questions • Established triangulation from multiple sources of evidence
Internal Validity	• Member-checking of transcripts and findings • Evaluated rival explanations
External Validity	• Conducted pattern matching • Analysis continued until saturation reached
Reliability	• Compared to existing literature • Used established protocol • Used database to minimize bias and errors

Yin's (2003) recommended qualitative study tactics were used in the study. To assure construct validity, I documented all data, including interviews, electronically. I also had study participants review their interview transcripts to ensure their accuracy. As part of the interview process, I asked participants to recommend other types of evidence (i.e., faculty evaluation forms or curricular materials) that participants felt might also inform the study. I also gathered participant feedback as I analyzed the findings and generalizations from the interviews. This circular engagement based on multiple types of evidence was key during the data collection and composition phases of the study. The design of this study involved developing cross-analyzable questions. Testing and refining these questions prior to the data collection phase yielded externally valid protocols.

Confirmability. Finally, Creswell (2007) asserted that how qualitative researchers write "is a reflection of our own interpretation based on our cultural, social, gender, class, and personal politics" (p. 179). This acknowledgement required reflection about the impact of the writing on the researcher, the participants, and the readers of the research. In order to capture my own reflections, I kept a journal of thoughts on the experiences that involved the following questions:

1. Should I write what people say or recognize that sometimes they cannot remember or choose to remember?
2. What are my political reflexivities that need to be disclosed?
3. Has my writing connected the voices and stories of individuals back to their experience?
4. How far should I go in theorizing the words of participants?
5. Have I considered how my words could be used for political purposes?
6. Have I used the passive voice and disconnected my responsibility from my interpretation?
7. To what extend has my analysis (and writing) offered alternatives to common sense or dominant discourse?

Finally, I evaluated all evidence with the following check-list adapted from Stake's (1995) systematic guidelines for writing a case-study research report:

1. Is the report easy to read?
2. Does it fit together, each sentence contributing to the whole?
3. Does the report have a conceptual structure (i.e. themes or issues)?
4. Are its issues developed in a serious and scholarly way?
5. Is the case adequately defined?
6. Is there a sense of story?
7. Does this convey to the reader an experience?
8. Have quotations been used effectively?
9. Are headings, figures, artifacts, appendixes, and indexes used effectively?
10. Was it edited well, then again with a last-minute polish?
11. Has the writer made sound assertions, neither over- nor under-interpreting?

12. Has adequate attention been paid to various contexts?
13. Were sufficient raw data presented?
14. Were data sources well chosen and in sufficient number?
15. Do observations and interpretations appear to have been triangulated?
16. Is the role and point of view of the researcher nicely apparent?
17. Is the nature of the intended audience apparent?
18. Is empathy shown for all sides?
19. Are personal intentions examined?
20. Does it appear that individuals were put at risk? (Stake, 1995, p. 131)

Participant protections. This study was intended to gather information that explored large issues rather than individual phenomena. In order to protect participant information, standards outlined by Oregon State University's (2009) Institutional Review Board were followed by both the principal investigator and the student researcher.

With the guidance of the IRB committee, a consent form was developed to communicate the scope, purpose, and potential usefulness of any potential findings from this research. A copy of this consent form can be found in Appendix B. Procedures were clearly articulated to the participants. To protect participant confidentiality, any identifying information about each participant (i.e. name, institution, and contact information) was destroyed after a fictitious name was assigned. The consent form was reviewed with participants as they were recruited to participate through an initial telephone conversation and again prior to the interview. The initial telephone conversation consisted of a brief introduction of the researcher, summarized the purpose of the research, reviewed the consent policies, and scheduled a mutual time for the interview meeting. Interviews were recorded and transcribed by the researcher. Electronic files were maintained in a password-protected folder. As prescribed, data were retained by the primary investigator for three years after completing of the study.

Summary

This study was designed to examine a complex and dynamic phenomenon. It was determined that qualitative research was the appropriate approach, given its ability to distill patterns from small, yet rich sources of data. Institutional systems are interesting systems to model but I believe they do naturally form patterns. Wheatley (2006) described these patterns as the "nature of life" (p. 130).

This data from this study was developed from six participants who agreed to be interviewed, provided supportive documentation, and reviewed the findings. At the most simplistic level, I examined the results to determine how they answered the research questions. I also explored the data across the cases to construct the relationships that existed. I searched for patterns and themes, deviations from patterns, and explanations for patterns and deviations. Finally, I attempted to corroborate the findings with evidence from supportive documentation.

Chapter 4 - Results

The findings from this study are presented in this chapter. The purpose of this research was to explore the issues involved with pedagogies of engagement in community college STEM programs. The questions were designed to focus on issues pertaining to the use of pedagogies of engagement from the perspective of community college faculty members and how those issues were successfully resolved. The final research question sought strategic recommendations from the participants so that questions for practice could be posed that might aid other community college educators as they inform themselves about the issues involved with implementing pedagogies of engagement into their programs. The specific research questions were:

1. What are the issues involving pedagogies of engagement in community college STEM programs?
2. How were the issues resolved?
3. What strategies can be used for implementing and using pedagogies of engagement?

This chapter is divided into two sections. The first section provides a brief profile of each participant. The next section discusses the qualitative results from the interview and document analysis. Finally, a summary discussion of the emergent themes and results concludes this chapter.

Participant Profiles

This section presents brief biographical profiles of the participants in this study. The participants were assigned fictitious names. Table 4.1 summarizes participants in alphabetical order, their primary teaching disciplines, and the type of pedagogy that they indicated using in the screening survey.

Table 4.1

Participants and Program Descriptions

Participant	Teaching discipline	Pedagogies
Professor Brian Biology	Biology & Ecology	Case studies, flipped classroom
Professor Charlene Biology	Non-majors Biology	Case studies, short-term research projects, calibrated peer-review
Professor Cindy Life Sciences	Life Sciences (Biology, Human Anatomy & Physiology)	Case studies, term-long student research projects
Professor Ernesto Biology	Biology	Case studies, problem-based learning
Professor Lisa Mathematics	Mathematics	Problem-based learning, flipped classroom
Professor Marie Geology	Geology	Field research, case studies

Professor Brian Biology. Professor Brian Biology described using active-learning techniques for almost 10 years in his biology and ecology courses. His pedagogy was at first traditional, with content-rich lectures and scripted laboratory sessions. Professor Brian Biology's desire to experiment in the classroom came from evaluating learning assessment data where retention of information was measured at "maybe 30%" (personal communication, December 20, 2012). Gradually, by building technology resources to move certain aspects of his instruction online, he was able to focus on more elaborate problem-based learning techniques and research projects in the classroom.

Professor Charlene Biology. Professor Charlene Biology had increasingly used pedagogies of engagement over the past 10 years but especially so in the past five years. Her instructional assignment was primarily focused on non-majors introductory biology courses where she often is challenged with students who are both, in her estimation, under-prepared and disinterested. At first, she identified these strategies as ways to *hook* students but found that they were also strategies to “build rigor into the curriculum” (personal communication, November 10, 2012). Faculty reluctance was the major issue in Professor Charlene Biology’s program. At the heart of that was not merely hesitation to try a new instructional method, but “how instructors view their role in the classroom” (personal communication, November 10, 2012). Active learning required her to let go of the notion that lectures were the most appropriate model for student learning. Moving toward that as a program was a slow, steady, and at-times, frustrating progress.

Professor Cindy Life Sciences. Professor Cindy Life Sciences taught a variety of courses that include non-majors and students who require coursework for admission into restricted allied health programs such as nursing and radiography technology. It was the need to get students doing research that was the key motivator for Professor Cindy Life Sciences to implement active-learning techniques. “Case studies are real and real science is what we should be doing” (personal communication, September 15, 2012). When Professor Cindy Life Sciences first tried replacing traditional curriculum with collaborative case studies, it was with a vein of skepticism. She remarked, however, that the change brought more classroom energy and on-task discussions. That initial positive experience was the impetus to make those student-centered learning experiences the predominate pedagogy in her classroom. The major issue that her program faced, in getting these practices mainstreamed, was lack of administrative leadership. Primarily, the frequent turn-over of administrators at her institution meant that faculty had to champion their own evolution toward active-learning. For her, this lack of administrator mentorship was a real problem. Time was another issue. Professor Cindy Life Sciences estimated that she spends several hours a week writing pertinent case-studies. “It requires that I keep up with the current literature. There is never enough time" (personal communication, September 15, 2012).

Professor Ernesto Biology. Professor Ernesto Biology realized that his students were not retaining information in the long-run. The realization that they could "always look up facts, but they might only get one opportunity to think critically about a subject with a mentor" motivated him to begin experimenting with problem-based learning techniques (personal communication, October 14, 2012). Battling the perception that content is paramount was described as a major issue by Professor Ernesto Biology. But long-term retention in traditional lecture format instruction was "consistently unsatisfying" (personal communication, October, 14, 2012). In addition to peer perceptions of active-learning that needed to be overcome, Professor Ernesto Biology outlined the need for newer assessment techniques. "Creative learning requires creative assessment," and those metrics do not necessarily exist (personal communication, October 14, 2012). In his experience, pedagogies of engagement meant faculty are challenged both in and outside of the classroom.

