EXAMINING THE RELATIONSHIP BETWEEN TEACHER SELF-EFFICACY AND INSTRUCTIONAL STYLE OF COMMUNITY COLLEGE STEM FACULTY

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Dedication

This dissertation is dedicated to my wife, Tiffany. I would have never made it to the end of the doctoral program without her. She has always seen something in me that I may not have seen in myself. The support she has shown me throughout this entire process even through the loss of our house in Hurricane Harvey kept me on track, even in the darkest of times. The love, caring, and understanding that she has shown me makes her irreplaceable. For this and even more, I dedicate this work to her and hope she is proud of it.

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ABSTRACT

EXAMINING THE RELATIONSHIP BETWEEN TEACHER SELF-EFFICACY AND INSTRUCTIONAL STYLE OF COMMUNITY COLLEGE STEM FACULTY

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The purpose of this study is to examine the relationship between teacher self-efficacy and the instructional style of community college STEM faculty to explore a possible connection between teacher self-efficacy, instructional style choice, and its possible impact on STEM reform for community colleges. This study is designed as a sequential mixed-method approach with a quantitative survey that is then followed by qualitative interviews to explore emergent themes not captured in the survey. Thirty-nine STEM community college faculty from two community colleges in southeast Texas participated. This study revealed that overall teacher self-efficacy, its subcategories in student engagement, and instructional strategies showed significant differences between the teacher-centered and student-centered STEM community college faculty. These discrepancies were explained by the interviews and included topics of disrespect from university faculty, differences in the accepted definition of student engagement and student-centered instructional styles, and beliefs that having a lab attached to the course makes your instructional style student-centered. Possible causes of these discrepancies were explored and were found to be tied to the lack of training in both pre-service and in-service. Recommendations for changes to both pre-service and in-service training and institutional response were discussed to repair the system of professional development and pre-service academics to get a stronger response to STEM reform in community colleges.

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CHAPTER I:

INTRODUCTION

Science, technology, engineering, and mathematics (STEM) education in higher education has been a heavily discussed topic since the early 1990s. National Science and Technology Council (NSTC), a presidential cabinet-level council established in 1993, started a discussion on the shortage of STEM graduates for projected STEM jobs from 2010-2020. Furthermore, increases in projected STEM jobs in the next decade were averaged to 14% in all STEM occupations leading to a shortage of one million STEM college graduates (American Association for the Advancement of Science [AAAS], 2011; Baiduc, Linsenmeier, & Ruggeri, 2015; National Science and Technology Council [NSTC], 2013; Whittaker & Montgomery, 2014). The message from AAAS, President's Council of Advisors on Science and Technology (PCAST), and NSTC is clear in that the United States is struggling to stay competitive in terms of STEM growth and development in the world market and change is necessary for higher education to prevent future STEM shortages.

Truly, this struggle moved the non-profit group American Association for the Advancement of Science (AAAS), with grant support from the National Science Foundation, to organize a national conference in 2009. Five hundred attendees ranging from biology faculty, college and university administrators, representatives of professional societies, students, and postdoctoral scholars worked to develop a shared vision of how undergraduate biology courses needed to change to address both raising STEM graduation rates and improve public critical thinking in biology. Next, AAAS developed a framework called “Vision and challenge: A call to action” from the 2009 conference on best practices for undergraduate biology courses and issuing a challenge in 2011 to STEM faculty nationwide to improve STEM education (AAAS, 2011;

Henderson, Finkelstein, & Beach, 2010). At the same time, the President's Council of Advisors on Science and Technology (PCAST) continued recommending sweeping changes to the first two years of college STEM curriculum through 2013, which prompted NSTC to release its own five-year strategic plan in 2013. Likewise, NSTC recommended sweeping changes and additionally making STEM a priority in education projects and policy for the U.S government (NSTC, 2013; Whittaker & Montgomery, 2014).

All the frameworks and plans, in the same way, are designed to focus on strengthening critical thinking skills and making critical thinking a priority in higher education courses. However, AAAS, NSTC, and PCAST agreed that the current teacher-centered instructional styles have limited potential in achieving the goal for better preparation of future workers in STEM fields (AAAS, 2011; Brownell & Tanner, 2012; Dubinsky, Roehrig, & Varma, 2013; Henderson et al., 2010; Henderson, Beach, & Finkelstein, 2011). One change that has shown promise in education research is a student-centered instructional style and is the focus of course changes by AAAS and NSTC. Yet, changes from teacher-centered to student-centered instructional styles have been slow or non-existent in most higher education institutions (AAAS, 2011; Alicea, Suárez-Orozco, Singh, Darbes, & Abrica, 2016; Baiduc et al., 2015; Brownell & Tanner, 2012; Dubinsky et al., 2013; Henderson et al., 2010; Henderson et al., 2011; NSTC, 2013; Whittaker & Montgomery, 2014). Indeed, there is a need for research into why this push for change in higher education has stalled. Therefore, this study will investigate the relationship between teacher self-efficacy and instructional style choice to understand if they may be a factor in the lack of reform. To set up this study, the research problem, significance of the study, research purpose, research questions, and definitions of key terms will be presented in this chapter.

Research Problem

The STEM learning environment of the college classroom for centuries past has not changed significantly from the traditional teacher-centered instructional style. It still consists of a heavy inundation of content knowledge, with activities focused on completing worksheets, homework, and conducting laboratory activities from a lab manual in the traditional "cookbook" fashion (Ayar & Yalvac, 2016; Bonet & Walters, 2016; Coil, Wenderoth, Cunningham, & Dirks, 2010). This traditional way of teaching limits deep levels of conceptual understanding and critical thinking abilities for many freshman and sophomore college students. The many scientists who are able to graduate from current traditionally designed courses are motivated individuals who are learning critical thinking on their own and are the exception to the rule (Cooper et al., 2015). Students of all majors, including those intending to start STEM careers, take the required STEM course as an undergraduate and then struggle in those courses when left on their own. Developing critical thinking abilities and finding a deep understanding of the concepts in a content-driven classroom is difficult considering prior experiences. More than half of the students that enter STEM courses make the decision that the STEM discipline is not for them and either never join a STEM career path or leave it. Women and underrepresented minority groups are being disproportionately affected by these decisions (Baiduc et al., 2015; Barthelemy, Hedberg, Greenberg, & McKay, 2015; Coil et al., 2010). The AAAS, NSTC, and PCAST are trumpeting the call for undergraduate STEM reform by asserting that new course designs should focus on strengthening critical thinking skill development by changing from a teacher-centered to a more student-centered instructional style (AAAS, 2011; Brownell & Tanner, 2012; Dubinsky et al., 2013; Henderson et al., 2010; Henderson et al., 2011).

The call for reform from AAAS, NSTC, and PCAST to increase critical thinking through a student-centered environment is supported through evidence. Students at all academic levels benefit from a student-centered environment. Below-average students benefit with peer support from higher achievers in student-centered classrooms compared to a teacher-centered environment where only the top students benefit (Chiu & Cheng, 2016). In other words, student-centered environments reach the class as a whole and not only a small percentage of high achieving students that are able to learn critical thinking on their own. Reaching all students is accomplished via the provision of a student supportive environment that is collaborative in nature where students work towards a common goal with teacher guidance (AAAS, 2011; Anderson et al., 2011; Bonet & Walters, 2016; NSTC, 2013). The teacher becomes less of a presenter of information and more a resource for students to bounce ideas off of or to provide guidance on how to think about a problem or where to look for pertinent information. The teacher also gives students the skills to take control of their learning by leading them to be proficient at self-re-evaluation, providing guidance related to integrating relevant personal histories, developing models, constructing explanations, engaging in arguments using evidence, and developing science process skills (Anderson et al., 2011; Bonet & Walters, 2016; Coil et al., 2010; Cooper et al., 2015). All of these techniques lead to assistance for students at all levels to make the learning personal, actively engage with the material, develop deep critical thinking abilities, and find deeper meaning in the content through assistance from the instructor and their peers. Student-centered approaches include critical thinking and enhance STEM learning through using a student-centered inquiry-based curriculum that is superior to teacher-centered approaches (AAAS, 2011; Anderson et al., 2011; Bonet & Walters, 2016; Brownell & Tanner, 2012; Ebert-May et al., 2011;

Ebert-May et al., 2015; Henderson et al., 2010; Gormally, Evans, & Brickman, 2014; Mulnix & Vandegrift, 2014; NSTC, 2013).

Over 30 years of evidence-based research shows student-centered instructional practices have a greater benefit for the widest student population. However, wide-scale change to student-centered instruction in higher education has been slow to nonexistent. While some of this change may be due to institutional focus, it does not explain the lack of reform in two-year community colleges. Unlike four-year universities, most two-year community college mission statements and faculty practices are focused on teaching (AAAS, 2011; Anderson et al., 2011; Henderson et al., 2010; Morest, 2015; Mulnix & Vandegrift, 2014). Community college faculty have heavy teaching loads with needs to provide remedial assistance to students while some full-time faculty must also take on the role of managing a large adjunct faculty population taking much of the faculty's focus (Austin, 1990; Morest, 2015; Twombly & Townsend, 2008). At the two-year community college level, the focus on education may be closer in nature to secondary education than its higher education equivalents in the four-year universities. While reform to a student-centered instructional style is being seen at the secondary level, it is not yet being seen with two-year community colleges.

Research into why STEM faculty are not changing to a more student-centered instructional style has identified several impediments for STEM faculty to modify their instructional style including: insufficient time, inadequate training, misunderstanding of evidence-based teaching practices, lack of support or incentives for implementation, and lack of institutional buy-in (AAAS, 2011; Anderson et al., 2011; Brownell & Tanner, 2012; Ebert-May et al., 2011; Ebert-May et al., 2015; Henderson et al., 2010; Gormally et al., 2014; Mulnix & Vandegrift, 2014). Much of this research finds that evidence from two-year community colleges is either included as a smaller percentage of the respondents from undergraduate courses at four-year universities or left out entirely. Impediments are frequenty explained away when implications arise that the STEM faculty approaches for the past 30 years are inadequate and may not be effective for today's students (Anderson et al., 2011; Bragg & Taylor, 2014; Brownell & Tanner, 2012). The change in instructional practices can lead to poor teaching evaluations which in turn affects STEM faculty's ability to rise to tenure and means that this call for change is met with significant resistance (Anderson et al., 2011; Bragg & Taylor, 2014; Brownell & Tanner, 2012). The way in which this research is being conducted and internal evaluations alone may not explain why impediments are happening at two-year community colleges. The differences between two-year and four-year institutional teaching loads, the need of their students needing remedial assistance, differences in course sizes, and the lack of a tenure system at many two-year community colleges may all play a role as barriers to instructional style shifts. The use of evidence-based research to create professional development plans from an environment that is vastly different than illustrated in the research may not render the same results. Simply stated, community colleges are a vastly different environment than traditional four-year institutions of higher education, yet evidence-based research from universities are being used to guide STEM reform.

A gap in the research of impediments to reform that seems to be overlooked is teacher self-efficacy. STEM faculty come from an environment of teacher-centered instruction. These faculty members are often the same individuals who, as students, taught themselves how to think critically. They may not have high teacher self-efficacy regarding student-centered instruction because they because they have not been exposed to student-centered instructional pedagogy, nor did they experience it themselves as students. This could lead STEM faculty to have a lower perception of their student-centered instructional capabilities and could negatively impact their potential to manage, organize, and successfully complete a given task using a student-centered instructional style (Bandura, 1997). These potential inadequacies could lead them to avoid changing to a student-centered style altogether. Identifying related features of a teacher's self-efficacy can help determine what characteristics of professional development are necessary to influence instructional style changes. A lack of research focusing on student-centered instruction at two-year community colleges and using four-year university data to direct the creation of professional development based on these drastically different environments will not lead to the same results. This study aims to focus on the impact of teacher self-efficacy on instructional style, as this is an aspect not currently explored in the literature. Why do two-year community college STEM faculty choose to continue with a traditional teacher-centered instructional practice versus a more learner-centered practice?

Significance of the Study

A student-centered instructional style in community college STEM courses improves student achievement and persistence toward graduation (AAAS, 2011; Anderson et al., 2011; Bonet & Walters, 2016; Brownell & Tanner, 2012; Ebert-May et al., 2011; Ebert-May et al., 2015; Henderson et al., 2010; Gormally et al., 2014; Mulnix & Vandegrift, 2014; NSTC, 2013). Traditional teacher-centered styles are inadequate to increase persistence towards graduation. This instructional style creates low teacher self-efficacy in a learner-centered environment causing instructors to avoid changing to a student-centered instructional style and leaving the current institutional environment at a stalemate where student graduation rates do not increase (AAAS, 2011; Bandura, 1995, 1997; NSTC, 2013; Peters 2009, 2013). Gaging the relationship of teacher self-efficacy to instructional style choice could potentially lead to better evaluation of STEM faculty.

This evaluation would be critical during the hiring stages and when determining which professional development related to student-centered instruction is needed to promote higher teacher self-efficacy for student-centered instructional practices at the community college level.

Research Purpose and Questions

The purpose of this study is to examine the relationship between teacher self-efficacy and the instructional style of community college STEM faculty. The following questions will guide this study:

R1: Is there a statistically significant mean difference between teacher self-efficacy and instructional style?

R2: Is there a statistically significant mean difference between teacher self-efficacy in student engagement and instructional style?

R3: Is there a statistically significant mean difference between teacher self-efficacy in instructional self-efficacy and instructional style?

R4: Is there a statistically significant mean difference between teacher self-efficacy in classroom management and instructional style?

R5: What factors contribute to higher and lower teacher self-efficacy in STEM faculty?

R6: What factors contribute to a STEM faculty’s instructional style selection?

Definitions of Key Terms

Academic Program: An instructional program leading toward an associate’s, bachelor’s, master’s, doctoral, first-professional degree or resulting in credits that can be applied to one of these degrees (Texas Higher Education Coordinating Board [THECB], 2012).

Adjunct Faculty: A person who holds a non-tenure-track appointment to the teaching staff of an institution. Adjunct faculties are generally part-time, with generally narrower expectations for involvement with the institution. Institutions hire adjuncts as needed, with no guarantees as to the continuation of employment (THECB, 2012).

Assistant Professor: A faculty member of an institution of higher education who ranks above an instructor and below an associate professor and who is tenured or is on a tenure track (THECB, 2012).

Associate Professor: A faculty member of an institution of higher education who ranks above an assistant professor and below a professor and who is tenured or is on a tenure track (THECB, 2012).

Classroom: A bounded space where the same individuals meet on a regular basis, over a set period, to engage in critical thinking and information exchange (Alicea et al., 2016).

Classroom Climate: Teacher and student perceptions of multiple dimensions (e.g. avoidant behaviors, academic rigor, situational interest, support, and organization) of the learning environment (Corkin, Yu, Wolters, & Wiesner, 2014)

Classroom Engagement: “What happens in classrooms” (Alicea et al., 2016 p.758)

Classroom Management: Two roles of leadership (the knowledge and management of classroom interaction and group processes) and teachership (content knowledge and pedagogy) a teacher engages with the students in the classroom. (Samuelsson, & Samuelsson, 2017).

Collaborative teaching-learning mode: A student-centered method of instruction in which authority for curriculum formation is shared by the learner and the practitioner (Conti, 1978 p. 12).

Community College: A two-year institution that awards associates degrees and lower and is classified by number of full time equivalent enrollment students; very small (<500), small (500-1,999), medium (2,000-4,999), large (5,000-9,999), and very large (>10,000) (Carnegie Classification, 2018).

Faculty: People hired to teach classes at institutions of higher education or whose specific assignments are for the purpose of conducting instruction, research, or public service as a principal activity (or activities) and who may hold academic rank titles of professor, associate professor, assistant professor, instructor, other faculty or the equivalent of any of these academic ranks (THECB, 2012).

First-Generation College Student: A student who is the first member of his or her immediate family to attend a college or university; neither of his or her biological or adoptive parents has ever attended a college or university (THECB, 2012).

The Institution of Higher Education: Any public community college, senior college or university, medical or dental unit, or other agency of higher education, such as the Texas Engineering Extension Service. It also includes independent junior, senior, and health-related institutions (THECB, 2012).

Instructional Style: An instructional preference on the student-centered practice which focuses on supporting the student through support, guidance, encouragement, positive feedback, and teacher-centered which focus on assessing behavioral objectives through course content and delivery (Conti, 1983: Peters 2009, 2013).

Instructor: A faculty member of an institution of higher education who is tenured or is on tenure-track and who does not hold the rank of assistant professor, associate professor, or professor (THECB, 2012).

Instructional Self-efficacy: A judgment of his or her capabilities of using an instructional style to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated (Tschannen-Moran & Woolfolk Hoy, 2001).

Learner (student)-centered: A focus on supporting the student through support, guidance, encouragement, and positive feedback (Conti, 1983: Peters 2009, 2013).

Learning: Understanding and a disposition that a student builds across the curriculum and co-curriculum, from making simple connections among ideas and experiences to synthesizing and transferring learning new, complex situations within and beyond the campus (Bonet & Walters, 2016)

Principles of Adult Learning Scales (PALS): A 44-item self-reported survey on the instructor's adherence to learner-centered or teacher-centered instruction pedagogy (Conti, 1978, 1983).

Professional Science Community: A scientists in professional science communities that perform scientific investigations, seek funding, debate their scientific claims with their colleagues, peer review, and publish their work (Ayar & Yalvac, 2016).

Professor: A faculty member of an institution of higher education who has the highest academic rank and who is tenured or is on the tenure track (THECB, 2012).

Self-efficacy: A person's perception of their capabilities and potential to manage, organize, and successfully complete a given task (Bandura, 1997).

STEM: Those courses and degree plans that fall into: Life Sciences, Biological, Biomedical, Health Sciences, Physical Sciences, Social Sciences, Psychology, and Engineering (Science, Technology, Engineering, and Math, 2018).

STEM Education: A means to help individuals develop different strategies in order to solve interdisciplinary problems and gain skills and knowledge as they are engaged with STEM-related activities through formal and informal learning programs (Ayar & Yalvac, 2016).

Student Engagement: The time and energy students invest in educationally purposeful activities and the effort institutions devote to using effective educational practices (Alicea et al., 2016)

Teacher-centered (traditional): A focus on assessing behavioral objectives through course content and delivery (Conti, 1983: Peters 2009, 2013).

Teacher Self-efficacy: is defined as a "judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated" (Tschannen-Moran & Woolfolk Hoy, 2001, p. 783).

Teacher Sense of Efficacy Scale (TSES): A 24-item (long form) or 12-item (short form) self-report survey that measures the teacher's beliefs of their efficacy in student engagement, efficacy in instructional practices, and efficacy in classroom management (Tschannen-Moran & Woolfolk Hoy, 2001)

Undergraduate: A student enrolled in a four- or five-year bachelor's degree program, an associate's degree program, or a vocational or technical program below the baccalaureate (THECB, 2012).

Conclusion

In 2011, AAAS issued a challenge to reform STEM higher education to spur students to think critically. National Science and Technology Council, President Obama, and many researchers have echoed the call for STEM reform to increase critical thinking through the use of student-centered pedagogy and to increase the graduation rates of students in the STEM field. Community colleges are the entry point for half of all students entering post-secondary education (AAAS, 2011; Anderson et al., 2011; Bonet & Walters, 2016; Brownell & Tanner, 2012; Ebert-May et al., 2011; Ebert-May et al., 2015; Henderson et al., 2010; Gormally et al., 2014; Mulnix & Vandegrift, 2014; NSTC, 2013). When community colleges attempt to make use of instructional practices derived from studies occuring at four-year colleges and universities, the mismatch results in concerns with reliability and generalizability (Alicea et al., 2016; Anderson et al., 2011; Barthelemy et al., 2015). This study seeks to examine the relationship between teacher self-efficacy and the instructional styles of two-year community college STEM to find insights into what effects teacher self-efficacy has on instructional style choice. In the next chapter, a literature review of the major topics that form this study will be presented.

CHAPTER II:

LITERATURE REVIEW

STEM, by definition, is an elusive construct. Defining the term seems to be above partisan politics and changes depending on the context (i.e. advertisements, classrooms, competitions, conferences, curriculum, presentations, workshops, and professional development, government funding) it is being used for and what kind of changes are being sought (Bybee, 2013). Colleges are flexible with the definition of STEM, based on how it is planned on being used. Degree plans require a different application of the STEM definition than those used to apply for institutional grants and external reports. An acronym like STEM holds political and decision-making influence yet the term itself is vague with many using it to refer to a single discipline, most likely science or mathematics, and used to determine access funding (Bybee, 2013). Table 2.1 contains examples of these definitions.

Table 2.1

Definition of STEM

Organization	Definition
National Center for Education Statistics (NCES)	Agriculture and Natural Resources, Architecture, Biology & Biomedical Sciences, Computer & Information Sciences, Engineering & Engineering Technologies, Mathematics & Statistics, Physical Sciences, Social Sciences
Department of Education (ED)	Life Sciences- Biological, Biomedical, Health Sciences, Physical Sciences, Social Sciences – Psychology, Engineering, Math
National Science Foundation (NSF)	Mathematics, Natural Sciences, Engineering, Computer and Information Sciences, Social and Behavioral Sciences – Psychology, Economics, Sociology, and Political Science
National Science Teacher Association (NSTA)	No formal definition. Definition changes depending on the publication. Some focus on a single discipline (Science, technology, engineering or math), others reference all disciplines.
U.S. Bureau of Labor Statistics (BLS)	Mathematical science occupations; Architects, surveyors, and cartographers; STEM-related postsecondary teachers; Physical scientists, Life scientists; Life and Physical Science technicians; STEM-related sales; STEM-related management; Drafters, engineering technicians, and mapping technicians; Engineers, Computer occupations
U.S. Census Bureau	Computer workers, Mathematicians, and statisticians, Engineers, Life scientists, Physical scientists, Social scientists
Government Accountability Office (GAO)	agricultural sciences; astronomy; biological sciences; chemistry; computer science; earth, atmospheric, and ocean sciences; engineering; material science; mathematical sciences; physics; social sciences (e.g., psychology, sociology, anthropology, cognitive science, economics, behavioral sciences); and technology.

Because the STEM acronym is not clearly defined, it allows for much ambiguity when discussing it in concert with educational practices. Many sources agree on some level that STEM education includes the areas of science, technology, engineering, and mathematics taught in an integrated fashion. However, the determinations of courses emphasized in the integration, selecting the instructional style are not clearly defined and seem to be up to the interpretation of the teacher or institution. In Table 2.2 are examples of the definitions for STEM education or how different institutions define STEM programs.

Table 2.2

Definition of STEM education/Programs

Organization	Definition
National Center for Education Statistics (NCES)	No Formal Definition
Department of Education (ED)	References article by Elaine J. Hom (https://www.livescience.com/43296-what-is-stem-education.html) that states STEM is a curriculum based on the idea of educating students in four specific disciplines — science, technology, engineering, and mathematics — in an interdisciplinary and applied STEM integrates them into a cohesive learning paradigm based on real-world applications. ED has been tasked with "initiate planning around the priority area of "Improve STEM Instruction." (NSTC, 2013, pp.13)
National Science Foundation (NSF)	References an article by Allison Mills (https://www.mtu.edu/news/stories/2017/september/what-stem-education.html) that states STEM education focuses on how to implement the best practices for teaching science, technology, engineering, and math through the integration of all subjects into one curriculum. NSF has been tasked with the priority area of "Enhance STEM Experience of Undergraduate Students," including assisting with improving the delivery of undergraduate STEM education through evidence-based reforms." (NSTC, 2013, pp.13)
National Science Teacher Association (NSTA)	STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy.
Government Accountability Office (GAO)	A STEM education program that met the definition had one or more of the following as a primary objective: attract or prepare students to pursue classes or coursework in STEM areas through formal or informal education activities attract students to pursue degrees (2-year, 4-year, graduate, or doctoral degrees) in STEM fields through formal or informal education activities; provide training opportunities for undergraduate or graduate students in STEM fields (this can include grants, fellowships, internships, and traineeships that are intended for students); attract graduates to pursue careers in STEM fields; improve teacher (pre-service or in-service) education in STEM fields; improve or expand the capacity of K-12 schools or postsecondary institutions to promote or foster education in STEM fields; and conduct research to enhance the quality of STEM education programs provided to students.

Table 2.2 (continued)

Organization	Definition
Maryland State Department of Education	STEM education is an approach to teaching and learning that integrates the content and skills of science, technology, engineering, and mathematics. STEM Standards of Practice guide STEM instruction by defining the combination of behaviors, integrated with STEM content, which is expected of a proficient STEM student. These behaviors include engagement in inquiry, logical reasoning, collaboration, and investigation. The goal of STEM education is to prepare students for post-secondary study and the 21st-century workforce.

STEM education in both K-12 and college environments has become synonymous with a student-centered pedagogy. The desired pedagogy including collaborative active learning strategies that encourage students to increase their critical thinking by writing, thinking, and talking about their learning on the road to mastering concepts in order to solve real-world problems (Bybee, 2013; Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012). This includes adding technology and engineering styled problem solving to a science and mathematics problem. While National Science Education groups addressed critical thinking and collaboration through new standards and context-based pedagogy, college standards have been lagging in their student learning outcomes (AAAS, 2011, Bybee, 2013, NSTC, 2013). In this chapter a review of why college reform is falling behind K-12 reform will be made in: (a) history of STEM, (b) teacher self-efficacy, (c) classroom climate, (d) student engagement, (e) material environment, (f) curriculum design, and (g) satisfaction.

History of STEM Reform

Community colleges are an important but overlooked institution in the discussion of STEM reform. STEM degrees awarded at a community college out of the total of all STEM degrees awarded were 44% in 2004, 43% in 2009, and 40% in 2011 (Hagedorn, Purnamasari, & Eddy, 2012; Fauria, & Fuller, 2015). These awarded degrees included a high percentage of underrepresented populations such as first-generation (42%), women (57%), and minority students (52%) (Hagedorn et al., 2012; Henry, 2010; Packard & Jeffers, 2013; Riccitelli, 2015). Lysne (2015) reported that in the first year of a student's college degree, STEM courses comprise 25% of all courses taken. Therefore, many of these students are getting their first higher education experience in STEM at community colleges. This creates a distressing predicament when the community college retention rate of 54% is compared to a university retention rate of 73% (Riccitelli, 2015). This establishes a situation where research into improvements for retention of students is not just desirable, but necessary.

Research indicates that the dominant teaching paradigm is a teacher-centered instructional style (Barr & Tagg, 1995; Bernstein-Sierra & Kezar, 2017; Divoll, 2010; Fishback, Leslie, Peck, & Dietz, 2015; McConnell, Chapman, Czajka, Jones, Ryker, & Wiggen, 2017). Colleges and universities have designed entire courses around delivering deep levels of content. In community colleges this has been evident over the last twenty years with Fishback (2015) reporting from the Community College Survey of Student Engagement (CCSSE) in 2006 that traditional teacher-centered instructional methods are being used anywhere from 33-90% of course time. This is especially concerning with two-thirds of all students say memorization is a significant feature of the course. The college professor becomes the transmitter of knowledge or the "sage on the stage" (Divoll, 2010; Unruh, Peters, & Willis, 2016). The instructor is the gateway to knowledge, spending much of their time developing and preparing for academic performances where the instructor is providing the content knowledge in their area of study. This content knowledge is then passively extended to the students. Many students leave these courses with the perception that science is more about the characteristics of the instructor's ability to engage the student a presentation of content than understanding the content (Baiduc et al., 2015). This creates an environment where the responsibility for learning rests solely on the ability of the instructor to share information.

The institution also holds this focus as a high priority for the instructors. Both professional and institutional epistemologies are congruent with learning pedagogies and principles that focus on the instructor delivering material and transmitting content (Howard, & Taber, 2010). In other words, the institution also expects a teacher-centered instructional style and sets the course structures, instructor evaluations, and student end of course surveys to assess for a teacher-centered classroom environment. Evaluations, that are used to determine whether faculty are performing to standard, are set up with words and phrases like presented, explained, articulated, engagement in discussion, and student participation is solely tied to the ability to ask questions. It creates an institutional expectation that all faculty are using teacher-centered instructional styles.

Courses are even set up block fashion to create a teacher-centered classroom climate where they have between 50 and 90 minutes to deliver instruction or make a presentation (Barr & Tagg, 1995). STEM faculty in these courses are isolated from the rest of the campus and tend to design their courses independently and autonomously with little input from the departmental unit that they are part of (Kezar, Gehrke, & Elrod, 2015). This isolation leaves the faculty to replicate the STEM learning environment of their own undergraduate courses focused on studying worksheets, completing homework, and conducting laboratory activities heavily inundated with content that covered the complete syllabus (Ayar & Yalvac, 2016; Coil, Wenderoth, Cunningham, Dirks, & Grossel, 2010). Faculty may have access to supplemental aids like PowerPoints provided to them from the textbook publisher, a colleague, or if they are an established instructor, they may have supplemental aides of their own design.

The faculty may use these supplemental aides either to teach several sections of the same course or to teach the same course over several semesters. This leads to a pattern of preparation much in the fashion of preparing for a theatrical performance where faculty spend time developing their delivery of the content rather than developing engaging student-centered curricula. This focus on the development of the instructor's content leads to issues with the courses later when students are not able to engage with or access the learning. In universities, these undergraduate STEM courses are used as "gatekeepers" or "weeding" courses to prevent those that are not seen as having an adequate skill and knowledge base from moving on to a STEM degree (Hoffman, Starobin, Laanan & Rivera, 2010). This process of gatekeeping affects women and minorities at higher rates in universities and is not well understood or documented in research from the community college setting (Hoffman et al., 2010).

Effects of the Teacher-Centered Paradigm

Student performance in these "gatekeeper" STEM courses is a key indicator of persistence in receiving a STEM degree (Gasiewski et al., 2012). Some faculty see it as their role to either explicitly or implicitly find individuals like themselves who are born to be scientists, are in the top tier of all students, and to eliminate the rest from the rosters (Gasiewski et al., 2012). This leads to a classroom climate where through verbal or non-verbal cues the faculty sets the presupposition that most students are not made to be here, should be happy just making their passing grade, and should leave to find more suitable career paths. An attainment rift arises between students and classroom values that are linked to the weed-out culture (Riccitelli, 2015). Daryl Chubin, the director of the AAAS & Center for Advancing Science & Engineering Capacity, is quoted in an Inside Higher Education interview from 2006 as saying, "The culture of science says, not everybody is good enough to cut it, and we're going to make it hard for them, and the cream will rise to the top" (Riccitelli, 2015, pp. 56). This type of classroom climate or culture sets an environment of low persistence for those high-risk students who are academically underprepared. It creates an exclusive culture of education where STEM is for some and not for all. As discussed before, the use of gatekeeping courses is very well understood in four-year universities but not in community colleges so attrition rates could be attributed to other causes that are not yet explored by research.

The overall attrition rate for both four-year universities and two-year community colleges for STEM degree programs is 45% for incoming freshmen with two-year community colleges contributing an attrition rate of their own of 86% at the end of two years (Riccitelli, 2015). A CCSSE review showed that student groups who were a part of the attrition rate were academically underprepared, first-generation, nontraditional learners, and students of color (Fauria, & Fuller, 2015). Minority students are a large part of this attrition rate as 91.5% African Americans, 90.5 % American Indian/Alaska Native, 91% Hispanic Americans, and 90% Asian/Pacific Islanders do not graduate with STEM degrees compared to 44% of Caucasians (Riccitelli, 2015). Graduation rates are significantly impacted by the attrition rate of two-year community colleges due to many community college students having to transfer to four-year universities to complete their degrees. Transfer students are four times more likely to persist and are less apt to receive a baccalaureate degree in six years or less (Fauria, & Fuller, 2015).

Results of the Teacher-Centered Paradigm

Researchers have linked high attrition to higher education's use of large lecture-based courses with a teacher-centered instructional style that focuses on the acquisition of content knowledge through memorization in introductory STEM courses (Gasiewski et al., 2012; Scott, McNair, Lucas, & Land, 2017). Attrition of this level becomes an issue when looking at international enrollment rates. National Academy of Sciences reported in 2010 that only 16% of U.S. students are registered in natural sciences and engineering degrees comparing poorly with China (47%), South Korea (38%), and France (27%) (Riccitelli, 2015). In other words, students of other countries are nearly twice as likely to enroll in STEM degree programs as those in the U.S. Even if it is assumed that these countries have the same attrition rates, which many do not, they will have more STEM graduates because they start with a larger student population. This shows an overall trend projection of the U.S. falling behind internationally on subjects of science and mathematics. The United States has consistently scored low for science (2006-25, 2009-23, 2017-24) and mathematics is the current crisis with a steady drop in ranking over the past decade (2006-25, 2009-30, 2017-38) (Hagedorn et al., 2012). The result of the teacher-centered paradigm has led the United States to be less competitive in STEM on the world stage.

Comparison to K-12

While looking at the use of a teacher-centered instructional style in colleges and universities, the question must be asked, is this the style used for students in primary and secondary education? The answer is mixed. Many various reform efforts have been instituted over the last 50 years to expose students to an inquiry-based curriculum (Feldman, Divoll, & Rogan-Klyve, 2009). The inquiry-based curriculum morphed into the Next Generation Science Standards (NGSS) calling for the integration of engineering design and scientific inquiry. NGSS utilizes a transdisciplinary STEM curriculum approach with a student-centered instructional style allowing students to engage in real-world problem solving (Chesney, 2017). This shift occurred because research indicates science achievement is higher for students using this type of approach (Mesa, Celis, & Lande, 2014). Many reform-funding initiatives promote shifts that include type of reform. The National Science Foundation [NSF] has been at the forefront of such initiatives creating the NSF Graduate STEM Fellows in K-12 Education program, the National STEM Education Distributed Learning Project, and the Transforming STEM Learning Initiatives (Hagedorn et al., 2012). All these initiatives focus on increasing learning and achievement in STEM fields.

The results of this approach have been mixed. Like the call for STEM reform in higher education, primary and secondary education reform is hindered due to ambiguous definitions and vague models of what transdisciplinary engineering design and scientific inquiry curriculum look like (Chesney, 2017). This leads to widely varying curriculum models being developed and implemented with many focusing only on science causing a hindrance to student's learning through the transdisciplinary curriculum approach (Chesney, 2017). Secondarily, with each school district having the ability to choose what curriculum they are implementing, success is isolated to individual districts.

One of the elements making progress for primary and secondary education is the focus on teacher development. Many teaching certification programs require yearly professional development as required in their program. This formal training occurs in professional learning communities, teacher leader development programs, cognitive coaching, and an array of professional development opportunities (Chesney, 2017). Training for K-12 is mandatory for employment and has a minimum requirement for certification renewals, while at community colleges and universities professional development is still only considered optional.

Even with these mixed results, gains are still being seen in K-12. The National Center for Education Statistics [NCES] for 2011 saw dropout rates lower to 8.1% in 2011 from 14.8% in 1972. The number of students taking advanced science courses increased from 35% in 1982 to 68% in 2004. Advanced mathematics course enrollments went from 20.9% in 1990 to 62.0% in 2009 with calculus enrollment jumping from 7% to 16%

in the same period. This shows that high school graduates are taking more advanced placement courses with one-third of all advanced placement courses being STEM based. Reform, even though mixed in K-12, is evident through increases in student STEM course enrollment. However, the increase in K-12 enrollment is not translating into college level STEM enrollment. So, the question becomes, what STEM instructional reform efforts are occurring in the higher education setting and how do they build on the K-12 models?

Types of Reform Efforts

Faculty reform in STEM has four foci that seek to improve pedagogical practices of individual faculty. The scope of this reform is in relation to the developers or "change agents" who drive the reform. Disciplinary-based STEM education researchers (SERs) are typically other faculty who primarily focus on changing the instructional practices of faculty through content acquisition (Henderson et al., 2010). Faculty development researchers (FDRs) are typically situated in centers for teaching and learning and primarily focus on changing individual faculty members' teaching practices through pedagogy acquisition (Henderson et al., 2010). Higher Education Researchers (HERs) are typically situated in departments of educational leadership (or similar) in a college of education, some in university administration, and their focus remains on changing educational environments and structures (Henderson et al., 2010). In other words, they are looking to change the faculty's physical environment or the policies and procedures needed to encourage faculty to change. Communities of Practice (CoP) are STEM reform efforts with the national agenda of improving the teaching practices of STEM faculty and promoting large-scale institutional change (Bernstein-Sierra & Kezar, 2017; Gehrke & Kezar, 2016). Unlike the previous three, CoPs are not directly associated with colleges and universities but are a loose collection of STEM faculty from many institutions who tied together through a common goal. This arrangement allows many scholars see the potential to push reform on a long-term scale (Gehrke & Kezar, 2016).