Professor Lisa Mathematics. A departmental priority required that Professor Lisa Mathematics adopt research-based pedagogy. Research experience was described as an important student learning experience in her program. According to Professor Lisa Mathematics, access to research opportunities, particularly for non-traditional or non-majors students without a declared major, has historically been lacking. While the decision to move to research-based curriculum originated from a departmental administrator, Professor Lisa Mathematics was excited to engage students in projects where they could "work with real data and answer real questions" (personal communication, June 15, 2012).

Professor Marie Geology. Professor Marie Geology had the unique experience of having been cultivated by a mentor who was interested in science education. Having that preparation was important because:

> Working with undergraduate non-majors is a tough assignment. If you can get the students who aren't especially suited to the quantitative aspects of science to love science, you're there (personal communication, August 27, 2012).

The challenge for Professor Marie Geology revolved around motivating students from a variety of backgrounds and interests to immerse themselves into science. Early mentorship was a key developmental process for Professor Marie Geology. Working with a graduate advisor who motivated her to explore pedagogy and education issues was described as key. Continuing on as a full-time faculty member, she sought out professional development opportunities that could sharpen her knowledge of student learning. She also championed the experience of doing research experiences in laboratory sessions. "Labs that produce obvious outcomes that have pre-determined answers are lousy" (personal communication, December 22, 2012). Bringing technology into the classroom was also an important revelation and priority for Professor Marie Geology. Technology, according to Professor Marie Geology, has changed higher education and made it easier to experiment in her classroom.

Summary of Participant Profiles

Each participant profiled in this study shared their own unique rationale for using pedagogies of engagement in their classrooms. Although each participant worked full-time in a community college STEM program, their teaching descriptions were varied and included a mixture of non-majors and majors-level course subjects. The reasons that participants adopted pedagogies of engagement in their instruction included personal motivation to try new things in the classroom, guidance from professional development experiences, and supportive peers and college leaders. These participants viewed pedagogies of engagement as ways to: get students more involved with STEM, improve long-term retention of key learning outcomes, increase research opportunities, and to make courses more enjoyable and contextualized.

Key Findings in Response to Interview Questions

Interview question comments were analyzed by identifying key words and themes using the qualitative data analysis tool CATMA (http://www.catma.de). For example, comments that included mention of student perceptions, student values, or lack of student buy-in were all tagged and coded as student issues. For visualizations, key-words were input into the visual organizer Wordle (http://www.wordle.net/) to determine the relative dominance of specific codes or themes.

The first two open-ended questions of the interview were designed to get to know each participant's personal experience with pedagogies of engagement. In addition to breaking the ice, these questions were intended to explore how and why they came to use those teaching strategies in their practice. Respondents indicated from these questions a personal desire to experiment with pedagogy. In addition, these interview questions asked participants to reflect on their motivation to adopt engaged pedagogy. Figure 4.1 summarizes this data, visualized as a logarithmic spiral. The visualization of this data is presented as a spiral, because I wanted to symbolize the continuous pursuit of student success. In addition, the spiral pattern allowed data to be positioned randomly and prevent any interpretation that one motivator is more or less significant than another.

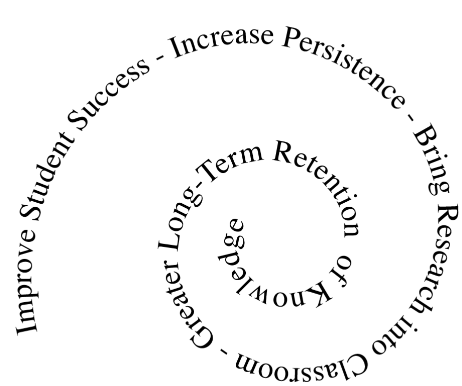

Figure 4.1 Motivators to adopt engaged pedagogy

The first two questions also allowed participants to reflect on how their pedagogy had evolved from traditional lectures to active and student-centered engaged pedagogy. The findings that emerged from these questions are summarized in Figure 4.2. Case studies were commonly the first step in the progression away from lecture-based instruction. The use of case studies that were from real-life or realistic scenarios and involved real data were highlighted as ideal curricula for guiding students into inquiry. Research experience was consistently mentioned as the ideal student-directed inquiry model, whether it be small-scale or long-term projects.

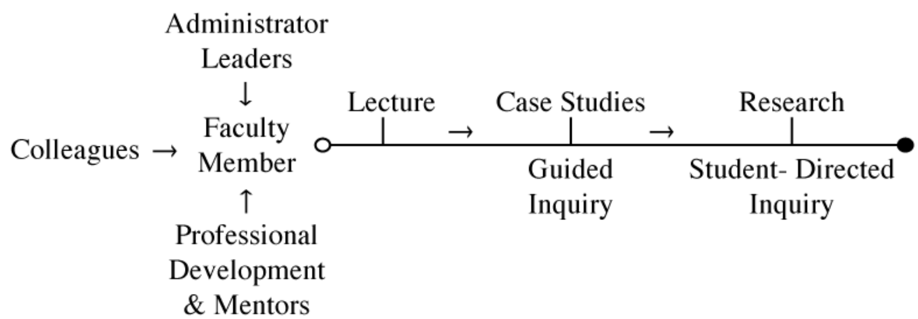

Figure 4.2 Progression of engagement from lecture to research

Student-directed inquiry as a goal to improve STEM educational experiences for students was a key finding in the National Research Council (2012) report referenced by Professor Ernesto Biology in a follow-up e-mail conversation (personal communication, October 16, 2012). According to the National Research Council, student-directed inquiry supports more in-depth conceptual mastery, retention, builds a foundation for future learning, hones critical thinking skills, and is more engaging for students. Other benefits of student research experiences, described by Jarrett and Burnley (2010), included a more positive attitude toward science and an improved understanding on the nature of science.

One of the most consistent themes to emerge from the interviews was that faculty who were using pedagogies of engagement sought those methods personally to replace traditional lecture-dominant instruction. Self-motivation was, therefore, a key component in their implementation. However, when asked who else was involved in the process, both leaders internal to the participant's organization and external to the organization were mentioned. This information is summarized in Figure 4.3. External mentors included educators from graduate programs that had an early influence on the participants. In addition, the role of professional societies was key. Conferences that had a focus on student engagement in combination with subject-specific knowledge were described as ideal.

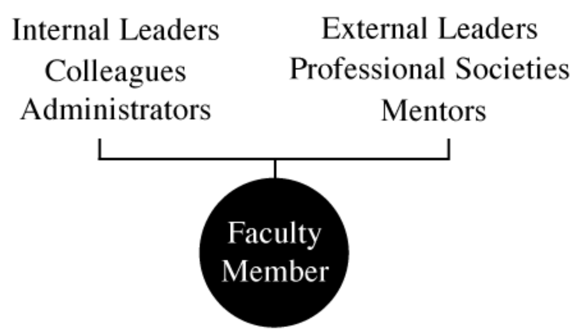

Figure 4. 3 Key leaders involved in implementation

Participants were next asked to discuss the issues they experienced in implementing pedagogies of engagement; Table 4. 2 is a summary of the issues that were mentioned more than once by participants.

Table 4.2

Common Issues Experienced Implementing Pedagogies of Engagement

Participant	Skepticism of Technique	Student Resistance	Need for Consistency
Prof. Brian Biology		X	X
Prof. Charlene Biology	X		
Prof. Cindy Life Sciences	X		
Prof. Ernesto Biology	X	X	
Prof. Lisa Mathematics	X		X
Prof. Marie Geology		X	

Despite some general inconsistency in the responses, two issues were especially prominent: (a) general skepticism from the instructors themselves or from colleagues regarding the equivalency of the pedagogy when compared to traditional lecture approaches and (b) student resistance. The need for consistency in academic programs was also an important issue brought up by two respondents, particularly in relation to adjunct faculty.

Planning time, inadequate assessment tools, and costs were also identified as important issues. Inadequate planning time is perhaps an issue that encompasses the issue of inadequate assessment tools. These participants described having to design their own curriculum and assessments; more time would likely result in locating or producing better assessment tools to measure student learning outcomes. The cost associated with transforming classrooms was also identified as an issue. Costs included the need for updated classroom furniture and research-grade equipment, online resources, and other tools such as clickers.

Inadequate instructor evaluation was an issue brought up by Professor Marie Geology when discussing the tenure process at her organization. In documentation provided by Professor Marie Geology outlining the criteria for faculty evaluation, it was clear that she was being scored on traditional teaching methods. The supervisory evaluation scoring criteria and student evaluation scoring component of her course evaluation form were both content-centered.

In a follow-up e-mail communication with Professor Ernesto Biology (personal communication, October 16, 2012), the underlying importance of discipline-based education research was identified when he referred to a publication from the National Research Council (2012). This report framed the need for STEM educators to embrace the empirical research on undergraduate learning and also examined instructional approaches to strengthen the knowledge and skills of students learning in the range of STEM disciplines. To support faculty skeptical as to the need for pedagogical changes or the value of pedagogies of engagement, reports such as this might be highly valuable as they begin to consider their instructional approaches.