Many of the faculty focused reform programs find funding through different federal, state, and private programs. Multiple sources of funding are available, but the National Science Foundation is a large contributor. “NSF has been tasked with the priority area of Enhance STEM Experience of Undergraduate Students, including assisting with improving the delivery of undergraduate STEM education through evidence-based reforms.” (NSTC, 2013, pp.13). NSF has many programs available and implemented to give funding to numerous STEM reform efforts. These programs were designed for the students who were working towards a baccalaureate degree at an institution (Hagedorn et al., 2012). Many funding streams focus on individual faculty or departments making grass root changes and providing seed funds to get them started. A few programs are focused on institutional change and cooperation among high schools, community colleges, and universities. These programs included NSF’s Science, Technology, Engineering, and Mathematics Talent Expansion Program or STEP program and The Advanced Technological Education (ATE) program. The STEP and ATE programs focus on community colleges developing partnerships for 2+2+2 transitions of STEM students. They impact STEM program by having better articulation policies, an improved curriculum, and professional development for advisors and faculty (Hagedorn et al., 2012; Hoffman et al., 2010). Both programs were designed using the P-16 pipeline model for STEM that has been in use for the last forty years (Metcalf, 2013). The P-16 pipeline model was used to understand the educational pathways of students going from pre-kindergarten to a baccalaureate degree and finding ways to align curricula from the beginning to the end of an educational path. The pipeline focused on the loss of students from the STEM workforce through problems of inequity and underrepresentation of genders and minorities (Metcalf, 2013).

Impediments to Reform

Impediments to STEM reform in higher education are as numerous as the number of higher education institutions. These various impediments can be classified into three categories: faculty-based, institutional, and government/private funding. Faculty impediments are those seen in reforms driven by individual faculty. Institutional impediments include issues dealing with the hiring, reward, and evaluation processes at the institution. Government and private funds impediments evaluate the use of funding sources to start and continually fund STEM reform practices.

Faculty

Reform for STEM has many issues preventing it from taking hold nationwide. Some limited reform at local levels has been spear-headed by driven individual faculty members. Faculty express frustration with the reform issues and assign blame for the problem with the institution saying they are limited due to bureaucratic reporting procedures, receiving poor in-services, and a lack of resources for improving teaching practices (Fishback et al., 2015).

Faculty at many institutions have trouble knowing where to start in addressing STEM reform. Faculty jump straight to a reform strategy or intervention believing they know the reason why students are failing (Kezar et al., 2015). Good practice is to collect data in an evaluative fashion to determine the needs of a specific institution. Data exploring the problem of poor performance is not gathered before faculty implements a reform effort. Yearly evaluations are self-reported after the semester is finished and are used to show a passing score instead of being part of a timely large-scale assessment to improve student performance during the semester. This leads to an interpretation of the data without any success tied to a specific reform strategy and without determine the root problems behind the lack of change.

In-services are one-time workshops that increase awareness of evidence-based strategies but alone are not adequate in creating experiences to help faculty adopt and successfully integrate strategies in their classrooms (Gormally et al., 2014). Faculty passively learn, usually through a presentation, about the strategy and then attempt to implement it in their own classrooms. The experts may present widely different strategies based on their focus for reform efforts. STEM Education Researchers focusing on content presentations through cookie-cutter activities, Faculty Development Researchers focusing on how to get faculty to be more reflective with teaching practices, and Higher Education Researchers focusing on the instructional environment and institutional policies. Faculty often do not have access to the experts after the in-service event to ask questions or troubleshoot if they run into problems. This leads to frustration for the faculty and either ending the use of the strategy or implementing it in a fashion that is not in line with how it was presented.

Faculty often reference a lack of resources available to improve their teaching practices. Faculty tend to spend their limited time and resources on getting better at what they feel they are good at, the subject matter content (Fishback et al., 2015). Many believe that if they improve their content knowledge it will improve their teaching, but these two elements are not directly connected. Most reform efforts are isolated and do not build on previous empirical or theoretical work. Researchers that have published work on STEM reform make claims about success when the real time data shows limited success without strong or significant gains (Henderson et al., 2010). When higher education institutions set aside time and resources for a specific in-service, they might not see the predicted increase in their own student success. This leads to a systemic problem where when they are requested to allocate resources it is rejected based on the belief it will be just an ineffective.

All the conditions aforementioned, along with personal questions such as commitment to content coverage, lack of confidence in student ability, employment as adjunct faculty with different expectations and campus involvement, and concerns over classroom management lead many faculty to disregard evidence-based teaching practices (Gormally et al., 2014). When individuals compound these systemic issues by being resistant to change and relying on their own knowledge of best practices, reform efforts struggle despite the resources and research-based practices available that could be used to shift institutional policy (Kezar et al., 2015). This leads to the failure of institutional change at both the departmental level and throughout the system above.

Institutional

While faculty in both two-year community colleges and four-year universities seem to react the same to reform efforts, community colleges and universities react radically differently to impediments. University's main impediments center on their reward structures for faculty. Reward structures are currently focused on rewarding faculty who focus on research productivity with tenure and course releases (Gehrke & Kezar, 2017). Institutional leadership fosters a culture devaluing teaching practices and creates a unique problem for universities. When they commit resources for professional development, the disconnects in the reward structures between espoused values and practice, leads faculty to resist participation in professional development on any other topic than research-focused ones (Howard, & Taber, 2010). This practice halts or slows any reform to teaching practices.

Community colleges, on the other hand, focus their values on teaching even though there is little valid research on the characteristics of effective community college teachers (Miller, 2015). Although they do not have a specific reward system, yearly evaluations focus on the faculty's ability to teach through professional development and community service to a lesser extent (Miller, 2015). There is significant diversity in how community colleges determine the criteria for faculty evaluations with some allowing for faculty participation in the criteria development and others leave criteria development to administration. The top three ways data is collected regarding faculty teaching evaluations includes chair evaluations, classroom visits, and student ratings (Miller, 2015). The use of classroom visits is unique to community colleges and is not currently in practice at universities.

Despite the differences in the reward and evaluation impediments with both university and community college systems, they have some similarities. Universities and community colleges have experienced a legacy of ill-conceived professional development reform efforts that both institutions refuse to recognize as a contributing factor of the faculty's aversion to participate in professional learning (Miller, 2015). Ineffective professional development has an accumulated effect on an institutional culture that can leech into the practices of newly hired faculty members. This prolongs the negative effects well beyond the end of the professional development sessions. Institutions can also exacerbate this effect by collecting data on institutional performance, identifying a specific set of weaknesses based on a small group of faculty, and then create a generalized professional development plan to correct the identified weaknesses. This plan is then forced on all faculty members (even those that did not show this weakness) to participate in the corrective professional development (Miller, 2015). Professional development needs to be specific and ongoing to specific faculty needs without being overgeneralized as targeted to the entire institutional population.

Governmental and Private Funding

With a focus on maximizing institutional resources, many agents of change are pushed to find funding to support change outside the institution. Faculty find this type of funding through a mix of governmental and private funders. This leads to isolated efforts to fund short one-time projects that are meant to be pilots to create reform in hopes of long-term dissemination. These short-term funding projects have been shown to be ineffective in creating long lasting institutional change (Bernstein-Sierra & Kezar, 2017; Kezar et al., 2015). This type of funding model is particularly problematic when applied to two-year community colleges. First, many policymakers assume that STEM careers require, at minimum, a bachelor's degree (Hagedorn et al., 2012). This leaves many community colleges left out of funding opportunities because they do not issue any degree higher than an associate degree. Second, many four-year universities have the experience and institutional resources to help researchers find grant funding. The university systems are better able to assist faculty with locating funders and completing grant proposals than those at community colleges, which rely on individual faculty members to take the time to find funding on their own. When community college STEM faculty primarily focus on the acquisition of funds to move educational reform efforts to institutional change, the community colleges is negatively impacted (Kezar et al., 2015). Reform is tied to finding funding because the institutions are not budgeting for the long-term application of the change. Faculty change agents are spending large amounts of time writing proposals to obtain grants. Once funding is obtained, the short-term reform effort is implemented. When the funding runs out, the reform effort ends because the institution does not or is not able to budget for its continuation. Pedagogical lessons learned are lost with each test case and the improvement cycle then goes back to the faculty writing proposals to develop the next reform effort. In summary, instead of seeing funding as a kick-start for reform, institutions are relying on it as the primary source of funding. As the funding dries up so does any reform effort leaving faculty in a never-ending cycle of finding funding for new and innovative reform that leads to no long-term institutional change.

Student-Centered Learning

The discussion of the use of student-centered learning in the higher education STEM classroom is steady and ongoing. As early as 1995, Barr was referencing the need for reform in what he termed a learning paradigm. The conversation was continued in 2009 with "Vision and change in undergraduate biology education: A call to action", that AAAS produced through the compilation of articles and discussions with undergraduate biology faculty at the conference of the same name. This led to a general agreement among several scientific organizations that an active learning instructional style is needed (Patrick, 2016). A glossary of terms is being used to describe student-centered reform including: interdisciplinary instruction, student participation, learning-centered model, intentionality model, learning paradigm, scientific inquiry, inquiry-based learning, active learning strategies, project-based learning, and learning outcome centered instruction. All these terms are used to describe the use of some or all aspects of a student-centered instructional style.

So, what do all these descriptors have in common? On some level, all describe a shift from the focus on the acquisition of content knowledge and basic skills to an active learning curriculum that focuses on problem-solving experiences (Divoll, 2010; Feldman et al., 2009; Lumpkin, Achen, & Dodd, 2015; McConnell et al., 2017).   This is created in an environment where lectures are replaced with active learning that is either self-paced and/or cooperative (teamwork) based learning (Lumpkin et al., 2015; Lysne & Miller, 2015). The paradigm shift changes from students being passive learners to students who are active participants in the learning processes as they participate in learning experiences and reflect on those experiences (Lumpkin et al., 2015; McConnell et al., 2017). As a part of this participation, students are provided the opportunity to engage in educational purposeful activities and share information from diverse perspectives (Lysne & Miller, 2015). Students often have a wide and varying background with varying experiences. The sharing of those backgrounds and experiences makes the learning personally relevant to each student. All of the descriptions are found in a continuum with each term emphasizing different elements of the descriptions along with the different aspects of STEM (Science, Technology, Engineering, and Math). Therefore, student-centered learning can be summarized as an instructional style that involves students' active engagement in collaborative learning activities facilitated by teachers and followed by a student self-reflective process.

As students become active participants in their own learning, it is necessary to redefine roles for both the instructor and the students. For instructors, the biggest shift is from being a provider of content knowledge to a facilitator on the student's journey to learning (Divoll, 2010; Howard, & Taber, 2010). It is imperative for instructors to not only create motivating educational environments but to provide appropriate positive reinforcement that supports student engagement within the learning process (Lumpkin et al., 2015; Peters, 2013). Instructors can do this by providing choices, opportunities, and student support while asking the students to challenge their way of thinking. The students and the instructors must be ready for the students to participate in all aspects of the course and instruction. Institutions and faculty need to trust students enough to give them a voice in the classroom and release some control (Divoll, 2010). Students need to be prepared to be creators, presenters, and debaters of new ideas (Hayward, 2016). When instructors encourage students to be creators, presenters, and debaters of new ideas, they facilitate the development of students as independent learners (Hayward, 2016 Smallhorn, Young, Hunter, & Silva, 2015).

Many community colleges define their purpose in terms of providing high-quality affordable education to its student population. They acknowledge that they serve the community to create the best-educated student population possible. Teacher-centered learning environments with the faculty member as experts that only present information were not achieving this community-based goal. There was a need to shift focus to a learning environment where student learning was the focus. Therefore, many community colleges have (in theory but not practice) changed their mission statements from missions of high-quality instruction to missions of high-quality learning (Barr & Tagg, 1995). When the focus is on learning, the method (student learning) and product (student achievement) are separated, allowing for the change to whatever instructional style works best at improving graduation rates to take place (Barr & Tagg, 1995). Shifts in college mission statements have fallen behind current recommendations in the K-12 research going beyond high quality learning statements, noting that inquiry-based instruction in

STEM demonstrates higher student achievement gains across all educational levels (Barr & Tagg, 1995; Divoll, 2010; Lumpkin et al., 2015; Hayward, 2016; Howard, & Taber, 2010; Mesa et al., 2014; Peters, 2013; Smallhorn et al., 2015).

Teacher Self-Efficacy

A key component influencing the effectiveness of instructional style and instructor behavior is teacher self-efficacy, which is defined as the belief or perception of one's capabilities. (Bandura, 1997; Morris, & Usher, 2011; Peters, 2013; Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998). In other words, the confidence an instructor has in teaching affects how the instructor teaches. A higher self-efficacy or confidence in their abilities should translate into better teaching practices. This idea is well known to primary and secondary researchers and has been well researched in those environments (Fishback et al., 2015). Research into teacher self-efficacy is lacking in higher education possibly due to teaching practices being undervalued in comparison to research skills (Gormally et al., 2014). Many STEM faculty at universities teach fewer classes to be more involved with research. STEM faculty at community colleges, while they do not do research, see this time replaced with college committees and community service.

The research is bereft of studies pertaining to the self-efficacy of STEM instructors in higher education. However, Albrecht and Fortney (2010) and others, found the way that STEM faculty approach teaching through their beliefs, skills, and knowledge of either research or teaching heavily influences their pedagogical choices (Albrecht & Fortney, 2010; Ebert-May et al., 2015; Eick & Reed, 2002; Hirschy, Wilson, Liddell, Boyle, & Pasquesi, 2015). Their pedagogical choices also influence their belief in their abilities. Many low self-efficacy faculty are unable to identify or connect to how lessons are integrated with other disciplines when the lesson becomes more abstract as critical thinking needs increase (Chesney, 2017). This leaves many instructors with low teacher self-efficacy clinging to content-driven lesson plans where the presentation of facts dominates the lesson.

On the other end of the spectrum, STEM faculty with high teacher self-efficacy are seen to have more positive traits such as being able to plan and organize instruction, motivate students, give better feedback, and choose more challenging pedagogical techniques (Gormally, et al., 2014; Morris & Usher, 2011). This could be translated into the idea that higher teacher self-efficacy leads faculty to choose a more student-centered instructional style and lower teacher self-efficacy faculty choosing a more teacher-centered instructional style. Faculty with the higher teacher self-efficacy can more efficiently lesson plan to use more engaging instructional strategies, increasing student engagement, and fosters resilience to obstacles in the instructor (Morris, & Usher, 2011). Higher teacher self-efficacy has been correlated to successful teaching experiences and positive student feedback; moreover, these instructors have a higher expectation of themselves, which then translates to higher student achievement (Fishback et al., 2015; Morris & Usher, 2011). This research is showing that teacher self-efficacy can be used as a diagnostic tool where it can be determined which activities and what educational orientation a faculty has.

Teacher self-efficacy development

Teacher self-efficacy is developed early in the STEM faculty career with many reporting being “thrown into the fire” with just a PowerPoint presentation that was given to them by another faculty member to rely on (Morris & Usher, 2011). The traditional lecture of the teacher-centered pedagogy is then passed from mentor to mentee. It is during this graduate training that most faculty have little or no teacher development in pedagogy and leaves many without even a basic awareness of pedagogical techniques (Gormally et al., 2014). This could lead them to recreate the instructional style of the instructors from the courses they took as an undergraduate and graduate student. This may explain why the teacher-centered instructional style has lasted for so long in the STEM disciplines at universities and community colleges. Ultimately, this process leaves faculty unable to provide instructional feedback or use evidence-based teaching methods and creates a performance gap between what they are doing and what they should be doing (Ebert May et al., 2011; Gormally et al., 2014). These gaps, while varied between disciplines, seem to be larger in the STEM fields due to a focus on research during graduate work. During this induction time, many faculty solidify their self-beliefs and develop teacher self-efficacy as they pursue a career in academia (Morris, & Usher, 2011). The focus on research in many STEM disciplines may be hindering the ability to improve STEM instruction.

Calls for change imply that this transferring of the higher education knowledge for the past five, 10, or 30 years may not be effective for today's students and therefore wrong (Anderson et al., 2011). This goes against the belief held by the faculty that the way they learned is the best way. After pre-service experiences, institutions rarely have effective professional development systems to change or influence the mindset and instructional style choices that develop as a byproduct.

Research into primary and secondary education has shown that to sustain effective pedagogical change it is necessary for intensive ongoing professional development that includes vicarious and mastery experiences, proficient teaching models, and metacognition on the instructors chosen teaching styles (Alicea et al., 2016; Gormally, et al., 2014; Morris & Usher, 2011). Many professional development programs are centered around an institutional need such as diversity training, active shooter preparedness, and institutional processes. Vicarious experiences are found to be necessary so that faculty can see the successes and failures of others to alter their self-efficacy (Morris, & Usher, 2011). Faculty need to observe their mentors as they teach classes and discuss the success or failure of the mentor afterward. The real need is for teacher mastery experiences. Previous teaching experiences with reflection can have a significant influence on and raise teacher self-efficacy (Morris, & Usher, 2011). Faculty have said that successful mastery experiences and positive feedback from students are powerful influences on teacher self-efficacy while negative experiences are unlikely to reduce their teacher self-efficacy (Morris, & Usher, 2011). This leaves the clean message that doing something will only have a positive effect and doing nothing has the same effect as having a negative mastery experience.

Community College Teacher Self-Efficacy

Community colleges also have a unique environment that effects teacher self-efficacy. Community college STEM faculty are view as less qualified by their university counterparts due to the reduced value for teaching and increased value for research in universities (Morest, 2015; Twombly & Townsend, 2008). This leaves many community college faculty feeling that they are less than their university counterparts are and feel excluded from conferences and STEM communities because they have no research to contribute.

Differences between community college and university faculty are often passed off as a deficiency in the community college faculty, further reducing teacher self-efficacy as they are treated as less capable simply because they choose to teach at a community college (Morest, 2015; Twombly & Townsend, 2008). University faculty usually know nothing about community college faculty other than they only teach. They question the rigor of the community college courses and universities may also hesitate to accept the transfer credits of those students (Twombly & Townsend, 2008). Community college faculty constantly have their teaching questioned by university officials. This shows the arrogance of university faculty and institutions in general regarding community college faculty and their courses. Universities often deem community college courses as easy with low grading standards that lead to academically weak students (Twombly & Townsend, 2008). This leads community college faculty to feel disrespected by university faculty and leads to an even lower teacher self-efficacy (Twombly & Townsend, 2008). Based on Bandura's theory, low teacher self-efficacy correlates to low student success (Bandura, 1997; Bandura, 1995; Peters, 2009, 2013). To produce long-lasting change in community college, addressing the sources of disrespect from university faculty may reduce some of the low teacher self-efficacy experienced by community college faculty.

Classroom Climate

Classroom climate is closely connected to student success. Perceptions of classroom climate can have more of an impact on classroom climate than objective reality (Corkin et al., 2014; Peters, 2009, 2013). The tendencies of these classroom climate perceptions lean toward the binary labels of positive and negative. Since Fraser in 1989, many studies in primary and secondary education have centered on classroom climate to support students' academic and social-emotional development (Alicea et al., 2016; Can & Kaymakci, 2015; Corkin et al., 2014; Fraser, 1989; Peters, 2009, 2013). This body of research connects many researchers to the higher education classrooms serving as a basis to describe the formation and maintenance of higher education classroom climates. Research suggests that peer interactions shape and influence positive classroom climates characterized by a trusting and emotionally supportive environment that contributes to increased student engagement (Alicea et al., 2016). Students want to feel comfortable and safe in their classrooms to the extent that they can openly share ideas and discuss topics in the classroom.

Barthelemy (2015) found that five factors account for 60% of the variability in classroom climate models. Those factors include comfort (24%), school avoidance (11%), relationship to the course (9%), academic stress (8%), and discomfort (2%). Barthelemy assessed comfort, which was the top factor that accounted for 25% of the variation, with questions that assessed instructor relations and feelings of comfort in the classroom. This becomes important as researchers have been looking into how classroom climate is affecting underrepresented persons in higher education and more specifically in STEM degree fields. Negative classroom climates can hinder students' integration into student life, their ability to learn, and underrepresented students' persistence in the course (Barthelemy et al., 2015). The instructors or students alone do not determine positive or negative classroom climate. It is a collaborative effort between the two groups and research into positive characteristics of both groups has been enlightening.

Positive Characteristics

Positive characteristics that build classroom climate start with the instructor. The instructor sets the tone for the classroom. Positive characteristics demonstrated by instructors include organization, enthusiasm, student support, caring, academic rigor, positive expectations, and interest in creating opportunities (Can & Kaymakci, 2015; Corkin et al., 2014; Peters, 2009, 2013). These characteristics are seen more often in newer (1-5 year) and highly experienced (20 or more years) instructors (Can &

Kaymakci, 2015; Corkin et al., 2014; Peters, 2009, 2013). It is important that instructors strive to develop the positive characteristics necessary to create rapport with the students and to foster student engagement. Once students are engaged, instructors can then drive high expectations and hard work from students (Barthelemy et al., 2015). This creates an environment where students not only expect more from the instructor but also from themselves. Students also have a potential impact on the classroom climate both directly and indirectly by having shared attributes, experiences, and ideologies among the group. If they do, they are more likely to emotionally support each other throughout the course of the class (Barthelemy et al., 2015). Instructors must take all of this into consideration when setting the tone for classroom climate. Should instructors ignore any factors, students can become disengaged from the learning process, and this disproportionately affects underrepresented groups (Barthelemy et al., 2015). This can occur either through instructor language (verbal or nonverbal) or because underrepresented students feel they do not share attributes, experiences, and ideologies with the other students.

All these previously mentioned factors combined positive characteristics of both instructors and students to build a positive classroom climate. A positive environment (defined expectations and fair evaluations where ideas can be discussed and shared freely) and engagement in the course work has the highest correlation to student persistence. Discomfort is the dominant factor for the creation of a negative environment and a decreased persistence to completion (Barthelemy et al., 2015; Peters, 2009, 2013). Although discomfort has a negative effect on classroom climate, it is relatively small in comparison to other positive factors. Thus, trying to create a positive classroom climate is better than doing nothing because even if the intervention is negative it will only have a slight negative effect.

It takes more than just the presence of positive characteristics in faculty to cultivate a positive classroom climate. Instructors must take an active role in cultivating a positive classroom climate. Research has shown that instructors are more likely to create a positive classroom environment through practices such as use of feedback, encouragement, and being approachable than if they focused only on minimizing negative student experiences (Barthelemy et al., 2015; Peters, 2009, 2013). Supported students in positive classroom climates are shown to have higher persistence, success, and overall achievement than those not in positive classroom environments. Supported students are more likely to use resources and study groups, which foster positive feedback leading to greater productivity in and out of the classroom and lead to greater student success (Barthelemy et al., 2015; Can & Kaymakci, 2015).

Though every STEM faculty member wants a high level of student success or achievement, there are barriers inherent specifically to STEM courses. These barriers contribute to many students leaving STEM degree plans and entering other degree plans that they consider "easier" or more welcoming. Gasiewski (2012) attributed this idea to Daryl Chubin, Director of the AAAS' Center for Advancing Science & Engineering Capacity with his statement that "the culture of science says, 'Not everybody is good enough to cut it, and we're going to make it hard for them, and the cream will rise to the top''. This classroom climate is created by instructors using large classroom (100 or more student) lectures that often consist of one-way, passive, superficial learning that is fast-paced with copious amounts of information that students must learn and memorize instead of utilizing critical thinking (Gasiewski et al., 2012; Scott et al., 2017). This leaves little to no time for students to talk to the instructor let alone ask questions if they need help. Students are left to their own devices to learn the material as they attempt to keep up with its demanding pace of presentation, often memorizing large quantities of information with little application or critical thinking development. If students are not able to master the content as it is presented, they are left with the impression that they are incapable of learning and often cannot proceed. Hence the creation of a gateway course philosophy begins. Generally, these gateway courses are situated as undergraduate introductory courses so the weed out may happen early in the students' college careers. This leaves many STEM faculty wondering why students are not persisting in getting STEM degrees.

Evaluation

Both STEM faculty and the institutions could evaluate classroom climate in several ways. Two of those methods are end-of-course surveys and peer evaluations, which are research-based practices shown to be effective for measuring classroom climate. End-of-course surveys consist of quantitative measurements and many institutions use these as common practice although they are summative or final evaluations rather than formative assessments. These assessments occur at the end of the semester, STEM faculty are unable to make pedagogical adjustments during the semester and must wait until the next semester to implement any changes. End-of-course surveys themselves are problematic. Typically, these surveys ask questions about instructor enthusiasm, clarity of syllabus and materials, rapport, and coverage of material that are key aspects of a teacher-centered instructional style (Gormally et al., 2014; Morest, 2015). These types of surveys are given in all courses, including STEM courses every semester. The survey is generalized to be applicable to all courses using questions on presentation of content, clarity of expectations or directions, helpfulness/availability, feedback on performance, and encouraging discussion. Depending on the wording of the questions, it can create an expectation in the student for traditional or teacher-centered instructional styles. Since many non-STEM courses use a teacher-centered style, it can create a bias for students leading to the expectation that all courses are taught in the lecture-based teacher-centered format. These evaluations are weak in evaluating student-centered pedagogy, and face difficulties from disciplinary bias compared to non-STEM courses (Gormally et al., 2014; Morest, 2015). STEM disciplinary bias manifests as lower overall scores for STEM faculty on the end-of-course surveys. This is due to students' anxiety toward STEM courses and the perceived difficulty of courses compared to other non-STEM courses. As a direct result of the lower evaluation scores, many STEM faculty choose one of three responses: continue with their teacher-centered instructional style, lower the rigor, or ignore the surveys (Gormally et al., 2014). These choices result in the survey being useless to both the institution and the faculty when making data-driven decision to improve student success.

The second type of evaluation, peer evaluation, uses mentors or supervisors of STEM faculty to observe faculty conducting a course. Peer evaluations are typically used once a year in one-time classroom observation and are used to evaluate how well the STEM faculty are performing in the classroom (Gormally et al., 2014; Morest, 2015). After the observation, there is a written report or a meeting held in which the STEM faculty's performance is discussed. The mentor, supervisor, or peer usually have no training in instructional feedback or pedagogy and stick to reports of content accuracy without curricular or objective alignment (Gormally et al., 2014). This lack of training leaves the peer discussing the accuracy of the content presented. If the peer steps into a student-centered classroom and sees a discussion happening, the peer does not know how to evaluate the quality of learning occurring. In a teacher-centered classroom, the evaluator can readily determine whether or not the STEM faculty presented accurate information and whether or not the instructor asked students questions to make sure they are processing the information presented. Another factor limiting the effectiveness of peer evaluation is that the one-time observation does not last more than one lecture period. After observing the peer once, a performance rating is determined without consultation with the instructor. In addition, evaluators often refrain from giving negative feedback (Gormally et al., 2014). Just like the end-of-course surveys, peer evaluation is also used as a final summative evaluation that is tied to the end of year evaluation or the tenure process. This creates a high stakes evaluation that leads to observer bias towards their own teaching style, reliability issues, and ultimately a lack of support for the STEM faculty being observed (Gormally et al., 2014). This creates a peer evaluation process that is not useful to either the faculty or the institution.

Peer observations and surveys need to be discussed to determine the breadth and scope of the feedback STEM faculty are receiving to insure it is aligned with program goals. Improvements are needed with not only the evaluation process but with the way in which feedback is given to STEM faculty. To improve teaching performance, feedback must be specific enough that a plan for improvement is either explained or can be developed and provided as close to the observation time as possible (Gormally et al., 2014). In other words, feedback needs to be early, often, ongoing, provide suggestions for improvement as close to the actual observation as possible, a plan for change, and a follow-up to confirm the change is happening.

Student Engagement

All of the calls for reform focus on changing to a student-centered learning instructional style with one goal in mind, increasing student engagement. Student engagement has been established as a critical predictor for college completion and transfer but explicitly for STEM programs and the diverse students in those programs (Alicea et al., 2016; Anderson et al., 2011; Barthelemy et al., 2015). Engagement levels have shown that students who are engaged have significantly higher GPAs than students who are less engaged (Riccitelli, 2015). Research into student engagement is complicated. Higher education considers student engagement both inside and outside the classroom and likens it to engagement, integration, involvement, and social belonging (Alicea et al., 2016). This becomes a problem for community colleges. While universities have a student population that is persistent, community college student populations are transient with most of their time spent in the classroom. Higher education research should be synonymous with the four-year university (Alicea et al., 2016). Higher education research into student engagement mirrors K-12, though while K-12 uses classroom observation methodologies, higher education focuses on using instructor and student surveys and interviews (Alicea et al., 2016). The difference in the research in student engagement and observational methodologies limits the generalizability of research results.

Student engagement has an extensive research library available with more in-depth studies being conducted at the K-12 level. Gasiewski (2012) summarized academic engagement as three parts; behavioral - student involvement in academic tasks including measures of effort, asking questions, and paying attention in class, emotional - students' feelings of boredom, anxiety, and excitement in the classroom, and cognitive - students' investment in learning with measures relating to individuals' commitment to working hard and exceeding expectations. This is not the definition embraced by higher education literature, which defines academic engagement akin only the behavioral engagement element. The emphasis is on the effort made by students (completing assignments, attending class, and complying with rules) while leaving out the interaction of the instructor with the student and focusing on interactions outside of the classroom environment (Alicea et al., 2016; Anderson et al., 2011; Barthelemy et al., 2015).

The student population at many four-year universities resides either on campus or very close to it. This residential population spends a great amount of time on campus, so it is not a stretch to have out of classroom interventions like tutoring and open labs to assist with student learning. Much of the work and research in four-year universities surrounding student learning focuses on support services, rather than the actual classroom environment (Alicea et al., 2016). Many university classrooms use a traditional teacher-centered instructional style, and as a result, most of the students do not cognitively process a question and participate in answering it, so learning does not take place (Gasiewski et al., 2012). Interactions between faculty and students at this level are difficult due to many factors including class sizes (Fauria, & Fuller, 2015). It is hard for faculty to challenge and give appropriate supports to students on an individual level. This makes support services necessary in university interventions. Support services that are segregated from classroom experiences have a deep positive impact on students at residential universities and can be used to predict persistence (Alicea et al., 2016; Bonet & Walters, 2016).

Support services are not as positive of an indicator of persistence for community colleges as it is for universities. While support services are provided at community colleges, students are non-residential or transient who go to school part-time and spend little time on campus. They are not able to utilize these services as often so they do not see a benefit and do not socially integrate into the community college culture like those at a university (Alicea et al., 2016; Bonet & Walters, 2016). This leads to a need for understanding how student engagement is impacted in the classroom. The faculty affects a large part of classroom climate and student engagement. Understanding of student engagement in the community college classroom is limited yet imperative considering it is underpinning many educational workshops offered to faculty to improve STEM instruction (Alicea et al., 2016; Ebert-May et al., 2011). Many community college level professional development opportunities are created based on the ideas and research of higher education (i.e. university) regarding how to improve student engagement with student services. Community colleges need to understand that creating a positive classroom climate to improve student engagement is impacted by instructional style and the effects of teaching efforts intentionally creating educational experiences make student engagement inescapable (Alicea et al., 2016; Barthelemy et al., 2015; Fischbach, 2015).

Institutional Support

Institutions set the tone of what is important by the policy decisions they make. Community colleges are no different from universities in that college administration sets the tone of the community college through decisions pertaining to faculty development, policy, space design, and funding. Community colleges are bureaucratic organizations where administration ultimately plays a dominant role in decision-making (Kim, Twombly, & Wolf-Wendel, 2008). This system created a policy where faculty are paid based on seniority and academic degrees rather than merit without any formal mechanisms for feedback or professional improvement beyond promotion or tenure evaluations (Fishback et al., 2015; Twombly & Townsend, 2008). When you combine these practices with a system that rarely incentivizes or evaluates the success of any of the professional development, this leads to an environment where mission statements and public statements expound the virtues of student achievement and good faculty rather than student engagement and learning (Howard & Taber, 2010). Many institutions are so focused on the product (student graduation rates) they rarely see that supports and incentives need to be in place for STEM faculty as well as for students (Henry, 2010; Howard & Taber, 2010).

Faculty development or professional development is rarely connected to college mission statements and are ad hoc, lack institutional support, rarely evaluated for intended change, and are voluntary, therefore participation is minimal (Howard, & Taber, 2010; Twombly & Townsend, 2008). Typically, they are not enough to guide institutional change. Faculty are often expected to become their own agents of change and join professional learning communities outside of their institutions to find the needed professional development. For many institutions, faculty development is being reverted to online companies that cover content like diversity in a video format that is presented at the faculty's convenience. To buck this trend, community colleges need to be financially healthy with an administration that is focused on providing clear leadership and direction regarding the importance of student-centered pedagogies with resources for faculty development and evaluation of change (Fishback et al., 2015). Decision-making processes need to be created with this mentality in mind. It needs to permeate all levels of institutional decision-making including space design.

The space where teaching and learning actually takes place can have a large impact on the instructional style chosen by STEM faculty. The decisions that administration makes on the architectural design of the class and lab setup set the tone of what instructional styles should be used. The classroom itself can provide a better environment for a student or teacher-centered instructional styles depending on characteristics such as size, seating arrangement, and whether the seating is fixed (Alicea et al., 2016; Chiu & Cheng, 2016). All these characteristics can either create or eliminate barriers for engagement between the instructor and students and among students. Student-centered instructional styles such as peer learning, team-based learning, cooperative learning, blended learning (flipped classroom), project-based learning, etc. can also be applied in teacher-centered classrooms (theater-style fixed seating facing a podium with either a board for writing or a projection screen). Classrooms that are designed to reduce barriers between instructor and students to facilitate collaborative learning and activities are more optimal (Alicea et al., 2016; Chiu & Cheng, 2016). Therefore, if the administration is selecting teacher-centered classrooms when designing spaces, it should come as no surprise that faculty are choosing the instructional style that matches. This choice can also then be reinforced with the availability of funding and resources.

The final piece of institutional support is funding and resources. Incentives can show many faculty where to spend their time and energy. When looking at motivation for faculty, it is clear that promotion and salary is key. If the administration is not supporting change through financial support for conferences and professional development with release time for attendance then faculty will not take the opportunity (Fishback et al., 2015). To combat this, funding agencies like the National Science Foundation, the National Science Resources Center, the National Science Teachers Association, the National Institutes of Health (NIH), and many professional scientific societies have been contributing billions of dollars to initiatives to reform undergraduate

STEM education (Gasiewski et al., 2012; Gehrke & Kezar, 2016). The idea is that funding these grassroots change efforts will lead to institutional and system-wide change. However, what happens is that once initial grant funding runs out the institution doesn't have systems in place to continue the reform and it tends to fade away (Gehrke & Kezar, 2016). This leads to a repeating cycle of reinvention of the reform for each grant project. Lessons that were learned with previous STEM projects are being lost with the newer project iterations.

Satisfaction

Self-efficacy, classroom climate, student engagement, and institutional support culminate with persistence and satisfaction of STEM programs. The question is whether student-centered learning creates satisfactory experiences for faculty and students. Faculty members are more likely to view themselves positively and experience greater work satisfaction when they practice active learning strategies that promote critical thinking among students (Fishback et al., 2015). Some faculty believe that students should take more responsibility to teach themselves and that that they shouldn't have to entertain their students using vast amounts of valuable teaching time when there is so much content in a course that they need to get through (Fishback et al., 2015). This leads many faculty to resist changing their teaching style and continue to use teacher-centered methods. These faculty still see active learning and critical thinking to be important, so they overemphasize the few times that those techniques are used. Shadle (2017) found that dissatisfaction with pedagogy was the key factor for driving successful change. This is a problem considering since 1993, community colleges have shown through Carnegie Foundation's National Survey of Faculty and National Survey of Postsecondary Faculty in 1998 that they are satisfied with their job situation (Kim et al., 2008). Faculty perceptions support the beliefs that they use active, collaborative learning techniques, engage students in experiences, emphasize higher-order cognitive activities in the classroom, interact with students, challenge students academically, and value enriching educational experiences (Lumpkin et al., 2015). STEM faculty may be under the perception that they are teaching in a student-centered instructional style even when they are not. This perception coupled with satisfaction leads many faculty to believe that they are doing a good job educating students, so nothing needs to be changed. This is quite different from the perceptions of the students.