Exploring the resolution of the issues involved using pedagogies of engagement was another primary research question in this study. The findings that were consistent amongst the participants are summarized in Figure 4.4. The three consistent resolution strategies were: continued experimentation with pedagogy to refine and improve the method, professional development to explore new strategies or approaches, and collaboration with mentors and colleagues.

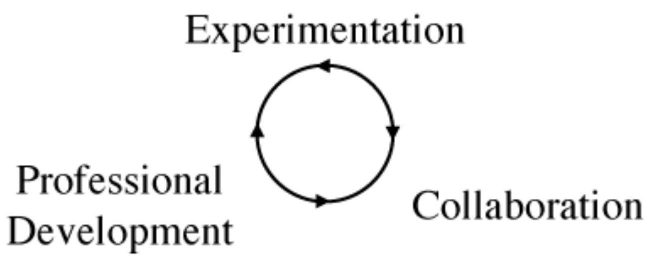

Figure 4.4 Resolution of issues

These findings were consistent with Rogers' (2003) theory of innovation-decision processing. According to Rogers, adoption of innovative practices initially involves knowledge of the practice, informed by persuasion from peers or professional networks, decision resolutions to adopt or reject the innovation, implementation of the practice, and finally confirmation to keep or discontinue the innovation. This process is cyclical until the needs of the innovator are met.

Asking participants to identify specific barriers that they experienced was a question intended to probe deeper into how they identified and resolved issues; the results are summarized in Table 4.3.

Table 4. 3

Summary of Barriers to Implementing Pedagogies of Engagement

Participant	Time	Lack of Quality Professional Development	Cost	Perception	Need for Meaningful Evaluation
Prof. Brian Biology	X		X		
Prof. Charlene Biology		X		X	
Prof. Cindy Life Sciences	X		X		
Prof. Ernesto Biology	X	X			
Prof. Lisa Mathematics		X			
Prof. Marie Geology	X				X

The results from this question indicated that a lack of planning time was a consistent challenge. The next most commonly mentioned barriers were lack of professional development opportunities, cost, perception that the techniques were ineffective, and the need for meaningful evaluation to reflect student engagement rather than faculty mastery of content.

The last semi-structured interview question was intended to encourage participants to reflect on their personal recommendations for other organizations on how to implement engaged pedagogy. There was some consistency in this finding. One recommendation, repeated by several participants, was the benefit of working in collaborative teams that function to support and encourage faculty leaders as they experiment with new pedagogy. In some cases, including administrators and instructors from various STEM disciplines, was noted. Planning time was emphasized as an important component to the process for the development of curricula, implementation of it, and data collection. Time for strategic planning focused on data analysis was also recommended.

As emphasized by the respondents, the collaborative team is the central aspect to the process. Collaborative teams support teacher leaders (often with additional encouragement from outside professional development networks) to implement pedagogies of engagement. The collaborative teams function to integrate the pedagogy into the strategic plan of the department. Student learning data are evaluated and analyzed by the collaborative team to close the loop. Figure 4.5 visualizes these findings in a form similar to a pedigree, a format that is often useful to show the succession of information.

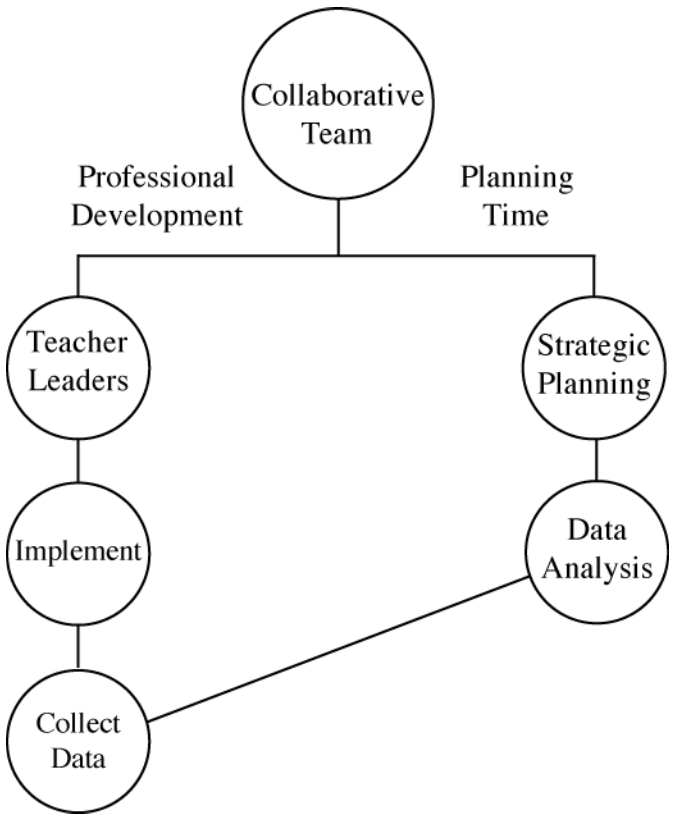

Figure 4.5 Recommendations for implementing pedagogies of engagement

Analysis of Interview Results

This subsection summarizes the qualitative results from data collected from the conducted interviews. Interview data were collected from reading through the interview transcripts multiple times, highlighting of key words, and finally interpreting the intended meaning of those key words from the context of the interview. The context was critical to avoid any potential misunderstanding of key words. They key words were then categorized into general themes. The themes that appeared from this process were: (a) student issues, (b) faculty issues, and (c) external issues. The following summarizes each theme:

Student issues. The interview data indicated that student resistance to engaged pedagogy was a challenge.

Faculty issues. The interview data also indicated that there were significant issues for faculty to address in regard to implementing and using pedagogies of engagement in their programs. These issues included skepticism of the technique, the need for consistency amongst courses and instructors, the need for facility and equipment upgrades, and a lack of time for designing curricula and assessment tools.

External issues. The participants for this study were full-time faculty, so external issues were those that included any individual outside of faculty, including administrators and other staff members within the organization. The interview data indicated that costs of facility and equipment upgrades, inadequate instructor evaluation criteria, and lack of access to quality professional development with a focus on engagement within subject areas were the main concerns.

Findings in Response to Research Questions

This section provides a summary of the study findings as they relate to the primary research questions. Within the framework of the research questions, the qualitative interview data, analyzed in the previous section, in addition to supporting curriculum materials and documents provided by the participants, were used to synthesize these findings. The primary research questions for this study were:

1. What are the issues involving pedagogies of engagement in community college STEM programs?
2. How were the issues resolved?
3. What strategies can be used for implementing and using pedagogies of engagement?

Research question 1: What are the issues involved with pedagogies of engagement in community college STEM programs? This research question sought to explore the key issues involved with the use of pedagogies of engagement in community college STEM programs. The rationale for this question was to understand the perspective of an instructor working with teaching methods designed to engage students. The goal of this research question was to determine if there were consistent issues for community college STEM programs.

The data revealed that there were consistent issues involved with the use of pedagogies of engagement. These issues were categorized into two general categories: (a) student perception issues, (b) faculty issues, and (c) external issues. The following subsections discuss those findings in detail.

Student perception issues. The crux of pedagogies of engagement was the student and their active participation in their learning. How students perceive the structure of their learning experience was, therefore, an important issue. The interview data indicated that this was a challenge, at least initially when the teaching methods were being implemented. As Professor Marie Geology articulated:

> The students had a voice but they are not always good at evaluating their own learning. They like lectures, funny lectures. (personal communication, August 27, 2012)

The conclusion that student biases are an important influence on learning is a finding supported in the literature. Corno and Mandinach (1983) examined cognitive engagement and proposed that engagement is evident when students demonstrate proficiency in challenging tasks. That is to say, students experienced deeper learning when engaged. According to Taylor and Parsons (2011) student perception biases behave as a filter on the information they learn. In this case, students perceived non-traditional courses to be of lesser value than the traditional passive-learning lecture environment. In a study by Bishop and Pfaum (2005), student perception was directly correlated to the level of engagement experienced by students. Student perceptions of course value can clearly influence their desire to engage. Working to diminish any student perception that engaged pedagogy was of lesser value was a constant challenge for Professor Charlene Biology. She described how this process unfolded in her experience:

> At first, I approached these strategies through a student engagement model: I simply wanted to "hook" students into learning, with whatever engagement strategies I could devise. This meant using role-plays, games, music, art, etc. in my teaching of my content. I found that these creative approaches were especially necessary to reach remedial students. As I gained more professional development in pedagogies of engagement, I began to see the strategies themselves as ways to build rigor into the curriculum, not just as "hooks" into the core content. For example, my students learn much better when they have to explain something to a partner before I call on them to give a choral response. I now look at ways to build engagement strategies into all parts of my instruction, and I focus on the following areas of pedagogies of engagement: student collaboration (examples: partner talk, jigsaws, group work on case studies), writing-to-learn (examples: quick-writes, writing higher-level questions, writing out solutions to case studies), reading-to-learn (examples: I teach students to actively and strategically mark texts they are reading through circling key words, underlining sections related to the main idea, and drawing arrows to show connections), and inquiry (examples: student-generated higher-level questions using Bloom's Taxonomy, students using multiple texts to generate an argument in response to a current scientific issue). (personal communication, November 11, 2012)

Technology can also be an important component to student perceptions. Raines (2003) examined millennial students and noted that they can at times have a short attention span when they perceive an experience to have little value. Technology, according to Raines (2003), can work well with millennial students to increase their perception of value. Creating technology tools for students, was mentioned as a key element of curriculum design for Professor Brian Biology:

> I am really interested in technology and it became easier to build learning objects and move things online. My class time was freed up to do other things like cases and research projects and presentations. (personal communication, January 4, 2013)

The relationship between student perception of course value and the level of engagement they experience also echoed the need for more engagement-centered faculty evaluation models. One respondent explained that during the tenure process, being evaluated on traditional teaching methods meant that she felt the need to compromise on her curriculum design. In the faculty evaluation scoring matrix that students used to evaluate their classroom experiences, questions were content-specific, such as: (a) the instructor knew the subject material, and (b) the exams only covered the material taught in the course.

Faculty issues. The findings of this study indicated the important role of instructional leadership. The data revealed that several issues persisted for faculty in the implementation process and ongoing utilization of pedagogies of engagement, including: skepticism of the technique, the need for consistency between colleagues and course sections, the need for curriculum planning time and support, and the cost barrier of equipment and laboratory resources.

Skepticism of technique. Engaged pedagogy embraces a conversation between a teacher and the students. As noted social activist and educational theorist bell hooks (1994) argued, “the work of an educator becomes not merely to share information but to share in the intellectual and spiritual growth of our students” (p. 14). Learning is not forced upon a passive audience; students are actively involved in the process. Another notable educator on the topic of engaged pedagogy is Paulo Freire, who mobilized Brazilian teachers to educate themselves and empower their students. In Friere’s (1970) seminal work *Pedagogy of the Oppressed,* he articulated:

> Through dialogue, the teacher-of-the-students and the students-of-the-teacher cease to exist and a new term emerges: teacher-students with student-teachers. The teacher is no longer merely the-one-who-teaches, but one who is himself taught in dialogue with the students, who in turn while being taught also teach. In this process, arguments based on “authority” are no longer valid. (p. 80)

The placement of authoritative power from teacher to student was a paradigm shift that departed from a long-standing tradition in education. Friere (1970) went further to describe a schism in the nature of truth:

> Things are true because the teacher says they're true. At a very early age we learn to accept two truths, as did certain medieval churchmen. Outside of class, things are true to your tongue, your fingers, your stomach, your heart. Inside class, things are true by reasons of authority. (p. 92)

Given the historical placement of authority and control that teachers enjoy at the front of the classroom, many instructors are reluctant to embrace the potentially uncontrolled classroom environment where students are empowered. This chaos was described in Professor Ernesto Biology's interview as "uncomfortable" in terms of classroom management (personal communication, October, 14, 2012). As Professor Charlene Biology stated:

> Some instructors see pedagogies of engagement as meaningless *fluff* that detracts from real instruction. Some instructors are afraid they will have to give up the control inherent in lecture-based instruction; having students engage in jigsaw discussions is certainly messier than lecturing. Another barrier is information about why to use pedagogies of engagement. Some instructors are comfortable relying on the direct instruction techniques they have always used, and they don't see a need to change. (personal communication, November 10, 2012)

Professor Charlene Biology also referenced classroom management techniques described by Lemov (2010) at the conclusion of her interview. This book describes dozens of instructional approaches that have been empirically successful in K-12 classrooms nation-wide. While these techniques were not specifically designed for, nor tested, in higher-education settings, Professor Charlene Biology indicated that knowledge of the techniques was useful in her approach to managing the chaos of specific learning activities.

Another faculty issue was the reliance on content-heavy course learning outcomes. Professor Cindy Life Sciences described the specific objectives as suffering from "content overload" (personal communication, September 15, 2012).

This was in part due to summative examinations that assessed broad mastery of content.

It was notable that engaged pedagogy does not deny the complications that can evolve from its format. That was perhaps why the majority of participants in this study described their independent motivation to change their curriculum to an engaged model. While peripheral management staff and administrators were mentioned as being involved and having supportive roles, it was the impetus to change and tackle the challenges that arose in each instructor that resonated in the findings.

Time for curriculum planning. Time was an issue of significance in the findings of this study. Although the type of curriculum planning, be it in departmental groups or individual planning, was inconsistent amongst the participants, time was a salient issue.

Teacher planning time, at any level of education, has been a part of school improvement efforts for many years. Flowers, Mertens, and Mullhall (1999) argued that planning time is not just beneficial for teachers, but essential. The findings from this study indicated that collaborative teams were key to the success of the planning component. According to Professor Ernesto Biology, "the more collaborative the process is, the more likely you are to go through with it" (personal communication, October 14, 2013). Professor Charlene Biology went further with the position that collaborative planning sessions must be teacher-driven:

> Peer-led professional development and an authentic strategic planning process builds buy-in. Top-down mandates don't build buy-in, and such mandates will inevitably get labeled as just another fad that instructors can ignore. (personal communication, November 10, 2012)

It was also important to note that the findings in this study indicated that these planning sessions should be structured around a strategic focus. Figure 4.6 illustrates collaboration as being the linkage between evidence-based instructional strategies and student learning outcomes.

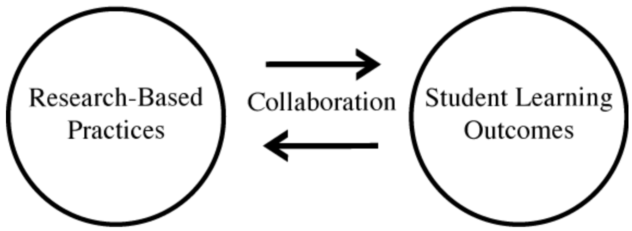

Figure 4.6 Linking instructional strategies and learning outcomes

Assessment tools. The inadequacy of tools to measure the engagement of students in active-learning centered classrooms was another key issue. While this topic could be addressed in the fore-mentioned collaborative planning sessions on institutional levels, the lack of engagement-focused measures in general is also a broader issue. Two respondents indicated that their assessments were informal. For example, Professor Lisa Mathematics asked students: (a) Did you enjoy this class? and (b) Would you take more science classes like this one? (personal communication, July 25, 2012). While these questions provided a modicum of feedback from students, Professor Lisa Mathematics went further to say that "inspiring students to like and become good at science is the most important measure" and that a satisfactory assessment for that has not yet been developed.

While the literature exerts the need for meaningful assessment to take place in education (Black & Wiliam, 1998; Ebel, 1962; McMillan, 2001), actual tools for measuring deep learning are difficult to find (Adamson & Darling-Hammond, 2013). The findings from this study echoed those sentiments. The respondents expressed relative dissatisfaction with the available tools even while continuing to use them.

Participants in this study emphasized that creative pedagogy requires creative assessment. They indicated that they used measures such as overall grades, exam scores, case study synthesis answers, homework completion, and student evaluations. The reliance on easy-to-gather data is also an issue. According to Professor Ernesto Biology, "at my school, the scantron machine rules the science ed assessment process. It's fast but it's not a meaningful picture of what students learned" (personal communication, October 14, 2012). Student satisfaction, persistence, formal and informal measures to know a student succeeded in a class were all mentioned as important elements of assessment by Professor Lisa Mathematics but "inspiring students to like and become good at science" and capturing that data was the elusive target (personal communication, July 25, 2012).

Ways to identify and measure the efficacy of engaged pedagogy was a future goal outlined in the National Research Council (2012) document referenced by Professor Ernesto Biology (personal communication, October 14, 2012). According to the National Research Council (2012), this goal could be accomplished through collaborations and ongoing research of pedagogy with a grounding in an understanding in "human thinking, motivation, and learning" (p. 189).

Cost. While general funding issues and budget cuts will be addressed in the following subsection as an external issue, the perception that existing facilities, equipment, and supplies were inadequate to accommodate engaged pedagogy also arose as a faculty issue. The findings from this study indicated that transitions to engaged pedagogy were gradual and required minimal retooling of existing resources. In this way, cost was merely a perceived issue, at least initially. In research-oriented laboratories, it was mentioned that updated equipment and enhanced supply budgets would be ideal but not necessary to implement the strategies. Respondents emphasized the need for creativity in their approach and working within their existing budgets.

Need for consistency between colleagues. Participants who were members of large departments with multiple instructors in a subject area noted the need for consistency among colleagues teaching equivalent courses. Professor Brian Biology remarked that a commitment to consistency was important because "if students think one teacher is easier or harder, we have an enrollment issue" (personal communication, January 4, 2013). The role of adjunct faculty and their limited involvement with strategic planning, professional development, and curriculum design was also noted as a particular challenge. According to Professor Lisa Mathematics, adjunct instructors “do not get paid enough to work that hard” (personal communication, July 25, 2012).

External issues. External issues included those that were outside of the student purview or issues that could not be directly addressed and resolved by faculty. The external issues identified in this study consisted of the need for stable and sufficient funding levels, inadequate instructor evaluation protocols that evaluated primarily lecture competencies, and professional development experiences that failed to link engaged pedagogy with content-specific information. Those topics are each addressed in more detail in the following subsections.