Students' positive perception of classroom experiences and course satisfaction relates directly to instructor-driven practices and well-designed classroom environments that make students feel comfortable, foster their engagement, and tie the material back to the students' lives (Alicea et al., 2016; Chiu & Cheng, 2016). Students are asking to be engaged in a multitude of ways. Teacher-centered instructional styles are no longer enough to fill this need. Faculty who demonstrate high expectations, provide student support, foster student engagement, encourage positive student interactions, offer experience with skills and content knowledge, and who are devoted to teaching contribute to positive student outcomes in achievement, persistence, and satisfaction (Alicea et al., 2016; Ayar & Yalvac, 2016; Ebert-May et al., 2011). This is even more evident in the community college arena where students need learning interventions early and often to help develop them into academically ready college students. Students' responses to student-centered instructional styles are positive, they believe that such instructional styles elicit student creativity and are more rewarding than teacher-centered lecture presentations (Chiu & Cheng, 2016; Coil et al., 2010; Lumpkin et al., 2015). The only greater influence on course satisfaction is whether the student had a previous strong course relationship (Alicea et al., 2016). Students are coming from K-12 primed for more student engagement and interaction.

Summary of Findings

In summary, the definition of STEM is an elusive and vague construct that is used for political influence. STEM education has become synonymous with a student-centered pedagogy though the exact iteration is ambiguous in higher education, but better defined in primary and secondary education. For STEM in higher education, reform has not gained traction and changes from teacher-centered pedagogy have not happened on a wide scale (AAAS, 2011, Bybee, 2013, NSTC, 2013). The focus for these courses has been on content retention and memorization. What research that has been conducted shows that the dominant teaching paradigm is teacher-centered instruction (Barr & Tagg, 1995; Bernstein-Sierra & Kezar, 2017; Divoll, 2010; Fishback et al., 2015; McConnell et al., 2017). The institution, as well as the faculty, expects a teacher-centered instructional style and sets course structures, instructor evaluations, and student end-of-course surveys to assess for a teacher-centered classroom climate. The effect of this paradigm is the development of gatekeeping courses that focus on weeding out students instead of assisting in student development. Reform efforts to reverse this trend have taken many forms that have just as many impediments. Barriers to reform have been identified to include inadequate training, insufficient time, a misunderstanding of evidence-based teaching practices, lack of support or incentives for implementation, and lack of the institutional buy-in. Many reforms have focused on the student while ignoring needs of STEM faculty (AAAS, 2011; Anderson et al., 2011; Brownell & Tanner, 2012; Ebert-May et al., 2011; Ebert-

May et al., 2015; Henderson et al., 2010; Gormally et al., 2014; Mulnix & Vandegrift, 2014).

Constructs being used in this study to better understand this lack of traction in reform to a student-centered learning environment are teacher self-efficacy, classroom climate, student engagement, institutional support, and satisfaction. Teacher self-efficacy is better understood in primary and secondary education rather than higher education. The development of teacher self-efficacy is correlated to instructional style choices as well as student success (Albrecht & Fortney, 2010; Ebert-May et al., 2015; Eick & Reed, 2002; Hirschy et al., 2015). The classroom climate is directly influenced by the instructional style choices and can either support or detract from a positive classroom climate. Student engagement is then impacted with classroom climate. Negative classroom climate influences due to a lack of student engagement can be alleviated by using support services outside the classroom (Barthelemy et al., 2015; Can & Kaymakci, 2015). Support services are not as readily available for community colleges due to the transitory nature of its student population. Institutional supports in place do not focus on supporting faculty teaching in a student-centered environment. Classroom configurations, lack of funding for professional development or incentives, lack of evaluation processes for student-centered pedagogy, and misaligned classroom performance evaluations to tenure or advancement are hindering STEM faculty from changing. Curricular design is mostly ignored in higher education (Alicea et al., 2016). Preparation time is not designated in higher education as it is in primary and secondary education. Self-efficacy, classroom climate, student engagement, institutional support, and curriculum culminate into persistence and satisfaction of the STEM program for students. Well-designed student-centered courses lead to higher satisfaction for both

STEM faculty and students (Alicea et al., 2016; Ayar & Yalvac, 2016; Ebert-May et al., 2011).

Theoretical Framework

Social Cognitive Theory

Bandura's social cognitive theory provides the framework that demonstrates how science professors and students direct learning by relating strategies to efficacy in their capabilities that will accomplish their goals (Bandura, 1997; Bandura, 1995; Peters 2009, 2013). Bandura even goes further to state that performance hinges on what efficacy the performer feels that they have, and people tend to avoid tasks that they feel less competent and confident successfully completing (Bandura, 1997; Bandura, 1995; Peters 2009, 2013). Science professors creating a science course with little to no training may have low efficacy in educational pedagogy, therefore they may not engage in creating their own curriculum, so they may try to replicate teaching styles of mentors from their own academic training (Brownell & Tanner, 2012; Peters 2009, 2013). Based on Bandura's theory, low self-efficacy would correlate to low student success (Bandura, 1997; Bandura, 1995; Peters 2009, 2013). This, in turn, would increase the pedagogical efficacy through professional development and would correlate to higher acceptance or higher student success.

Constructivism

Bruner's constructivism theory includes the framework of an active learning process that is student-centered and using the students' own knowledge and beliefs to construct new ideas. Bruner (1986) surmised through structure an analytical and intuitive thinker could conceptualize and categorize information by revisiting basic ideas and then adding complex ideas (Duffy & Cunningham, 1996).

Long-term cognitive development comes from reviewing and linking complex ideas together in the students' minds many times. Bruner (1986) also states that all of this is achievable in a social environment that encourages student and professor interaction. It is the case with constructivism that many cognitive neuroscience models of information processing and learning strengthen this theory (Anderson, 2014).

Conclusion

The review of literature forms a foundation to support the constructs of this study by including information regarding the: (a) history of STEM, (b) teacher self-efficacy, (c) classroom climate, (d) student engagement, (e) material environment, (f) curriculum design, and (g) satisfaction. The following Methodology chapter will explain the exact procedures that will be utilized by the researcher during the study. The chapter will include an overview of the research problem, operationalization of constructs, research purpose and questions, research design, population and sample, instrumentation, data collection procedures, data analysis, privacy and ethical considerations, and research design limitations for this study.

CHAPTER III:

METHODOLOGY

The purpose of this study is to examine the relationship between teacher self-efficacy and the instructional style of community college STEM faculty. This mixed-methods study collected survey and interview data from a purposeful sample of community college STEM faculty employed in southeast Texas. Quantitative data obtained from the Principles of Adult Learning Scales (PALS) and Teacher Sense of Efficacy Scale (TSES) surveys were analyzed using frequencies, percentages, and a two-tailed independent t-test. Semi-structured interviews were conducted with survey participants concerning their perceptions of what factors contribute to a STEM faculty's instructional style selection and inductive coded to be analyzed for emergent themes. This chapter presents an operationalization of theoretical constructs, research purpose, research questions, hypothesis, research design, population and sample, instrumentation, data collection procedures, data analysis, validity, privacy and ethical considerations, and research design limitations of the study.

Overview of the Research Problem

The way STEM faculty approach instructional practices are through their teaching self-efficacy, which influences their classroom climate, and either supports or detracts from student achievement (Albrecht & Fortney, 2010; Bandura, 1997, 1995; Ebert-May et al., 2015; Eick & Reed, 2002; Hirschy et al., 2015; Peters, 2009, 2013). Community college STEM faculty are creating science courses with little to no pedagogical training. With a low self-efficacy in educational pedagogy, they may not create their own positive classroom climate, instead opting to replicate the teacher-centered instructional practices of mentors from their academic training (Brownell & Tanner, 2012; Peters, 2009, 2013). These teacher-centered practices focus on delivering content in a way that has been the norm in STEM courses for many years. Any deviations from these practices are passed off as a deficiency in community college faculty by university faculty (AAAS, 2011; Brownell & Tanner, 2012; Coil et al., 2010; Dubinsky et al., 2013; Henderson et al., 2010; Henderson et al., 2011; Morest, 2015; Twombly & Townsend, 2008). Designing a student-centered curriculum that engages and supports students while developing a teacher/student relationship is not an area where many STEM faculties have high self-efficacy in (Alicea et al., 2016; Brownell & Tanner, 2012; Coil et al., 2010; Chiu & Cheng, 2016). Research has shown that this teacher-centered style of teaching does not lead to the development of critical thinking skills in many students (AAAS, 2011; Brownell & Tanner, 2012; Dubinsky et al., 2013; Henderson et al., 2010; Henderson et al., 2011).

Operationalization of Theoretical Constructs

This study consists of two constructs: (a) teacher self-efficacy and (b) instructional style. Teacher self-efficacy is defined as a "judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated" (Tschannen-Moran & Woolfolk Hoy, 2001, p. 783). This construct was measured using the *Teacher Sense of Efficacy Scale* (TSES) (Tschannen-Moran & Woolfolk Hoy, 2001). The instructional style is defined as an instructional preference of the student-centered practice that focuses on supporting the student through support, guidance, encouragement, and positive feedback or a teacher-centered practice that focuses on assessing behavioral objectives through course content and delivery (Conti, 1983: Peters, 2009, 2013). This construct was measured using the *Principles of Adult Learning Scales* (PALS) (Conti, 1978, 1983).

Research Purpose, Questions, and Hypothesis

The purpose of this study is to examine the relationship between teacher self-efficacy (student engagement, instruction, and classroom management) and instructional style of community college STEM faculty. The following questions guided this study:

R1: Is there a statistically significant mean difference between teacher self-efficacy and instructional style?

Ha: There is a statistically significant mean difference between teacher self-efficacy and instructional style.

R2: Is there a statistically significant mean difference between teacher self-efficacy in student engagement and instructional style?

Ha: There is a statistically significant mean difference between teacher self-efficacy in student engagement and instructional style.

R3: Is there a statistically significant mean difference between teacher self-efficacy in instructional self-efficacy and instructional style?

Ha: There is a statistically significant mean difference between teacher self-efficacy in instructional self-efficacy and instructional style.

R4: Is there a statistically significant mean difference between teacher self-efficacy in classroom management and instructional style?

Ha: There is a statistically significant mean difference between teacher self-efficacy in classroom management and instructional style.

R5: What factors contribute to higher and lower teacher self-efficacy in STEM faculty?

R6: What factors contribute to a STEM faculty's instructional style selection?

Research Design

For the purposes of this study, a sequential mixed-methods design (QUAN→qual) was employed to examine the influence of teacher self-efficacy on instructional style. This design consisted of two phases: first, a quantitative phase that determined the instructional style and teacher self-efficacy through survey and second, a qualitative phase looking for emergent themes that may have been overlooked or not captured in the quantitative data. The advantage of implementing this design is it allows for a more in-depth exploration of the quantitative results by following up with a qualitative phase. A purposeful sample of community college STEM faculty from various community colleges in a large metro area in southeast Texas were solicited to provide responses to the PALS and TSES. Faculty also participated in semi-structured interviews used to gather information about influences of teaching self-efficacy on their ability to teach STEM courses. Quantitative data were analyzed using frequencies, percentages, and a two-tailed independent t-test, while qualitative data were analyzed using an inductive coding process to identify emerging themes.

Population and Sample

The population for this study consisted of community college STEM faculty from various community colleges in southeast Texas. The National Center for Education Statistics (NCES, 2013) reports in the U.S. there are 1.5 million faculty employed by universities and community colleges and of that total 35.0% (n = 518,023) are designated as STEM faculty. Twenty percent of these faculty (n = 103,604) work full-time at community colleges. The community college districts chosen for this study were in southeast Texas with multiple campuses having STEM faculty teaching various STEM courses. Table 3.1 displays the faculty demographics and Carnegie size and setting classification of the community colleges for 2016-2019. Purposeful samples of community college STEM faculty were solicited to participate in this study. This study only includes those faculty who align with the Department of Education (DoE) definition of STEM course taught: Life Sciences - Biological, Biomedical, Health Sciences, Physical Sciences, and Social Sciences – Psychology, Engineering, and Mathematics.

Table 3.1

Demographic Data of Faculty (%)

Community College	A	B	C	D	E
Total Faculty (n)	2,375	240	110	333	116
Carnegie Classification	Two Year Very Large	Two Year Large	Two Year Large	Two Year Medium	Two Year Medium
Full-Time	35.0	73.1	100.0	30.9	48.3
Adjunct	65.0	26.9	0.0	69.1	51.7
Male	47.5	52.5	42.0	38.0	42.0
Female	52.5	47.5	58.0	62.0	58.0
White	54.7	77.1	87.0	43.0	87.0
Hispanic	9.9	7.3	8.0	8.4	8.0
Black	24.7	11.4	3.0	24.7	3.0
Asian	10.2	2.9	0.0	23.9	0.0
Other/Multi	0.5	1.2	2.0	0.0	2.0

Instrumentation

Principles of Adult Learning Scales

The Principles *of Adult Learning Scales* (PALS) developed by Conti (1978), is a pre-existing validated survey that uses self-reported data to measures the instructor's adherence to more collaborative teaching-learning mode (See Appendix A). Conti defined the collaborative teaching-learning mode as, "a student-centered method of instruction in which authority for curriculum formation is shared by the learner and the practitioner" (Conti, 1978, p. 12). It is comprised of seven factors: (a) Student-Centered Activities – evaluation by formal tests and to a comparison of students to outside standards (12 - items), (b) Personalizing Instruction – personalizing instruction to meet unique needs of learner (6 - items), (c) Relating to Experience – constructing activities based on learner experience and encourage learner to relate new knowledge to experiences (6 - items), (d) Assessing Student Needs – finding out what the student wants and needs to know (4 - items), (e) Climate Building – classroom environment conducive to learning (4 - items), (f) Participation in the Learning Process – involvement of the student in determining the evaluation of content material (4 - items), and (g) Flexibility for Personal Development – provider or facilitator of knowledge (5 - items). Many researchers have used the PALS instrument to classify an instructor as either using student-centered or teacher-centered instruction practices (Atkinson, 1993; Barrett, 2004; Hughes, 1997; Johnson, 1999; Lee, 2004; Miglietti, 1994; Peters, 2009, 2013; Quillin, 2004; Roberson, 2002; Wang, 2002).

The survey is comprised of 44 - items rated on a six-point Likert scale (*0 = Never 5 = Always*). A practitioner's composite score represents his/her overall preference for teaching behavior and ranges from 0 to 220. Composite scores closer to the extreme ends of the scale indicate differences in practices with scores toward zero supporting teacher-centered instructional practices and scores toward 220 supporting student-centered instructional practices. Conti (1982) used a mean score of 145.6 for adult basic education practitioners as a way of distinguishing between teacher-centered (below the mean score), student-centered (above the mean score), and a mixed instructional approach (close to the mean score). Peters (2013) found the mean score to be 110 for university mathematics instructors. This falls within Conti's teacher-centered range, so Peters validated using the lower composite mean through a validation process that included 20-30-minute semi-structured interviews. Peters' findings showed that the more teacher-centered instructors keep a more traditionally structured classroom climate of lecture and testing, while those student-centered instructors used a combination of lecture and group work. Commonalities in course structure were dictated by the mathematics department and explained why instructors may not have as much leeway in allowing students to be involved with course design, hence the lower overall score. Table 3.2 displays the Cronbach's alpha that was calculated for PALS by Conti (1983), Premont (1989), and Peters (2013).

Table 3.2

Reliability Coefficients for PALS

	Cronbach's α
Conti, 1983 (adult education instructors)	.92
Premont, 1989 (adult education instructors)	.97
Premont, 1989 (higher education instructors)	.96
Peters, 2013 (higher education instructors)	.81

Teacher Sense of Efficacy Scale

The *Teacher Sense of Efficacy Scale* (TSES) was developed and piloted by Tschannen-Moran (College of William and Mary) and Woolfolk Hoy (Ohio State University) and is based on Bandura's (1997) teacher self-efficacy scale (see Appendix B). This survey measures teacher self-efficacy overall and in student engagement, instructional strategies, and classroom management. This undertaking was conducted at a seminar of self-efficacy in the College of Education at The Ohio State University. The results were a 52-item scale that was then piloted in three studies comprising in-service and pre-service teachers; (a) study one (N = 224), (b) study two (N = 217), and (c) study three (N = 410) (Tschannen-Moran & Woolfolk Hoy, 2001). The 52-items were then reduced to 32-items during study one, then 18-items with three subscales for study two, and finally developed into a 24-item long-form, which this study is using, and a 12-item short form. Since then, the *Teacher Sense of Efficacy Scale* has been used by several researchers in college and university settings to test for teacher self-efficacy (Horvitz, Beach, Anderson, & Xia, 2014; Poore, Stripling, Stephens, & Estepp, 2014; Weisel, 2015)

The survey consists of 12-items on a 9-point Likert scale (1 = Nothing; 9 = A Great Deal). Table 3.3 displays the items for scoring in each subscale. Calculations on each unweighted mean are taken for the overall survey score as well as each subscale (student engagement, instructional strategies, and classroom management) and then compared against the mean in Table 3.4. with deviations higher or lower than the overall indicated. Cronbach's alpha for the TSES is also included for each subscale and for the overall survey as indicated in Table 3.4.

Table 3.3

Subscale TSES Categories and Corresponding Items, Short Form

Subscale	Item #
Efficacy in Student Engagement	2, 3, 4, 11
Efficacy in Instructional Strategies	5, 9, 10, 12
Efficacy in Classroom Management	1, 6, 7, 8

Table 3.4

Reliability Coefficients for TSES, Short Form

	M	SD	α*
Overall	7.1	0.98	.90
Student Engagement	7.2	1.20	.81
Instructional Strategies	7.3	1.20	.86
Classroom Management	6.7	1.20	.86

*Cronbach's α for the TSES was obtained from Megan Tschannen-Moran and Mary Anita Woolfolk Hoy (2001).