Need for stable and sufficient funding. The funding challenges that community colleges face are not new. In a report compiled by the non-partisan Century Foundation Task Force (2013), community college funding between 1999 and 2009 has only increased by a single dollar per student. Enrollment pressure, aging infrastructure and equipment, and economic downturns that motivate students into the education or re-education pipeline – represent just some of the challenges that strain community college resources. Tschechtelin (2011) related the general funding scenario for community colleges to the story about the frog that when placed in boiling water jumps out but when placed in warm water heated to a gradual boil stays until it gets cooked. Tschechtelin (2011) suggested that it is the across-the-board cuts that frequently sacrifice professional development. There are two aspects of cost that became apparent from this research: (a) budget reductions that inhibit professional development access, and (b) the cost of laboratory equipment and supplies when changing curriculum and laboratory activities. The findings from this research identified that access to professional development was a key issue. Several respondents emphasized that it was exposure to professional development opportunities that motivated them to experiment with their curriculum in the first place.

Inadequate instructor evaluation protocols. Just as the research literature supported the benefits of updating curriculum into engagement-centered instruction, the literature emphasized a need for evaluation tools to measure those styles of teaching and learning. According to Frick, Chadha, Watson, and Zlatkovska (2010), course evaluations typically have few items that empirically relate to student learning. The findings of this study echoed that sentiment. Indeed, as Professor Cindy Life Sciences related, this was actually a barrier to experimenting with curricula during her early years as a faculty member. Professor Marie Geology went into great detail in criticizing the faculty evaluation matrix that was used in her organization. Professor Marie Geology related that "it's scary to be evaluated using an old fashioned matrix" (personal communication, August 27, 2012). In a careful examination of the template faculty evaluation materials provided by Professor Marie Geology, it was clear that the inputs from student course surveys and classroom observations performed by peers and supervisors were reduced to a numerical scale between 1 and 5. Among the evaluation questions were items that had students, peers, and supervisors judge the instructor's mastery of the content and if exam questions correlated to the textbook material. It is understandable that Professor Marie Geology perceived this tenure mentoring process to have had little impact on her development as a teacher. A key point with this issue is that there is an opportunity for administrators, faculty, and students to participate in a re-design of tenure evaluation tools, ideally ones that capture more than numbers.

Quality of professional development. The perceptions from the participants in this study were that quality professional development matters. According to Professor Charlene Biology, peer-led professional development is needed to build buy-in because "top-down mandates don't always have traction and such mandates will inevitably get labeled as just another fad that instructors can ignore" (personal communication, November 10, 2012). The literature supported this notion. Professional development opportunities, according to Beaudoin, Johnston, Jones, and Waggett (2013), enhanced both content-area knowledge and pedagogy. The need for quality professional development with a focus on engagement was also echoed in the National Research Council (2012) report mentioned by Professor Ernesto Biology (personal communication, October 14, 2012).

Research Question 2: How were the identified issues resolved? This research question sought to examine how the participants resolved the issues that they experienced while implementing pedagogies of engagement into their teaching praxis. The rationale for this question was to better understand issues involved in the process. The goal of the question was to explore strategies that other practitioners might find useful in their own exploration on the topic of pedagogies of engagement.

Specifically in regard to the issue of inadequate assessment tools for measuring the efficacy of engaged pedagogy, Professor Marie Geology expressed frustration. Professor Brian Biology stated that he was still using the same assessment tools that he used prior to adopting engaged pedagogy (personal communication, January 4, 2013). Despite this need, participants did emphasize the important role of collaborative departmental problem solving.

An important revelation from these data was that issues were ongoing. Two respondents indicated that resolution of issues had not yet been fully achieved to their satisfaction. However, a pattern did emerge from the data indicating that issues were successfully addressed in regular team meetings, often with strategic planning as a focus, or issues were addressed by individual faculty members continuing to refine their pedagogy to deliver more satisfactory results. This pattern is visualized in Figure 4.7. This circular pattern of team collaboration focused on a strategic effort is supported by Senge, et al (1994) who remarked that "a good strategic priority is both clearly linked to the shared vision, and capable of galvanizing commitment from the people in the team" (p. 344).

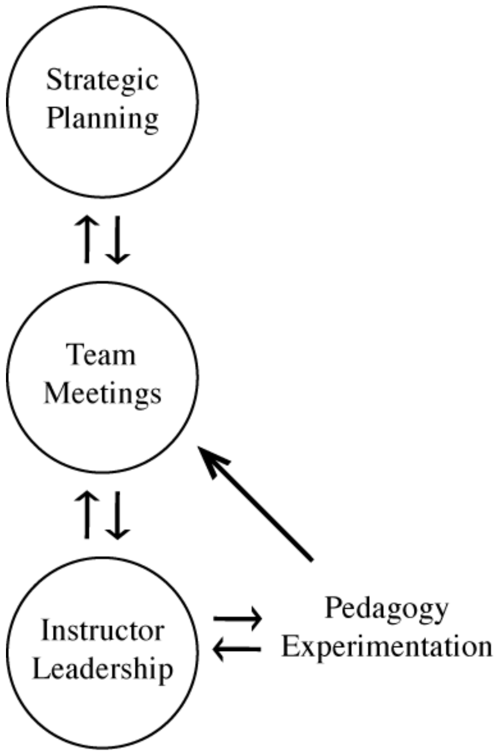

Figure 4.7 Visualization of issue resolution

As emphasized by the respondents, instructional leadership was the key element leading to pedagogy experimentation. This was especially emphasized by the participants who worked with colleagues harboring some degree of skepticism about the efficacy of the techniques. Their impetus to work through those perceptions in collaborative teams gave their departments the opportunity to work through the issues. Professor Charlene Biology specifically emphasized the need for teams to "use a strategic plan that is reviewed and revised throughout the process" (personal communication, November 10, 2012).

Research Question 3: What strategies can be used for implementing and using pedagogies of engagement? The strategy recommendations from participants emphasized the need for leadership and collaborative support teams. Several respondents noted the benefit of frequent meetings to ensure ongoing progress with the implementation process. The findings indicated that team meetings should focus on: supporting faculty leaders, mentoring new faculty with engagement strategies, analyzing data, and connecting pedagogy to student learning outcomes. Professional development was also deemed a key strategy for providing insight and support toward all of these endeavors. These recommendations are summarized in Figure 4.8

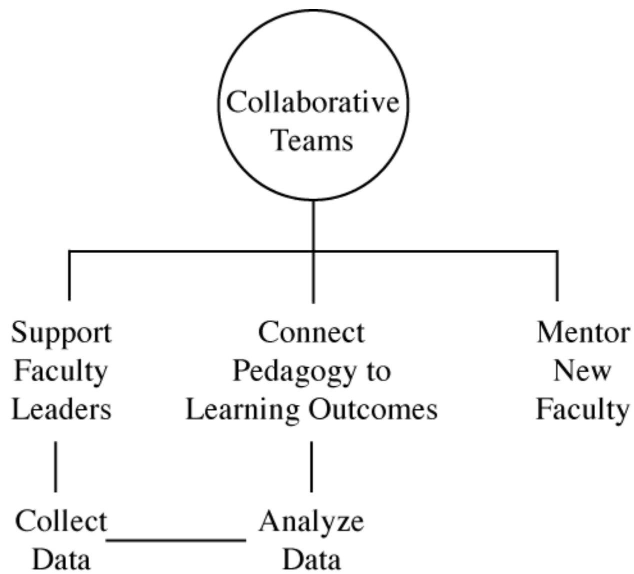

Figure 4.8 Strategy recommendations

This research indicated a broad consensus regarding the value and efficacy of a collaborative team approach to problem solving. This finding was consistent with the notion that collaboration is vital to sustaining significant organizational change (Senge, et al, 1994). In this study, the description of collaborative teams was consistent with how Katzenbach and Smith (1993) described ideal problem-solving units: small groups of individuals, with complementary skills, committed to a common approach, for which they hold themselves accountable. Professor Brian Biology indicated weekly meetings were key and that the "hardest part was starting" (personal communication, January 4, 2013). Professor Charlene Biology remarked that mentoring other instructors as part of an ongoing strategic process during team meetings, was valuable (personal communication, November, 10, 2012). Support, for Professor Ernesto Biology, involved talking about the curriculum process and that "the more collaborative the process is, the more likely you are to go through with it" (personal communication, October 14, 2012).

Summary of findings from the research questions. The research questions provided the infrastructure for this study's discovery of the issues of pedagogies of engagement in community college STEM programs. The findings associated with Research Question 1 revealed three distinct categories of issues: student perception issues, faculty issues, and external issues. Research Question 2 indicated that these issues were not always definitively resolved in the cases but that resolution strategies included frequent collaborative team meetings, participation in professional development, and instructor leadership.

The final research question asked participants to recommend strategies from their experience that might aid organizations in implementing engaged pedagogy into their STEM programs. These recommendations included forming collaborative support teams to mentor and support faculty, aid in the analysis of data, research evidence-based practices, and connect pedagogy to student learning outcomes. Seeking out professional development that offered a focus on engagement in addition to content-knowledge enhancement was also recommended. These findings are summarized in Table 4.4.

It is important to note that these findings were from the exclusive perspective of faculty members and thus the results from this study emphasize the importance of teacher leadership. This study found that in order to foster teacher leadership, there should be collaborative support, meaningful supervisory evaluation and feedback to improve teaching, knowledge of research-based best practices, and access to professional development. Figure 4.9 visualizes this relationship.

Table 4.4

Summary of Finding Related to Research Questions

Research Question 1: Issues	Research Question 2: Resolution	Research Question 3: Recommendations
Student Issues		
Perception of decreased value	Circular student feedback	Connect learning to real life
	Increase use of technology	Professional development
	Refine curricula and approach	Explore research-based practices
Faculty Issues		
Skepticism about efficacy of pedagogy	Leadership	Explore policy and research
	Collect and analyze data	Evaluate data measuring retention and learning
Need for planning time	Prioritize collaborative planning	Connect engagement to learning outcomes
Need for consistency across courses	Collaboration	Gradual implementation within existing infrastructure
Perception of costs	Strategic planning	Strategic budget decision making
External Issues		
Budget	Creative planning	Utilize strategic planning to minimize impact on professional development opportunities
Professional development	Internal and external collaboration	Seek professional development that includes a focus on engagement

Figure 4.9 Summary of findings that support teacher leadership

The findings from this study indicated that teacher leaders who work in collaborative teams will have an ideal support structure for addressing the student issues and external issues that may arise with the implementation and use of engaged pedagogy, as shown in Figure 4.10.

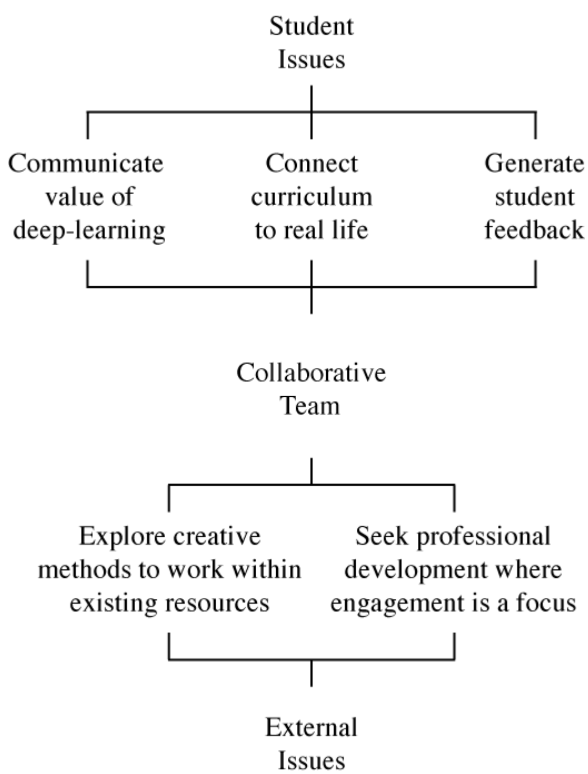

Figure 4.10 Collaborative team structures for addressing issues

The documents that participants recommended consisted of Lemov's (2010) *Teach like a champion: 49 techniques that put students on a path to college* and *Discipline-based education research: Understanding and improving learning in undergraduate science and engineering*, produced by the National Research Council (2012). In addition, the report from American Association for the Advancement of Science (2011) *Vision and change in undergraduate biology education* was referred to more than once. Lastly, I was given a copy of a case study that examined the implications from implementing student-centered curriculum into a high school setting. An annotated bibliography of these resources can be found in Appendix C.

Assurance of Trustworthiness

The recommendations from Lincoln and Guba (1985) were used to assure trustworthiness of this qualitative research. Those recommendations involve the following considerations: (a) credibility; (b) transferability; (c) dependability; and (d) confirmability. The following summarizes how this study met those criteria:

Credibility. According to Lincoln and Guba (1985), credibility involves an evaluation of whether the research findings are a credible interpretation of the data. The first strategy employed to ensure credibility was a test of the interview questions. A pilot interview was conducted to test the interview questions. Feedback from this experience helped refine the wording so that the questions were exploring the intended issue. Participant interviews were conducted in person. This allowed for greater observation of the nuances, such as body language, that contextualized any conversations. The researcher transcribed the interview recordings personally. Interview transcripts were reviewed to ensure that all data were transcribed. The interview transcripts were member-checked for accuracy, allowing for participants to validate their information. Byrne (2001) stressed the importance of the member checking process for confirming the findings of interpretive research. Participants were also allowed to expand on their points. Finally, I gathered other types of information to triangulate the data into credible themes from documents referred to by participants, a method that Patton (2002) described as a way to analyze research questions from multiple perspectives, including the research literature. In this way, I attempted to interpret the related data among the participants and understand the common themes.

Transferability. Effort was made to ensure that the findings from this study were generalizable or applicable to other organizations by recruiting participants from a variety of STEM disciplines. While geographical distribution was not prioritized in recruitment, each participant was from a unique community college, representing unique community college districts in four states.

This study was intended to be a rich exploration into the cases. I was careful to summarize and explain the results in such a way that readers are free to determine their intrinsic value. But it was my goal to reveal patterns, when applicable, so that a clearer picture of the issues is available to community college practitioners seeking information on this topic.

Dependability. This research process was meticulously documented in several ways. The interviews were recorded and transcribed verbatim. The transcripts were highlighted for key words and themes. I used a spreadsheet to organize the words and themes within each case and across the cases. I attempted to visualize each case in such a way that I would not lose the context of big picture. My goal in visualizing the information was to make the coding results more meaningful and contextualized.

I also utilized memo-writing during this process. Memo-writing about my own perceptions and observations provided me with an opportunity to document and bracket my own bias during the data collection and analysis phases of this study.

Confirmability. My personal reflections were minimized during the data analysis process because they were written (as described above). As is the custom in interpretive social science studies, I did write a personal reflection at the conclusion of this process, a reflection that was ultimately cathartic as well as self-critical.

Summary

The findings from this study indicate that the issues involved with pedagogies of engagement in community college STEM programs are complex. The most common issues that participants experienced implementing pedagogies of engagement were student resistance, skepticism of technique efficacy, and the need for consistent pedagogy across departments. Other issues included the need for additional curriculum planning time, the lack of adequate assessment tools, costs of upgraded facilities and equipment, and instructor evaluation methods that did not emphasize student engagement and thus discouraged instructor experimentation. The findings indicated that these issues were resolved through ongoing experimentation of classroom techniques, collaboration with like-minded colleagues, and mentorship in professional development experiences. The recommendations from participants in this study for programs intending to implement pedagogies of engagement into their programs were focused around collaborative teamwork with a strategic focus.

This chapter presented an overview of this study's findings as they related to the research questions within the framework of relevant research literature. Also outlined were the steps taken to assure trustworthiness during data collection and analysis based on Lincoln and Guba's (1985) recommendation concerning: (a) credibility; (b) transferability; (c) dependability; and (d) confirmability for qualitative research. The goal was to produce results that are applicable and useful on a larger scale. From the interview pilot process, I was confident in the accuracy of the interview instrument. Member-checking and feedback assured that participant responses were accurate and conveyed the intended meaning. Outside documentation was analyzed to triangulate the results when applicable. Involving participants feedback of the results also aided in the overall credibility of the findings. And finally, I maintained documentation and written records of the process, including personal memo-writing for self-analysis.

Chapter 5 – Conclusions

The goal of this research was to explore the issues involved with the implementation and use of pedagogies of engagement in community college STEM programs from the perspective of full-time faculty members. This study also sought to provide insight on how the participants succeeded in resolving those issues. The purpose of this study was to discover how community college STEM faculty implemented high-impact teaching methods to improve the learning experience in their classrooms by engaging students. Interviews in this study were intended to explore the issues involved in the process, if any barriers were present, and how those barriers were resolved. This study focused on the role of faculty in community college STEM programs from a variety of STEM disciplines with the goal that these findings might transfer to practitioners with similar circumstances. This chapter includes concluding remarks about the findings of this research. It also frames the limitations of the study and poses questions for further research.

Final Thoughts

This study found that the issues involved with pedagogies of engagement in community college STEM programs included student issues, faculty issues, and external issues. Student issues were focused on a low perception of value of engaged pedagogy in courses and the pre-existing expectation for lecture-based classroom instruction. Faculty issues included the need to address skepticism about the efficacy of the technique, a need for curriculum planning time, the challenge of creating pedagogical consistency between colleagues who teach the same course throughout a department, and the need for better assessment tools to measure deep learning. External issues implicated budget cuts as an issue that impacted instruction, particularly when cuts result in diminished access to professional development. The other external issue identified was that instructor evaluations could be a more useful tool if they were focused on capturing engagement.

Participants in this study indicated that resolution of these issues was not necessarily accomplished at their organizations but that working in collaborative teams meeting frequently to discuss and problem-solve was a general strategy that supported their efforts. Professional development focused on student engagement within the framework of discipline-specific knowledge and skills was a consistent finding identified as a helpful strategy for implementation. Finally, these participants voiced the importance of faculty leadership as well as the need for a faculty willingness to experiment with new pedagogy, fail, assess, and ultimately lead by example.