Data Collection Procedures

Quantitative

Approval from the Committee for Protection of Human Services (CPHS) at the University of Houston-Clear Lake (UHCL) and Institutional Review Board (IRB) at each community college were obtained prior to data collection. Once completed, a request to each community college was made for a list of names and email addresses for STEM faculty that fit the DOE definition. Emails were sent to faculty with the Qualtrics link and included copies of UHCL's CPHS approval, a cover letter explaining the purpose of the study (see Appendix D), and that participation in the study is voluntary, along with a copy of the community college's IRB approval letter. Participants were informed at the first of the Qualtrics survey that consent is assumed by completing the online survey. The survey included 44 items from the PALS (see Appendix A), 12 items from the TSES (see Appendix B), and demographic questions (see Appendix C). Emails were sent four times. An informational email was also sent to department chairs and deans asking for support for the study. Then an initial information email was sent out a week ahead of the survey to all faculty detailing the purpose of the survey along with pertinent forms such as IRB approval and CPHS approval for the STEM faculty to review and when to expect the survey to be released. Emails with the survey link were then sent with follow up emails sent afterward.

Qualitative

A purposeful selection of interviewees was based on responses to the PALS section of the survey between those faculty who identify as student and teacher-centered as well as whether the participant volunteered to participate in semi-structured interviews. Six interview volunteers were selected with three that identified as student-centered and three that identified as teacher-centered from his/her PALS composite scores. Interviews explored their perceptions of what factors contribute to a STEM faculty's instructional style selection. At the onset of the interview, the interviewer read aloud the Informed Consent Notification (see Appendix E). Special emphasis was paid to protecting confidentiality, disclosure of audio recording of the interview, that participation is voluntary, and they may stop participation at any point during the interview. The interviewer asked if there are any questions about the procedures and both signed to show consent. During the interview, questions (see Appendix F) were asked to explore what factors contribute to a STEM faculty's instructional style selection. The data collected will remaining securely locked in a cabinet and pin drive in the researcher's office. All participant information will be destroyed after three years.

Data Analysis

Quantitative

All survey data were imported into IBM SPSS for further analysis. To answer research questions one, a two-tailed independent t-test was used to determine if teacher self-efficacy influenced instructional style. The independent variable was a categorical variable representing teacher-centered and student centered. The dependent variable, teacher self-efficacy, was a continuous variable. For research question two, the data further examined using independent samples t-tests to determine if instructional style influenced teacher self-efficacy in student engagement. The independent variable was a categorical variable representing teacher-centered and student centered. The dependent variable, teacher self-efficacy in student engagement, was a continuous variable.

To further analyze research question three, the data further examined using independent samples t-tests to determine if instructional style influenced teacher self-efficacy in instruction. The independent variable was a categorical variable representing teacher-centered and student centered. The dependent variable, teacher self-efficacy in instruction, was a continuous variable. For research question four, the data further examined using independent samples t-tests to determine if instructional style influenced teacher self-efficacy in classroom management. The independent variable was a categorical variable representing teacher-centered and student centered. The dependent variable, teacher self-efficacy in classroom management, was a continuous variable. Statistical significance was measured using a p-value of 0.05 and Cohen's d and r^2 were used to calculate effect sizes.

Qualitative

To answer research question 5 and 6, a word cluster analysis was conducted using Nvivo software to set a baseline of the beliefs of the teacher-centered and student-centered groups. Then a grounded theory designed by Glaser and Strauss (1967) and then expanded on by Corbin and Strauss (1990) was utilized to explore STEM faculty perceptions of the influence of their self-efficacy to teach STEM subjects on their chosen instructional style. Through a constant comparative method, a series of codes were inductively discovered using an open coding method that was used to breakdown provincial codes in an interpretive process. Saldana (2013) describes a code as "most often a word or phrase that symbolically assigns a summative, salient, essence-capturing, and evocative attribute for a portion of language-based or visual data" (p. 3). Throughout this process, the researcher referred to the literature to ensure the validity of data analysis. Categories were then be grouped and analyzed further for emergent patterns and themes and confirmed with triangulation with survey data. Triangulation of data sources were used, as was peer-review, to ensure the validity of data analysis. The interviews were coded using NVivo software that can be categorized into beliefs and viewpoints which can lead to the interpretation of the participant's view of reality.

Validity

This study was spent interviewing an equivalent number of STEM faculty that survey data reveals to be student or teacher-centered from various community colleges. This provided ample time to gain a well-rounded perspective on the effect of self-efficacy on instructional style choice. The researcher personally conducted all interviews to ensure reliability. The researcher peer-reviewed interview questions with research colleagues to check the content and validity of protocols. Questions and protocols were refined from the initial interviews in 2016-2017 and ongoing into 2018-2019 both after peer-review and during the interview process. Changes to either question or protocol during the interview process were notated. Transcribing was completed through a third party with additional checking by the researcher to ensure proper transcription.

Qualitative analysis was validated by using the triangulation of individual survey responses and the various community colleges. To ensure validity, data obtained from surveys and interview submission were compared to see if answers given by individuals that are grouped in the student-centered and teacher-centered groups were similar in both interviews and surveys. Interviews were also member checked with those being interviewed to ensure the accuracy of the message. Interview questions and results were peer-reviewed both before data collection and after data analysis.

Privacy and Ethical Considerations

Before collecting data, permission was obtained from UHCL's CPHS and Institutional Review Board (IRB). Approval with a site letter from the participating college districts was provided along with a cover letter that explained the purpose of the study (see Appendix D), that participation in the study is voluntary, a consent statement on the first screen of the online Qualtrics surveys (see Appendix A, B, and C), and with an informed consent form (see Appendix E) from interviewees. A series of emails were sent to all participants with detailed information related to the purpose of the study, a link to the Qualtrics survey, directions for completing the survey, and copies of CPHS and IRB approval. Participants were informed at the first of the Qualtrics survey that consent is assumed by completing the online survey. At the onset of the interview, participants were instructed on voluntary participation, were given an Informed Consent Notification form, and asked to sign that they understand the risks. Pseudonyms were chosen for participants and were used in referencing interview participants. The interviewer was as neutral and objective as possible and interviews were transcribed from audio recordings as accurately as possible. The data collected remain securely locked in a cabinet and pin drive in the researcher's office. The researcher will maintain the data for 3 years as required by the CPHS guidelines.

Research Design Limitations

In this study, there are several limitations to take into consideration. First, the primary external validity issue is generalizability. Findings cannot be generalized to other community colleges or other faculty who are not STEM due to the purposeful sampling technique and sample size of the research study. This purposeful sampling technique may also cause certain faculty to more readily willing to respond to surveys and volunteer for interviews, so the sample may not be representative of the community college STEM faculty in southeast Texas. Second, internal validity issues resulting from the inability to control for compounding variables are also present in this study. One compounding variable is faculty giving honest answers on the PALS and TSES surveys. On the PALS, faculty may have a bias and report they adhere to collaborative teaching-learning mode more than they actually do. On the TSES, faculty may also have a bias and report they feel more confident in student engagement, instructional strategies, and classroom management than they do. Third, internal validity issues would be with instrumentation. The language on both the PALS and TSES may not be clearly understood by community college STEM faculty and may cause answers that are not representative of the sample. Fourth, the selection bias would be another compounding variable. If one group of faculty is over-represented in survey responses, it may bias the results toward the answers of that one group. The fifth and final limitation would be that the research was conducted once. This short time period may not yield significant impacts of findings and will not show long-term changes in faculty.

Conclusion

The purpose of this study was to examine the relationship between teacher self-efficacy and the instructional style of community college STEM faculty. This chapter identified the need for further examination of the relationship between the constructs. To understand STEM faculty self-efficacy and its relationship to instructional style better, both quantitative and qualitative findings are essential to the study. In Chapter IV, survey and interview data were analyzed and discussed in further detail.

CHAPTER IV:

RESULTS

The purpose of this study was to examine the relationship between teacher self-efficacy and the instructional style of community college STEM faculty. This chapter presents the results of the quantitative and qualitative analysis of this study. Survey and interview results were analyzed by comparing teacher self-efficacy between two groups of community college STEM faculty, teacher-centered and student-centered. This chapter begins with demographic characteristics followed by instrument reliability and data analysis for each of the five research questions. The chapter concludes with a summary of the findings.

Participant Demographics

Survey

Thirty-nine faculty initially responded to the survey request; 20 were teacher-centered and 19 were student-centered. Tables 4.1 and 4.2 display the survey participants' demographics regarding degree, STEM track classes taught, gender, race/ethnicity, age, employment status, and whether they had a teaching certificate for K-12. Overall, there were 33.3% male (n = 13) and 66.7% female (n = 26). The racial/ethnic majority of the faculty were Caucasian representing 51.3% (n = 20). The faculty were full-time employees mostly at 74.4% (n = 29) and taught science courses at 87.2% (n = 34). These faculty were more likely to have a Ph.D. at 48.7% (n = 19) but almost equally had an M.S. at 43.6% (n = 17) with very few 15.4% (n = 6) having K-12 teaching certification. Age was divided almost evenly between 45-54 at 28.2% (n = 11) and 35-44 at 23.1% (n = 9). Teacher experience varied within the total sample population according to survey responses with the total number of years of teaching experience averaging 15.3 years.

In the teacher-centered participant group, there were 25.0% male (n = 5) and 75.0% female (n = 15). The racial/ethnic majority of the faculty were Caucasian representing 40.0% (n = 8). The faculty were full-time employees mostly at 70.0% (n = 14) and taught science courses at 100.0% (n = 20). These faculty were more likely to have a Ph.D. at 50.0% (n = 10) but almost equally had an M.S. at 40.0% (n = 8) with very few 15.0% (n = 3) having K-12 teaching certification. The majority age group was 45-54 at 35.0% (n = 7) with the rest of the group distributed evenly between the other age groups. Teacher experience varied within the total sample population according to survey responses with the total number of years of teaching experience averaging 15.6 years.

In the student-centered participant group, there were 42.1% male (n = 8) and 57.9% female (n = 11). The racial/ethnic majority of the faculty were Caucasian representing 63.2% (n = 12). The faculty were full-time employees mostly at 78.9% (n = 15) and taught science courses at 78.9% (n = 15). These faculty were equally likely to have a Ph.D. at 47.4% (n = 9) but almost equally had an M.S. at 47.4% (n = 9) with very few 15.8% (n = 3) having K-12 teaching certification. Age was divided almost evenly between 45-54 at 36.1% (n = 6) and 65^+ at 36.1% (n = 6). Teacher experience varied within the total sample population according to survey responses with the total number of years of teaching experience averaging 14.6 years.

Table 4.1

Survey Demographics

		Frequency (n)	Percentage (%)
1. Degree	M.S.	17	43.6
	M.A.	1	2.6
	Ed.D.	1	2.6
	Ph.D.	19	48.7
2. STEM Track	Science	34	87.2
	Technology	1	2.6
	Engineering	1	2.6
	Mathematics	2	5.1
3. Gender	Male	13	33.3
	Female	26	66.7
4.Race/Ethnicity	African American	9	23.1
	Asian	4	10.3
	Caucasian	20	51.3
	Hispanic/Latino	1	2.6
	Other	3	7.7
	Two or More	2	5.1
5. Age	25 – 34	5	12.8
	35 – 44	9	23.1
	45 – 54	11	28.2
	55 – 64	4	10.3
	65+	9	23.1
6. Employment	Full-Time	29	74.4
	Adjunct	10	25.6
7. Teaching Certificate	K-12	6	15.4

Note. One individual did not include “age” data

Table 4.2

Survey Demographics per Instructional Style

		Teacher-Centered		Student-Centered	
		Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
1. Degree	M.S.	8	40.0	9	47.4
	M.A.	1	5.0	1	5.3
	Ed.D.	1	5.0	0	0.0
	Ph.D.	10	50.0	9	47.4
2. STEM Track	Science	20	100.0	15	78.9
	Technology	0	0.0	1	5.3
	Engineering	0	0.0	1	5.3
	Mathematics	0	0.0	2	10.5
3. Gender	Male	5	25.0	8	42.1
	Female	15	75.0	11	57.9
4.Race/Ethnicity	African American	6	30.0	3	15.8
	Asian	1	5.0	3	15.8
	Caucasian	8	40.0	12	63.2
	Hispanic/ Latino	1	5.0	0	0.0
	Other	3	15.0	0	0.0
	Two or More	1	5.0	1	5.3
5. Age	25 - 34	4	20.0	1	5.3
	35 - 44	3	15.0	6	31.6
	45 - 54	7	35.0	4	21.1
	55 – 64	2	10.0	2	10.5
	65+	3	15.0	6	31.6
6. Employment	Full-Time	14	70.0	15	78.9
	Adjunct	6	30.0	4	21.1
7. Teaching Certificate	K-12	3	15.0	3	15.8

Note. One individual did not include “age” data

PALS – Instructional Style

To determine the instructional style of the instructors, the PALS was administered. Each instructor was assigned a composite score that could range between 0 and 220. For this study, scores ranged from 85 to 176 with the average PALS score being 140.2 (median = 144, standard deviation = 22.6, range = 91). Faculty scoring on the higher end were classified as being more student-centered and those scoring in the lower end were classified as being more teacher-centered. Table 4.3 provides a list of the participating community college STEM faculty and their corresponding PALS scores.

Peters (2012) demonstrated that four-year university college algebra instructors tended to be lower than a 146 mean score so her established sample mean (M=110.3) was used as the cutoff to determine the score for more teacher-centered instructors from the more student-centered instructors. The four-year university college algebra instructors were skewed more toward teacher-centered, so it was found necessary to use the sample mean as the cutoff. Unlike the current study where the STEM faculty only scored six points lower than Conti's (1983) established a score of 146, suggesting that the community college instructors in the current study scored similarly to the adult educators in Conti's study.

Table 4.3

PALS Score and Classification per Instructor

	PALS Score	Classification
Instructor 1	85	More Teacher-Centered
Instructor 2	92	
Instructor 3	92	
Instructor 4	107	
Instructor 5	108	
Instructor 6	111	
Instructor 7*	114	
Instructor 8	117	
Instructor 9*	124	
Instructor 10	127	
Instructor 11	131	
Instructor 12	135	
Instructor 13*	136	
Instructor 14	138	
Instructor 15	138	
Instructor 16	140	
Instructor 17	141	
Instructor 18	141	
Instructor 19	142	
Instructor 20	144	
-----------------------------------	--------------------------	----------------------------------M = 146
Instructor 21*	147	
Instructor 22	149	
Instructor 23	151	
Instructor 24	153	
Instructor 25	154	
Instructor 26*	154	
Instructor 27	156	
Instructor 28	156	
Instructor 29*	157	
Instructor 30	157	
Instructor 31	158	
Instructor 32	158	
Instructor 33	160	
Instructor 34	160	
Instructor 35	161	
Instructor 36	162	
Instructor 37	166	
Instructor 38	168	
Instructor 39	176	More Student-Centered

*Instructors who have volunteered to be interviewed

Interview

Six faculty initially responded to the interview request; three were teacher-centered and three were student-centered. Tables 4.4 and 4.5 display the survey participants' demographics regarding degree, STEM track classes taught, gender, race/ethnicity, age, employment status, and whether they had a teaching certificate for K-12. Overall, there were 16.7% male (n = 1) and 83.3% female (n = 5). The racial/ethnic majority of the faculty were Caucasian representing 66.6% (n = 4). The faculty were full-time employees mostly at 83.3% (n = 5) and taught science courses at 83.3% (n = 5). These faculty split evenly between Ph.D. and M.S. degrees (50.0%, n = 3) and none of them had K-12 teaching certification. Age majority was 35-44 at 50.0% (n = 3). Teacher experience varied within the total sample population according to survey responses with the total number of years of teaching experience averaging 20.1 years.

In the teacher-centered participant group, there were 33.0% male (n = 1) and 67.0% female (n = 2). The racial/ethnic majority of the faculty were Caucasian representing 67.0% (n = 2). The faculty were full-time employees and taught science courses. These faculty were more likely to have a Ph.D. (67.0%, n = 2) and none of them had K-12 teaching certification. Age groups were evenly distributed evenly between 25-34, 35-44, and 55-64 age groups. Teacher experience varied within the total sample population according to survey responses with the total number of years of teaching experience averaging 23.3 years.

In the student-centered participant group, there were 100.0% female (n = 3). The racial/ethnic majority of the faculty were Caucasian representing 67.0% (n = 2). The faculty were full-time employees mostly at 67.0% (n = 2) and taught science courses at 67.0% (n = 2). These faculty were more likely to have an M.S. (67.0%, n = 2) and none of them had K-12 teaching certification. The age group was divided between 25-34, 35-

44, and 65+. Teacher experience varied within the total sample population according to survey responses with the total number of years of teaching experience averaging 16.0 years.

Table 4.4

Interview Demographics

		Frequency (n)	Percentage (%)
1. Degree	M.S.	3	50.0
	Ph.D.	3	50.0
2. STEM Track	Science	5	83.3
	Engineering	1	16.7
3. Gender	Male	1	16.7
	Female	5	83.3
4.Race/Ethnicity	Asian	1	16.7
	Caucasian	4	66.6
	Other	1	16.7
5. Age	25 – 34	1	16.7
	35 – 44	3	50.0
	55 – 64	1	16.7
	65+	1	16.6
6. Employment	Full-Time	5	83.3
	Adjunct	1	16.7

Table 4.5

Interview Demographics per Instructional Style

		Teacher-Centered		Student-Centered	
		Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
1. Degree	M.S.	1	33.0	2	67.0
	Ph.D.	2	67.0	1	33.0
2. STEM Track	Science	3	100.0	2	67.0
	Engineering	0	0.0	1	33.0
3. Gender	Male	1	33.0	0	0.0
	Female	2	67.0	3	100.0
4.Race/Ethnicity	Asian	0	0.0	1	33.0
	Caucasian	2	67.0	2	67.0
	Other	1	33.0	0	0.0
	Two or More	0	0.0	0	0.0
5. Age	25 - 34	1	33.0	1	33.0
	35 - 44	1	33.0	1	33.0
	55 – 64	1	33.0	0	0.0
	65+	0	0.0	1	33.0
6. Employment	Full-Time	3	100.0	2	67.0
	Adjunct	0	0.0	1	33.0

Instrument Reliability

Cronbach α was calculated to assess the reliability or internal consistency of the PALS and TSES and it's three subscales. Table 4.6 provides the Cronbach's alpha coefficients for this study and the reliability coefficients reported from Conti (1983), Tschannen-Moran & Woolfolk Hoy's (2001), and this study. According to Fraenkel and Wallen (2006), acceptable reliability coefficients are greater than .70.