The barriers that participants identified during the interview process consisted of time, lack of access to quality professional development opportunities, the perception that engaged pedagogy was inferior to lecture-based instruction, and also the perception that the techniques require expensive laboratory upgrades. In addition, faculty evaluation formats that do not assess student engagement were described as a potential barrier that prevented faculty from experimenting with pedagogy in the first place, particularly during the tenure process when mentoring and supervision is most prevalent.

The recommendations condensed from the data in this study included the need for a collaborative support team. The participants relayed that their teams examined evidence-based practices, revised student learning outcomes and connected those outcomes to engaged pedagogy, supported faculty leaders, and also assisted in the data collection and analysis process. In addition, these teams were described as key for mentoring new faculty in their use of engagement strategies.

The final goal of this research was to synthesize questions from the research findings that might offer useful information to other practitioners seeking to implement engaged pedagogy into their programs. These focused on issues related to collaborative teams with access to both professional development opportunities and planning time.

Questions for Practice

The findings based on recommendations from the participants in this study have potential implications for community college STEM educators. These were summarized as questions for practice in Table 5.1.

Table 5.1

Questions for Practice Based on Recommendations

	Recommendations	*Questions*
Student Issues	Anticipate the need to explain the value of deep learning to students, connect curricula to real life	How can the value of deep learning be communicated to students; how can curriculum connect to real-life situations and scenarios?
Faculty Issues	Assemble a collaborative and supportive team to evaluate and implement pedagogies	What does a supportive team look like; who are the ideal participants; how can adjunct faculty be brought into the loop?
	Collaborate with an emphasis on accountability	What is the best schedule to come together with a focus on strategic planning for accountability? How can planning time be prioritized?
	Establish an awareness of current education policy, evaluate pedagogy techniques	What are the relevant policy recommendations that might justify how student engagement should be a primary focus of the curriculum; what are some evidence-based practices suitable for experimental implementation?
	Examine the mission and program learning outcomes	How do student learning outcomes connect to engaged pedagogy?
External Issues	Seek professional development opportunities that explore content information with an engagement focus	What type of professional development will help connect content to student engagement; how can funding be secured to ensure professional development opportunities?

This study revealed some potential barriers that practitioners should anticipate when evolving their pedagogy to an engaged model. Considering the pressure to improve student learning and increase student success, an awareness of these issues and recommended strategies to avert them is potentially significant to practitioners.

Limitations of the Study

The purpose of this study was to explore the issues involving pedagogies of engagement in community college STEM programs. Conclusions from this study were informed by an examination of the literature, a preliminary screening survey, in-depth face-to-face interviews with six community college full-time STEM faculty members, analysis of supportive documents, and participant feedback of the results. With such a small source of data, it is important to highlight the limitations of this study so that conclusions are appropriately drawn. The following specific limitations to this study are highlighted to reflect on both the research process and possible areas for future research:

1. This study involved participants who indicated significant experience with using pedagogies of engagement in their programs. Additional research to add the voice of new faculty and adjunct faculty would be relevant in future research. It would also be insightful to examine the perspectives of administrators and support staff. Insight from these capacities would perhaps provide findings with a more holistic point of view.
2. This study included participants from community colleges with varied types of campus organization structures. College processes can vary between organizations and, thus, not all findings in this study would be relevant for a particular college. A study involving a larger sample size could group participants into categories where organizational structures were similar,

and might produce important findings. Alternatively, multiple case studies using the same procedures would help to lead to more generalizable findings (Yin, 2012).

3. This study was intended to examine a small number of participants in significant depth. Given this small albeit deep process, generalizations were considered carefully. A study that could envelope a larger sample size might elucidate a more specific understanding of the topic that would transfer to practitioners from a wider array of organizations. Also, a research approach that included a focus group would potentially provide insight.
4. This study included participants who have experienced successful implementation of pedagogies of engagement into their programs. Research into failure to implement or use these methods would be illuminating. It would also perhaps generate a more complete picture of the issues that programs face.
5. Observation of the participants in their teaching environment would serve to validate the participant claims of actually using pedagogies that engage students. My hope in setting out to do this research was that my own experience as a science educator would help me relate to the participants in this study. This study assumed that their claims of using these techniques were valid.
6. Additional research exploring community college student perceptions of pedagogies of engagement would also be valuable.

Topics for Additional Research

This study indicated a need for further research in the following areas: professional development, faculty leadership, strategic planning, assessment of engagement, and faculty evaluation models focused on engaged pedagogy.

Professional development. The literature supports the notion that faculty prosper when given ample time and resources to develop new knowledge and skills. Pedagogy is an area where educators should also be given time and resources to explore and experiment. How can professional development offer quality programming in this capacity? How can engagement effectively be integrated throughout the spectrum of professional development opportunities? What types of professional development activities are best suited to cultivating these competencies? What are the perceived needs of educators?

Faculty leadership. The study profiled faculty members who were motivated to lead. Further exploration into what motivates high-performing faculty would be insightful. In addition, the voice of community college educators is often missing from the literature involving science education policy. How can community college faculty use their experience to guide policy directives in the future?

Strategic planning. The participants in this study indicated that strategic planning can be either a useful process or a hindrance, depending on the approach. When plans are simple and clear, with easily-prioritized goals and measureable outcomes, it can work. When plans are too abstract, the process can be less effective. How can strategic planning be streamlined so that it is a helpful input rather than an easily ignored afterthought?

Assessment of engagement. As described in the literature review, defining engagement is difficult. Further research defining and describing engagement is needed. Ultimately, a better understanding and consensus of what *engagement* means would go far to assist in the development of tools that are designed to measure it. This study indicated that there is a need for creative assessment tools to measure pedagogies of engagement. What do creative assessments look like? How can these tools be developed and deployed to instructors?

Faculty evaluation models focused on student engagement. This research brought into focus the need for faculty to be measured by evaluation criteria that focus on student engagement. Using criteria that scores traditional lecture-based pedagogy highly perpetuates that status quo.

Personal Reflection

In the custom of interpretive social science, I offer a personal reflection on this exploration and experience. As a science faculty member at a community college program, I began this process as a matter of professional interest. As this study provided me with the opportunity to learn from some of the best and brightest STEM faculty in community colleges, it became a source of great inspiration.

My first insight was the key role of faculty. This research has brought into focus the crucial importance of front-line teacher work and leadership. Faculty buy-in and participation in the vision and implementation process can be the difference between success and failure.

My love of science was a product of my innate curiosity about the world. And my second insight was that these participants cultivated curiosity in their approach to teaching and learning. The participants in this study were not conducting ordinary classroom sessions on the minutia of any particular topic. They each brought real and future science into their classrooms. In addition, they also approached their role as a teacher with scientific curiosity. They experimented and adapted their processes.

Having been deeply immersed in educational research and educational best practices has given me insight into my own practice as a science instructor. I have always been eager to explore new strategies, particularly those based in constructivism and adult learning theory, or andragogy. But this experience has also made clear the role of teachers as leaders.

Conducting qualitative research was an insight in itself. I found it to be a temptation to distill this data into mere words, themes, and categories. When I did these forms of analysis, I found that the exploration became myopic and less meaningful. Roam's (2009) approach to visualizing ideas ultimately inspired my attempt to approach the data as pictures. What I wanted to produce was a visualization that contributed something to all the data points, definitions, word maps, and matrices. I believe that pictures can change the way we approach information and learn from information.

Facilitating this study made me appreciate the rich and valuable resource in the community colleges system. Their mission is complex, but it is also adaptive to the needs of their students and stakeholders. This study exemplified how community colleges are critical in the national education landscape.

During my committee planning session of the initial proposal for this research, a question arose about the concept of epistemological validity, that is to say – how can I really know if these findings are true? How can I know if my participants are being truthful? At first, I thought that my disclosure about my approach and study design in the interpretive social science paradigm would be enough to counter the notion that any findings might be misleading, or that I as a researcher had been misled. The data can be saturated, triangulated, and verified – but can you know when a person is telling the truth? Perhaps the elegance of qualitative research is that it the findings are deeply personal and reflective. Rather than propose that these findings are the only truth, I offer that they are one truth in a dynamic and complex educational framework.

This experience has indicated to me the need for further research on this topic. What is engagement? Is it a connection to a topic, a mentor, or experience? What does engagement look like in a classroom setting? How can it be measured? Where is the student voice? As the ultimate consumers of education systems, the student experience must be included in this conversation. As an instructor challenged to engage and inspire students in the life sciences, I find myself reflecting on these questions.

The final question that I pose in this reflection concerns how this study might support and contribute to national community college conversations about student success and degree completion. Recently, the American Association of Community Colleges (2010) issued the completion challenge to dramatically increase the numbers of graduates whose skills fulfill critical workforce needs. Among the key suggestions for advancing the completion agenda are: enhance student and faculty engagement, adapt instructional programs to be more flexible, and establish accountability systems with transparent and authentic assessment of student success. While the issues that community college STEM faculty experience enhancing their programs through evidence-based pedagogical approaches may not solve the completion challenge, they do contribute to the conversation about how to organize around that goal.