Table 4.6

Reliability Coefficients for PALS

	Cronbach's α
Conti, 1982 (adult education instructors)	.92
Premont, 1989 (adult education instructors)	.97
Premont, 1989 (higher education instructors)	.96
Peters, 2013 (public four-year college algebra faculty)	.81
Unruh, 2019 (public two-year STEM faculty)	.85

Table 4.7

Reliability Coefficients for TSES - Short Form

	Tschannen-Moran and Woolfolk Hoy (2001)	Unruh (2019)
TSES	.90	.85
1. Efficacy in Student Engagement	.81	.75
2. Efficacy in Instructional Strategies	.86	.64
3. Efficacy in Classroom Management	.86	.92

Research Question One

Research question one, *Is there a statistically significant mean difference between teacher self-efficacy and instructional style?*, was answered by conducting a two-tailed independent t-test to determine if there was a statistically significant mean difference in teachers' self-efficacy between the two instructional types (teacher and student-centered). Table 4.6 provides the results of the two-tailed independent t-test. Results indicated there was a significant mean difference in teacher self-efficacy for teacher-centered versus student-centered suggesting that instructional style did influence teacher self-efficacy, $t(37) = 2.60$, $p = 0.013$, $d = 0.84$ (large effect size), $r^2 = 0.15$. Teacher-centered instructors ($M = 7.19$) reported a higher mean teacher self-efficacy than student-centered instructors ($M = 6.34$). Fifteen percent of the variance in teacher self-efficacy can be attributed to instructional style.

Table 4.8

Teacher Self-Efficacy Teacher-Centered and Student-Centered

Model	N	M	SD	T	df	p-value	d	r^2
1. Teacher-centered	20	7.19	1.23	2.60	37	0.013*	0.84	0.15
2. Student-centered	19	6.34	0.73					

*Statistically significant ($p < .05$)

Research Question Two

Research question two, *Is there a statistically significant mean difference between teacher self-efficacy in student engagement and instructional style?,* was answered by conducting a two-tailed independent t-test to determine if there was a statistically significant mean difference in efficacy in student engagement between the two instructional types (teacher and student-centered). Student engagement relates to how faculty view their ability to reach difficult students, encourage critical thinking, and motivate and support valued learning. Results indicated that there was a significant mean difference in teacher self-efficacy related to student engagement for teacher-centered versus student-centered. It suggested that instructional style does influence teacher self-efficacy in student engagement, $t(32.52) = 2.89$, $p = 0.007$ $d = 0.92$ (large effect size), $r^2 = 0.18$. Teacher-centered instructors (M = 6.45) reported a higher mean teacher self-efficacy in student engagement than student-centered instructors (M = 5.23). Eighteen percent of the variance in teacher self-efficacy in student engagement can be attributed to the instructional style.

Table 4.9

Teacher Self-Efficacy: Student Engagement

Model	N	M	SD	t	df	p-value	d	r^2
1. Teacher-centered	20	6.45	1.57	2.89	32.52	0.007*	0.92	0.18
2. Student-centered	19	5.23	1.01					

*Statistically significant ($p < .05$)

The frequency/percentage of individual responses to the TSES survey instrument are shown in Table 4.10 per instructional style in relation to student engagement. Differences in questions were considered significant if the difference was greater than 20%. All the survey questions related to student engagement displayed a higher teacher self-efficacy in student engagement by those that identify as teacher-centered. Four of the items (item #2, 3, 4, 11) display large disparities between groups. Item 2 shows teacher-centered individuals choosing *Quite a Bit* to *A Great Deal* at a 23.6% higher rate than student-centered individuals. This item shows that teacher-centered faculty believe they are more capable of reaching difficult students. Item 3 shows teacher-centered individuals choosing *Quite a Bit* to *A Great Deal* at a 21.5% higher rate than student-centered individuals. This item shows teacher-centered faculty believe that they are more capable of encouraging critical thinking and getting students to do better in the course. Items 4 and 11 are questions that consider beliefs with motivating and supporting students. Item 4 shows teacher-centered individuals choosing *Quite a Bit* to *A Great Deal* at an 11.9% higher rate than student-centered individuals. Item 11 shows teacher-centered individuals choosing *Quite a Bit* to *A Great Deal* at a 25.0% higher rate than student-centered individuals. These items show teacher-centered faculty believe that they are more capable of motivating and supporting students in the classroom. Based on the significantly higher scores on the survey instrument, these results seem to indicate that teacher-centered STEM faculty have a higher teacher self-efficacy in student engagement.

Table 4.10

Student Engagement: Teacher-Centered and Student-Centered

Survey Item		Nothing	Nothing/ Very Little	Very Little	Very Little/Some Influence	Some Influence	Some Influence /Quite a Bit	Quite a Bit	Quite a Bit/A Great Deal	A Great Deal
2. How much can you do to motivate students who show low interest in schoolwork?	Teacher-centered	0.0 (n = 0)	0.0 (n = 0)	15.0 (n = 3)	0.0 (n = 0)	30.0 (n = 6)	5.0 (n = 1)	25.0 (n = 5)	5.0 (n = 1)	20.0 (n = 4)
	Student-centered	0.0 (n = 0)	0.0 (n = 0)	26.3 (n = 5)	5.3 (n = 1)	21.1 (n = 4)	21.1 (n = 4)	21.1 (n = 4)	0.0 (n = 0)	5.3 (n = 1)
3. How much can you do to get students to believe they can do well in schoolwork?	Teacher-centered	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	10.0 (n = 2)	0.0 (n = 0)	45.0 (n = 9)	10.0 (n = 2)	35.0 (n = 7)
	Student-centered	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	15.8 (n = 3)	15.8 (n = 3)	57.9 (n = 11)	5.3 (n = 1)	5.3 (n = 1)
4. How much can you do to help your students' value learning?	Teacher-centered	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	10.0 (n = 2)	15.0 (n = 3)	25.0 (n = 5)	15.0 (n = 3)	35.0 (n = 7)
	Student-centered	0.0 (n = 0)	5.3 (n = 1)	5.3 (n = 1)	0.0 (n = 0)	21.1 (n = 4)	5.3 (n = 1)	52.6 (n = 10)	0.0 (n = 0)	10.5 (n = 2)
11. How much can you assist families in helping their children do well in school?	Teacher-centered	25.0 (n = 5)	15.0 (n = 3)	5.0 (n = 1)	0.0 (n = 0)	10.0 (n = 2)	20.0 (n = 4)	5.0 (n = 1)	5.0 (n = 1)	15.0 (n = 3)
	Student-centered	31.6 (n = 6)	21.1 (n = 4)	15.8 (n = 3)	10.5 (n = 2)	15.8 (n = 3)	5.3 (n = 1)	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)

Research Question Three

Research question three, *Is there a statistically significant mean difference between teacher self-efficacy in instructional self-efficacy and instructional style?,* was answered by conducting a two-tailed independent t-test to determine if there was a statistically significant mean difference in teacher self-efficacy in instructional strategies between the two instructional styles (teacher and student-centered). Instructional strategies relate to how faculty view their ability to respond to difficult questions, implement alternative strategies, and providing students with appropriate challenges. Results indicated that there was a significant mean difference in teacher self-efficacy in instructional strategies for teacher-centered versus student-centered suggesting that instructional style did influence teacher self-efficacy in instructional strategies, $t(37) = 2.81$, $p = 0.008$ $d = 0.90$, $r^2 = 0.17$. More teacher-centered instructors ($M = 7.73$) reported a higher mean teacher self-efficacy in instructional strategies than student-centered instructors ($M = 6.79$). Seventeen percent of the variance in teacher self-efficacy in instructional strategies can be attributed to the instructional style.

Table 4.11

Teacher Self-Efficacy: Instructional Strategies

Model	N	M	SD	T	df	p-value	d	r^2
Teacher-centered	20	7.73	0.95	2.81	37	0.008*	0.90	0.17
Student-centered	19	6.79	1.13					

*Statistically significant ($p > .05$)

The frequency/percentage of individual responses to the TSES survey instrument are shown in Table 4.12 per instructional style in relation to instructional strategies. All of the survey questions related to instructional strategies displayed a much higher teacher self-efficacy in instructional strategies by those that identify as teacher-centered, with the exception of item 10, “To what extent can you provide an alternative explanation or example when students are confused?” Three of the items (item #5, 9, 12) display large disparities between groups. Item 5 shows teacher-centered individuals choosing *Quite a Bit* to *A Great Deal* at a 16.2% higher rate than student-centered individuals. This item shows teacher-centered faculty believe that they are more capable of providing students with appropriate challenges.

Item 9 shows teacher-centered individuals choosing *Quite a Bit* to *A Great Deal* at a 22.3% higher rate than student-centered individuals. Item 12 shows teacher-centered individuals choosing *Quite a Bit* to *A Great Deal* at a 33.1% higher rate than student-centered individuals. These items show teacher-centered faculty believe that they are more capable of finding and implementing alternative strategies for instruction. Item 54 shows teacher-centered individuals choosing *Quite a Bit* to *A Great Deal* at a lower percentage of 5.5% higher rate than student-centered individuals. This item shows both faculty believe that they are more capable of responding to difficult questions though they are approximately the same mean for this item (teacher-centered = 8.3, student-centered = 7.7). Based on the higher scores on the survey instrument, these results seem to indicate that teacher-centered STEM faculty have a higher teacher self-efficacy in instructional self-efficacy.

Table 4.12

Instructional Strategies: Teacher-Centered and Student-Centered

Survey Item		Nothing	Nothing/ Very Little	Very Little	Very Little/Some Influence	Some Influence	Some Influence /Quite a Bit	Quite a Bit	Quite a Bit/A Great Deal	A Great Deal
5. To what extent can you craft good questions for your students?	Teacher-centered	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	10.0 (n = 2)	45.0 (n = 9)	15.0 (n = 3)	30.0 (n = 6)
	Student-centered	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	10.5 (n = 2)	15.8 (n = 3)	31.6 (n = 6)	21.1 (n = 4)	21.1 (n = 4)
9. How much can you use a variety of assessment strategies?	Teacher-centered	0.0 (n = 0)	5.0 (n = 1)	0.0 (n = 0)	0.0 (n = 0)	5.0 (n = 1)	15.0 (n = 3)	10.0 (n = 2)	35.0 (n = 7)	30.0 (n = 6)
	Student-centered	0.0 (n = 0)	5.3 (n = 1)	5.3 (n = 1)	10.5 (n = 2)	10.5 (n = 2)	15.8 (n = 3)	15.8 (n = 3)	21.1 (n = 4)	15.8 (n = 3)
10. To what extent can you provide an alternative explanation or example when students are confused?	Teacher-centered	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	5.0 (n = 1)	15.0 (n = 3)	25.0 (n = 5)	55.0 (n = 11)
	Student-centered	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	5.3 (n = 1)	0.0 (n = 0)	5.3 (n = 1)	26.3 (n = 5)	31.6 (n = 6)	31.6 (n = 6)
12. How well can you implement alternative strategies in your classroom?	Teacher-centered	0.0 (n = 0)	0.0 (n = 0)	5.0 (n = 1)	0.0 (n = 0)	5.0 (n = 1)	20.0 (n = 4)	10.0 (n = 2)	20.0 (n = 4)	40.0 (n = 8)
	Student-centered	0.0 (n = 0)	5.3 (n = 1)	10.5 (n = 2)	5.3 (n = 1)	26.3 (n = 5)	15.8 (n = 3)	10.5 (n = 2)	21.1 (n = 4)	5.3 (n = 1)

Research Question Four

Research question four, *Is there a statistically significant mean difference between teacher self-efficacy in classroom management and instructional style?* was answered by conducting a two-tailed independent t-test to determine if there was a statistically significant mean difference in teacher self-efficacy in classroom management between the two instructional types (teacher and student-centered). Classroom management relates to how faculty see their ability to control disruptive behaviors, clearly communicating expectations, calming students, and hindering behavior issues from derailing a lesson. Results indicated that there was not a significant mean difference in teacher self-efficacy in classroom management for teacher-centered versus student-centered suggesting that instructional style does influence overall teacher self-efficacy, $t(37) = 0.75$, $p = 0.461$. Teacher-centered instructors ($M = 7.68$) reported approximately the same mean teacher self-efficacy as student-centered instructors ($M = 6.99$). These results suggest that instructional style does not influence teacher self-efficacy in classroom management.

Table 4.13

Teacher Self-Efficacy: Classroom Management

Model	N	M	SD	t	df	p-value
Teacher-centered	20	7.38	1.76	0.75	37	0.461*
Student-centered	19	6.99	1.46			

*Not statistically significant (p > .05)

The frequency/percentage of individual responses to the TSES survey instrument are shown in Table 4.12 per instructional style in relation to teacher self-efficacy in classroom management. All of the survey questions related to classroom management displayed moderately higher teacher self-efficacy in classroom management by those that identify as teacher-centered, with the exception of item 8, “ How well can you establish a classroom management system with each group of students?” Three of the items (item #1, 6, 7) display moderate disparities (<20%) between groups. Item 1 shows teacher-centered individuals choosing *Quite a Bit* to *A Great Deal* at an 11.5% higher rate than student-centered individuals. This item shows both faculty believe that they are more capable of controlling disruptive behaviors.

Item 6 shows teacher-centered individuals choosing *Quite a Bit* to *A Great Deal* at a 16.3% higher rate than student-centered individuals. This item shows both faculty believe that they are more capable of clearly communicating expectations. Item 7 shows teacher-centered individuals choosing *Quite a Bit* to *A Great Deal* at a 17.1% higher rate than student-centered individuals. This item shows both faculty believe that they are more capable of calming students and hindering behavior issues. Item 8 shows teacher-centered individuals choosing Quite a Bit to A Great Deal at 1.0% higher rate than student-centered individuals. This item shows both faculty believe that they are more capable of clearly communicating expectations. Based on the scores on the survey instrument, these results seem to indicate that teacher-centered STEM faculty have approximately the same teacher self-efficacy in classroom management.

Table 4.14

Classroom Management: Teacher Self-Efficacy Teacher-Centered and Student-Centered

Survey Item		Nothing	Nothing/ Very Little	Very Little	Very Little/Some Influence	Some Influence	Some Influence /Quite a Bit	Quite a Bit	Quite a Bit/A Great Deal	A Great Deal
1. How much can you do to control disruptive behavior in the classroom?	Teacher-centered	0.0 (n = 0)	5.0 (n = 1)	5.0 (n = 1)	0.0 (n = 0)	5.0 (n = 1)	5.0 (n = 1)	25.0 (n = 5)	15.0 (n = 3)	40.0 (n = 8)
	Student-centered	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	5.3 (n = 1)	26.3 (n = 5)	0.0 (n = 0)	21.1 (n = 4)	15.8 (n = 3)	31.6 (n = 6)
6. How much can you do to get children to follow classroom rules?	Teacher-centered	0.0 (n = 0)	5.0 (n = 1)	0.0 (n = 0)	0.0 (n = 0)	5.0 (n = 1)	0.0 (n = 0)	30.0 (n = 6)	40.0 (n = 8)	20.0 (n = 4)
	Student-centered	0.0 (n = 0)	0.0 (n = 0)	5.3 (n = 1)	5.3 (n = 1)	10.5 (n = 2)	5.3 (n = 1)	31.6 (n = 6)	10.5 (n = 2)	31.6 (n = 6)
7. How much can you do to calm a student who is disruptive or noisy?	Teacher-centered	5.0 (n = 1)	5.0 (n = 1)	0.0 (n = 0)	0.0 (n = 0)	5.0 (n = 1)	10.0 (n = 2)	25.0 (n = 5)	20.0 (n = 4)	30.0 (n = 6)
	Student-centered	0.0 (n = 0)	5.3 (n = 1)	0.0 (n = 0)	10.5 (n = 2)	15.8 (n = 3)	10.5 (n = 2)	26.3 (n = 5)	10.5 (n = 2)	21.1 (n = 4)
8. How well can you establish a classroom management system with each group of students?	Teacher-centered	0.0 (n = 0)	0.0 (n = 0)	5.0 (n = 1)	0.0 (n = 0)	5.0 (n = 1)	10.0 (n = 2)	15.0 (n = 3)	25.0 (n = 5)	40.0 (n = 8)
	Student-centered	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	10.5 (n = 2)	10.5 (n = 2)	42.1 (n = 8)	21.1 (n = 4)	15.8 (n = 3)

Qualitative Results

For research questions 5, *What factors contribute to higher and lower teacher self-efficacy in STEM faculty?,* and 6, *What factors contribute to a STEM faculty's instructional style selection?,* were answered by utilizing grounded theory and word cluster analysis to determine emerging themes as well as incorporating themes from the survey data from research questions 1, 2, 3, and 4. Analysis was continued with an open and axial coding process using the interview responses of the participants. Key themes and patterns were identified and organized into meaningful pieces of information pertaining to the study. One male and five female participants were individually interviewed to provide responses to questions. The group was divided between three teacher-centered and three student-centered individuals. The qualitative analysis is sectioned into: (a) Word Cluster Analysis, (b) Research Question 5, and (c) Research Question 6.

Word Cluster Analysis

In this study, six participants were interviewed. The three participants that were found to be teacher-centered through the PALS survey were Geo (114), Captain Planet (124), and Wheeler (136). The three participants found to be student-centered were Vinca (147), Sonya (154), and Varna (157). NVivo software used a word frequency query to list the most frequently used words with each group and then referenced with cluster analysis used to determine which words occurred together. Word associations from the different interview groups were then used to identify group perceptions of word associations that were then used to determine themes in the coding process. Word associations of words common to both groups found within each group's interviews are shown below in Table 4.15.