Acknowledgement of Participants

This study evolved from conversations with innovative and inspirational STEM faculty. I am so deeply grateful that these individuals were interested in the discussion of the questions that I sought out to explore. While all the participants in this study were eager to help me explore this topic, it did require significant effort and sacrifice on their behalf. Their willingness to share their experience and wisdom made this study possible. The passion that the participants had for education was palpable. It is my hope that I have encapsulated their passion, ideas, and insights in a way that represents their exceptional practice as educators.

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Appendices

Appendix A

Participant Screening Survey

Pedagogies of Engagement Survey — Exit this survey

About this survey

The purpose of this survey is to identify participants for a multiple-case study focused on the issues involving pedagogies of engagement in community college STEM programs. This is a low-risk study that will benefit community college STEM faculty, administrators, and students. Participation in this research is voluntary. This survey is designed to screen for participants that best suit the criteria of the study. Responses from individuals not selected for further participation in the study will be destroyed.

This survey will take approximately 10 minutes to complete. Participation is voluntary.

By completing this survey, I understand that I will be asked my name and the name of the institution I serve, but that that information will be kept confidential to best of the researcher's ability although the security and confidentiality of information collected over the internet or sent by email cannot be guaranteed. Information can be intercepted, corrupted, lost, destroyed, arrive late or incomplete, or contain viruses.

I also understand that my responses may appear in the study, but that the content of those responses will be made anonymous by the researcher.

If you have any questions about this research project, please contact PI: Dr. Darlene Russ-Eft, darlene.russeft@oregonstate.edu, (541) 737-9373 or the Student Researcher: Valory Rae Anna Thatcher, thatchev@onid.orst.edu, (503) 896-2105.

If you have questions about your rights or welfare as a participant, please contact the Oregon State University Institutional Review Board (IRB) Office, at (541) 737-8008 or by email at IRB@oregonstate.edu

Next

***1. College name - this will be kept confidential but will be used to track responses and ensure that there is only one response per institution.**

***2. Your name - this will be kept confidential but will be used to track responses and send reminders if necessary.**

***3. How do you define pedagogies of engagement?**

***4. Do you currently use pedagogies of engagement in your curriculum?**

- [ ] Yes
- [ ] No

5. What kinds of pedagogies of engagement do you use?

***6. How often do you use these methods?**

- [ ] Always
- [ ] Often
- [ ] Rarely

Other (please specify)

***7. Please indicate how experienced you are with the issues involving the implementation of pedagogies of engagement into your program**

- [ ] Very experienced
- [ ] Somewhat experienced
- [ ] Neutral
- [ ] Not very experienced

8. Would you be willing to participate further in this research by being interviewed confidentially?

- [ ] Yes
- [ ] No

Thank you for your time!

Appendix B

Interview Consent Form

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1. WHAT IS THE PURPOSE OF THIS FORM?

This form contains information you will need to help you decide whether to be in this study or not. Please read the form carefully and ask the study team member(s) questions about anything that is not clear.

2. WHY IS THIS STUDY BEING DONE?

This study is being done to explore the issues involved with the implementation and use of pedagogies of engagement in community college STEM programs. This research will be useful to community college educators that are considering adopting these instructional methods.

This study is being done to complete a dissertation in the Community College Leadership Program at Oregon State University. It is also of personal significance to the student researcher, who is presently a faculty member at Mt. Hood Community College interested in improving STEM education.

10 faculty members may be invited to take part in this study.

3. WHY AM I BEING INVITED TO TAKE PART IN THIS STUDY?

You are being invited to take part in this study because of your involvement with an organization whose mission supports the implementation and use of pedagogies of engagement in the reform of STEM education.

4. WHAT WILL HAPPEN IF I TAKE PART IN THIS RESEARCH STUDY?

By taking part in this study, you will be asked questions about your experiences involving pedagogies of engagement. The study activity consists of an interview that will take approximately 1 hour. If during the interview, you refer to any specific documents that clarify your interview answers, the researcher may ask for copies of those documents. You understand that any documents that you wish to provide will have any individually identifying information removed to ensure confidentiality and will be destroyed at the conclusion of the study.

If needed, a second short interview may occur to clarify research findings and ensure validity.

Interviews will be digitally recorded so that transcription will be reviewable and accurate. If you do not desire to be recorded, you should not enroll in the study.

5. WHAT ARE THE RISKS AND POSSIBLE DISCOMFORTS OF THIS STUDY?

Although the student researcher and PI will attempt to safeguard your identity and information, there is a risk of an accidental break of confidentiality. Should a breach occur, risk to you will be negligible. Another possible risk is fatigue of being contacted, interviewed, and potentially re-contacted for clarifying information.

The security and confidentiality of information collected from you online and sent by email cannot be guaranteed. Information sent by email can be intercepted, corrupted, lost, destroyed, arrive late or incomplete, or contain viruses.

6. WHAT ARE THE BENEFITS OF THIS STUDY?

By participating in this study, community colleges will benefit from your experience as they design STEM curriculum that better serves and prepares students.

7. WILL I BE PAID FOR BEING IN THIS STUDY?

You will not be paid for being in this research study.

8. WHO WILL SEE THE INFORMATION I GIVE?

The information you provide during this research study will be kept confidential to the extent permitted by law. Research records will be stored securely and only researchers will have access to the records. Federal regulatory agencies and the Oregon State University Institutional Review Board (a committee that reviews and approves research studies) may inspect and copy records pertaining to this research. Some of these records could contain information that personally identifies you.

If the results of this project are published your identity will not be made public.

9. WHAT OTHER CHOICES DO I HAVE IF I DO NOT TAKE PART IN THIS STUDY?

Participation in this study is voluntary. If you decide to participate, you are free to skip any questions that you would prefer not to answer or completely withdraw from the study at any time without penalty. You will not be treated differently if you decide to stop taking part in the study. If you choose to withdraw from this project before it ends, the researchers may keep information collected about you and this information may be included in study reports.

10. WHO DO I CONTACT IF I HAVE QUESTIONS?

If you have any questions about this research project, please contact: Dr. Darlene Russ-Eft, darlene.russeft@oregonstate.edu, (541) 737-9373 or Valory Rae Anna Thatcher, thatchev@onid.orst.edu, (503) 896-2105.

If you have questions about your rights or welfare as a participant, please contact the Oregon State University Institutional Review Board (IRB) Office, at (541) 737-8008 or by email at IRB@oregonstate.edu

12. WHAT DOES MY SIGNATURE ON THIS CONSENT FORM MEAN?

Your signature indicates that this study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Participant's Name (printed):
____

(Signature of Participant) (Date)

Appendix C

Interview Questions

Foundational questions: What are the issues involving the implementation and use of pedagogies of engagement in community college STEM programs? How were those issues resolved? Supporting questions:

1. Describe your experience with pedagogies of engagement.
2. Why did you implement these teaching methods?
3. How was the *success* of these teaching methods assessed?
4. Who was involved in the implementation process?
5. What was your role in the implementation process?
6. What issues did you experience with the implementation process? Who was involved?
7. How did those issues get resolved? Who was involved?
8. What advice would you give to other college faculty/staff/administrators who are considering implementing these teaching strategies?
9. Many do not implement these pedagogies, what do you think are the barriers?
10. Based on your experience, what strategies or guidelines should direct their implementation?
11. Would you like to share any other information based on your experience?
12. Could you recommend other faculty/staff/administrators involved in your process of implementing and using pedagogies of engagement whom you think it would be useful to interview?
13. Could you recommend any other type of documentation or data that could inform me on this issue?

Appendix D

Annotated bibliography of resources referred to or recommended by study participants

American Association for the Advancement of Science (AAAS). (2011) *Vision and change in undergraduate biology education*. Retrieved from http://visionandchange.org/files/2011/03/Revised-Vision-and-Change-Final-Report.pdf

This report documents the need for change in undergraduate biology education. Highlighted in this report are the national calls for improving science education to emphasize biological literacy by increasing student-centered learning techniques. It also proposes new models for professional development and lists examples of student-centered curricula and assessment strategies.

Brush, T., & Saye, J. (2000). Implementation and evaluation of student-centered learning unit: a case study. *Educational Technology Research and Development, 48*(3), 79-100.

This case study examined the implementation of student-centered curriculum in a high school course where students used technology and collaboration to solve problems. The study exams the issues that students encountered and the problems that the teacher faced.

Lemov, D. (2010) *Teach like a champion: 49 techniques that put students on a path to college*. San Francisco, CA: Jossey-Bass.

This book describes 49 teaching techniques to increase student skills. The techniques emphasize high expectations, lesson planning, and strategies to engage students. The book also has guidelines for managing classroom behavior, creating a student-centered culture, and building trust between teacher and student.

National Research Council. (2012). *Discipline-based education research: Understanding and improving learning in undergraduate science and engineering*. Washington, DC: The National Academies Press.

This book synthesizes the present status and future direction of discipline-based education research (DBER) in the physical and life sciences. For educators, this book explains how to converge discipline-specific content knowledge in ways that promote deeper student learning.