Table 4.15

Word Cluster Analysis

	Teacher-Centered	Student-Centered
1. Teaching	Lecture	Action
2. Community	Work, Profession, Events	Question, Connections
3. Student	Master	Reason, Want, Language
4. Content	Make, Study	Ask, Sense, Know, Knowledge
5. Quality	Class, Think, Reason	Understanding, Interaction, Activity, Positive, Feel, Changing
6. Classroom	Judge, Connect, Care	Judge, Status, Designed, Community, Question, Connections
7. Knowledge	Act, Take, Good	Content, Ask, Sense, Know, Content
8. Activity	Maybe, Cutting, Convey	Understanding, Interaction, Quality, Positive, Feel Changing

The overall results of this analysis show that teacher-centered and student-centered groups see their relationship to teaching and their students differently. The words above were chosen due to all eight being used in interviews in both groups. Teacher-centered interviewees saw teaching associated with lecture while student-centered interviewees saw teaching as an action. Teacher-centered participants saw their world as compartmentalized where students, community, classroom, and knowledge are separate entities that are lightly associated with each other. The student-centered individuals used more descriptors in their associations, they show a more integrated world with students, community, classroom, and knowledge integrated together. They also add feelings, positive, and change in their associations.

Research Question Five

Research question five, *What factors contribute to higher and lower teacher self-efficacy in STEM faculty?* was answered by utilizing grounded theory to determine emerging themes as well as incorporating themes from the survey data from research questions 1, 2, 3, and 4. Analysis was continued with an open and axial coding process using the interview responses of the participants. The statements included in the study were from participants who responded to the survey and volunteered to be interviewed individually. The qualitative analysis identified four major themes: (a) Teacher Self-Efficacy, (b) Student Engagement, (c) Instructional Strategies, and (d) Classroom Management. Each of these themes are defined in Chapter 1 and will be explored further in the following sections. Those categories and the themes associated with the interviews are marked below in figure one.

Thematic Analysis of Interview Participants							
		Teacher-Centered			Student-Centered		
Theme	Categories	Geo	Captain Planet	Wheeler	Sonya	Vinca	Varna
Teacher Self-efficacy	Positive - Community College (CC)	X	X	X	X	X	X
	Positive - Students	X			X	X	X
	Positive – Academic freedom		X	X	X	X	
	Negative - Disrespect from University Faculty	X	X		X	X	
	Negative - Isolation or "Bubble"	X	X				
	Negative - Self-reflection	X	X	X			
	Negative - Students lack skills				X	X	X
	Negative - Lack of Time/Forced to use other instructional styles					X	X
Student Engagement	Defined: Communication with Students (telephone, email, and open-door policy)	X	X	X		X	
	Defined: Instructional Strategy				X	X	X
	Student-centered engagement	X	X				
	Students Having Difficulty	X	X	X	X		X
Instructional Strategies	Mistaken Student-centered definition	X	X	X			
	Content acquisition/gatekeeping	X	X	X			
	Lecture	X	X	X			
	Communication	X	X	X			
	A positive view of Student-centered	X		X	X	X	X
	Student-Centered pedagogy				X	X	X
Classroom Management	No Problem with Classroom Management	X		X	X		
	Enforcement of Classroom Rules (i.e. removal of a cell phone)	X			X		
	Did not Discuss or Confused question with Instructional strategies		X			X	X

Figure 4.1. Display of theme and subcategory responses broken down by participants.

Teacher Self-Efficacy

In the TSES survey, teacher self-efficacy was defined as a teacher's judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated. It was found to have a statistically significant difference between teacher-centered and student-centered groups. Based on participant responses that were coded within teacher self-efficacy theme, several catagories were identified between the teacher-centered and student-centered groups. The participant responses were classified into positive and negative responses. Positive responses included mentions of: (a) community colleges, (b) pedagogy, and (c) students at community colleges. All participants in both groups made mentions of positive mentions of the community colleges that they worked for. One teacher-centered and all three student-centered participants gave postitive responses toward their students. Two teacher-centered and two student-centered participants gave postitive responses toward pedagogy at community colleges. Negative responses included: (a) disrepect from university faculty, (b) isolation or "bubble", (c) negative self-reflection, (d) students lack skills, and (e) lack of time/forced to use other instructional styles. Two participants from each group referenced the disrepect that they felt from university faculty. Two or more teacher-centered participants mentioned isolation and negative self-reflection while these catagories were missing from the student-centered group. Instead the student-centered group focused their responses on student lack of skills and the lack of time causing them to use a non-prefered teacher-centered instructional style. The teacher-centered and student-centered groups were explored individually in terms of the emerged catagories.

Teacher-centered group.

The STEM faculty identified as teacher-centered includes Geo, Captain Planet, and Wheeler. In expressing their teaching self-efficacy, the teacher-centered participants responded that they all felt positive in the perspective of how they viewed teaching at their community college. Captain Planet describes the community college environment in a very positive way:

> Yeah, I'm at the two-year because I want to teach. I want interaction. I want a small classroom. I want to get to know my students and I want to help them get where they want to go. I enjoyed teaching at the other [university] but those students didn't need me, not in the same way. (Captain Planet, interview, November, 4, 2016)

Geo mirrored this description when discussing her thoughts of working at a community college:

> Honestly, I think I have the best job in the world because I get to actualize dreams I get to help students figure out what their goals are and how to achieve them and that's very powerful. When you stand back and think about just how much of an influence you can have on somebody's well-being. (Geo, interview, November, 2, 2016)

These responses leave the impression that the teacher-centered STEM faculty have high positive opinions of the institution that they work for.

All the teacher-centered interviewees had positive views of the community college that they worked for. These positive views related to the faculty's view of the amount of academic freedom that they were allowed in their pedagogy and the interactions with their students. Captain Planet saw the community college as, "much, much further ahead in terms of their understanding of how students learn, implementing different methodologies, and technologies, teaching technology, and instructional technology in the classroom" (Captain Planet, interview, November, 4, 2016). Wheeler enjoyed that the institution encourages you to, "come in with an open mindset, change constantly, and meet student's needs because community college faculty have student success always at the center of everything" (Wheeler, interview, April 25, 2019). Geo said that she enjoys the diverse student population at community college when she said:

> I like to have diversity (*with student populations*) and especially with environmental science. It is such an interdisciplinary topic and with environmental issues, you have so many stakeholders so it's really nice to have the mix I think. And I think if it was just a 75% environmental science major or tree huggers that it would be a very different group dynamic and I think that the importance of environmental science is that it has to fit into society. So I'm really happy with the diversity. (Geo, interview, November, 2, 2016)

All the statements of academic freedom and student interactions lead to an overall positive view of the faculty's institution.

The positive nature that the interviews for the teacher-centered group started with turned around later in the interview with the participants having much more negative things to say. When counted, this group had a two to one ratio of negative to positive comments. These negative comments centered on how the teacher-centered faculty perceive they are judged by their university colleagues at the four-year universities, how isolated they are from other faculty, and negative self-reflections. One of the main negative topics was teacher-centered community college STEM faculty perceiving disrespect from the university faculty. Captain Planet mentioned these interactions because she had worked first at a university where she formed her opinion of her fellow faculty:

> They think they're better, they think they are more knowledgeable, they are more cutting edge. More up to date on the research and they are because they are doing it every day in that respect. They also realize that the two-year faculty just have a master's degree and that they all at the four year have Ph.D.'s so there is a little bit of looking down on the two-year faculty by the four-year faculty. There is a looking down on the two-year programs because they don't typically have the same level of rigor and sometimes not even close, in some colleges traditionally in the past. (Captain Planet, interview, November, 4, 2016)

Geo also discussed what she saw as disrespect and was able to give several examples she had experienced from four-year faculty. Geo said about the perception of two-year faculty, "there is certainly a stigma against community colleges" and that she heard from another community college faculty at a conference say:

> Why is it that community colleges have such a great purpose in our community Wnd yet we do not value the people who go to a community college? We think of them as sort of the outcasts of society, low-income blah blah blah and she said if community colleges are going to be successful then we first have to value the members of that community college. (Geo, interview, November, 2, 2016)

This impression was then reinforced by an interaction that Geo experienced at a conference with another four-year faculty:

> Earlier this semester I was at a hydrology workshop and I wanted to get some more information from the keynote speaker of that workshop because she took her environmental science students to Belize. The honors program has been asking me to take students to Costa Rica so with that in mind I approached the keynote speaker and said, "*Hey can you give me your itinerary and contacts for that trip I would like to see if I could replicate it at my institution?*" We got to talking and I

started bragging about my environmental science students, and how they were reading those scientific journal articles and blowing it out of the water. She said, "*Oh my gosh that's incredible.*" (Geo, interview, November, 2, 2016)

This causes Geo to speak about her interaction with the students. She seemed to need to defend both the ability of the students and the rigor of her classes and the community college:

> I said I know right, I'm so proud of them. So I think that's an interaction that stands out for me and I really do have the utmost in admiration for my students. I have tears in my eyes as I'm saying this, the challenges that they overcome and the things that they accomplish are absolutely incredible. I'm so thankful to be part of their lives to help them achieve that because they come from such diverse backgrounds and such trying home lives in many situations that it's really wonderful to make a difference in their lives in a positive way. (Geo, interview, November, 2, 2016)

Captain Planet had also seen this reaction and was perplexed that many four-year faculty expressed disappointment with the teaching of community college students.

> Oh, the (four-year) faculty? Uh, it was more about technical expertise. You don't talk instruction on very seldom do you talk about instruction. It's about your field, it's about your research, it's about the cutting edge it's about the curriculum, it's not about what you're doing in your class, it's about how your class in the overall picture of how you're preparing your students to fit into the field. What are the requirements of the field and how is your program meeting it? Very little discussion about what instructional technology or instructional methodology you were using in the classroom, Very, very little. (Captain Planet, interview, November, 4, 2016)

This leads to a situation where four-year faculty, in her eyes, are making a judgment call on the fitness of community college students without knowing how they were instructed or the materials that they are asked to learn.

This lack of discussion on pedagogy is seen by Captain Planet who had some ideas on why this was the case due to her experience at both four-year university and two-year community college. She described how it is a two-part problem of isolated with their courses and the perception of education degrees:

> I find we (two-year faculty) really do share more instructional [pedagogy] but the four-year, the faculty member is in their own bubble, and then the department is in their own bubble, and then the university is in its own bubble and unless it's something that can be published it probably doesn't get out. (Captain Planet, interview, November, 4, 2016)

When she was asked about education degrees since they are a part of almost every university, she said that most four-year STEM faculty saw education degrees as a detriment that ultimately served no purpose:

> Heavens no, heavens no, they actually look down on the education process. They look down on education degrees. The fact is that I told you I almost have a master's in education. I am two or three classes away from it and I was actually told at one point in time to not get education degree and not have it on my credentials because it would not help me get a college or university position in the four year… There at the four-year, if they are at the research institution, they are there to do research and it is in their field, not in education. (Captain Planet, interview, November, 4, 2016)

She went on to further to discuss the impact of most community colleges having criteria for hiring new faculty that includes consideration for master's and Ed.Ds degrees.

Captain Planet also saw the interactions as negative between four and two-year colleges around collaboration stating that:

> The four years, until recently, have seen no reason to even talk to the two-year much less collaborate with two-year colleges and two-year faculty its only that they've started to realize that now most of their students are starting at the two-year and then transferring in you would have to conversations going on between the two. (Captain Planet, interview, November, 4, 2016)

The perceptions of the two-year community college faculty qualifications negatively influenced interactions between four and two-year faculty.

The final topic for this section is how the teacher-centered participants felt about their self-reflection. All three interviewees questioned on some level how well they could teach. These negative feelings started as early as their first teaching assignment as Geo explained in more detail:

> My first semester as a grad student at the University of Florida, you know the day before the semester started, they said you're teaching lab, and I was like uhhhhh so it was, and I very much felt alone and scared and responsible for things that I shouldn't have been responsible for. (Geo, interview, November, 2, 2016)

Wheeler stated that he questioned whether he had the talent or skill to be an instructor. He understood that teaching required a special set of skills that is not conveyed in the STEM degree alone and stated that:

> Now keep in mind I did not think that I would be able to teach. A lot of people need to understand that just because you are experts in the field does not mean you have the ability to teach. Teaching is a completely different aspect of how to deliver the material to the student. How are you able to articulate between a real-

> life into an actual understand the level of understanding for the student? (Wheeler, interview, April 25, 2019)

This worry and negative emotion was described by Geo as a generalized worry of how she interacts and engages her students. Geo is always, "about taking it a step too far with the brutally honest mentality" but soothes herself by telling herself that "I would rather them hear it from me than see it on Blackboard and be shocked by their exam grades" (Geo, interview, November, 2, 2016). Captain Planet mirrors this sentiment in that she worries:

> I don't know what the answers are going to be or what they are going to find that day. Therefore, the student and I both face every day an assessment of the data and the analyzing it and critical thinking and trying to figure out an explanation so I can be answering some really off the wall things that I have no way of preparing for. (Captain Planet, interview, November, 4, 2016)

Geo also sees that many colleagues are having trouble with the changing student demographics and using resources that are available to help faculty avoid interruptions to student learning when she stated that,

> Yah a lot of people are scared of it but as soon as you start producing it the students really like it and I sort of started getting some opinions from students and then the other benefit to that is if I'm sick for a week. You know at least the lectures are still online and you know you don't lose all the time in class. (Geo, interview, November, 2, 2016)

Geo summed up the challenges when she said,

> The most difficult thing for me is always the feeling I could have done better. And you know frequently I'll start talking about something and then I don't have a picture, or I don't have quite all the details because I haven't thought about it for

> six months, so that’s frustrating me when I feel like oh you should have thought this out a little bit better. But sometimes that’s out of your control. I guess what’s difficult is when you know you think that you're gonna do right by the students then it turns out that you’ve made a bad decision. (Geo, interview, November, 2, 2016)

These comments present an overall commentary that the teacher-centered STEM faculty have a dismal outlook on their perceptions of themselves and how they are perceived by other faculty outside of the community college.

To summarize statements in this section, teacher-centered STEM faculty feel that there is a benefit and have a positive outlook to working at a community college. Teacher-centered faculty see this as tied to the ability to use preferred pedagogy, having a diverse student body, and their enjoyment of the interaction with students. Teacher-center faculty also had much more negative things to say in the interviews than positive. They are unhappy with the disrespect that they feel they get from four-year universities and the perception that they have about their teaching ability coming up lacking. This led the group to worry more about how they are teaching their students and to feel alone or scared about changes happening to the community college teaching profession.

Student-centered group.

The student-centered faculty described positive elements of their communicty college, students, and pedagogical practices while also including the negative elements discussing disrepect from university faculty, students lacking skills, and lack of time. STEM faculty identified as student-centered include Sonya, Vinca, and Varna. In expressing their teaching self-efficacy, the student-centered responded in much the same way that the teacher-centered group did in that they all felt positive in the perspective of how they viewed teaching at their community college. Vinca was positive about many aspects of the community college environment and summed it up by saying:

> I think in terms of a commitment a person that chooses a community college is a person choosing to teach, it's a sense of fulfillment, it's almost like teaching and counseling at the same time. (Vinca, interview, November, 11, 2016)

She continued to express that with the choice to teach was one in which she chooses to address the student's social, emotional, and intellectual well-being. Vinca mentioned how the focus on teaching is on learning and growing as a person, not just a grade when she stated:

> My focus is on teaching, teach biology in such a way that they love and they will really learn from it, it's not for a grade your grade will come if you learn the material and it's to create people that more aware of what life is, that's why I feel that that's why I do what I do. (Vinca, interview, November, 11, 2016)

In addition, she feels more willing to try to learn to teach better. Vinca said that teaching is about continually growing as a professional and improving for your students when she said,

> I'm willing to [have other faculty in my classroom] if someone is willing to sit and listen and tell me ok you could have done this differently. I'm more than happy, because it's not about me it's about learning so I don't mind I would love it we had a program where we would just look at it was in a friendly respectful way look at each other's teaching. (Vinca, interview, November, 11, 2016)

This leaves the impression that the student-centered group also has a high positive opinion of the ability to learn and grow as a community college STEM faculty member.

The student-centered group saw the ability to have the academic freedom to choose pedagogy as directly tied to improvement of student interaction and addressing the whole student. Vinca described the community college environment as more personal with the students because the difference in the number of students in the classroom allows the instructor to be more social and to get to know the students. Sonya mirrored this thinking when she described her institution's focus on the student and compared it to her perception of a four-year university:

> I think we focus on students a bit more than four-year faculty would, they might have to do research so they can't have that closer association with students, they might have over 100 students so it's hard to get to know their students and we have that closer bond, that one on one. (Sonya, interview, November, 11, 2016)

Sonya commented that if she had to move to a four-year university there would be aspects of student interactions that she would miss:

> I think that's what I would miss, because that is what I enjoy, the interaction with the students, getting to know them. You know if I'm going to write them a recommendation letter I want to know who they are, not just a number in my grade books. So you know research isn't a big focus for me so I don't miss that I can't say I would want to do that and publish and that is a big factor for four-year. (Sonya, interview, November, 11, 2016)

Vinca further discussed the focus on student interaction with the smaller number of students in the classroom and of how she is able to address the needs of the students because of it:

> I'm more one on one because I have a smaller class so I can cater to the individual needs of the students. I think I do a decent job at being aware of each student and what they need, on the other hand, if I were at a four-year college, I don't think they would be able to what I do in the classroom. (Vinca, interview, November, 11, 2016)

While the student-centered group likes academic freedom they have, they also see it as a means to the end of improving student interactions to improve the whole student. Unlike the teacher-centered group, the positive aspects of teacher self-efficacy constituted a two to one ratio when compared to the negative aspects related in the interviews.

The negative aspects of teaching covered by this group were far less than the teacher-centered group. Much as the teacher-centered group, negative comments centered on how the student-centered faculty perceive that their university colleagues at the four-year universities judge them. Instead of discussing disrespect and interactions, this group focused on defending the rigor of their instructional style. Vinca gave an example of how "ingrained interaction is that two-year would talk to two-year, I think, four-year don't respect you the way you would want them to maybe they think you're not there yet" (Vinca, interview, November, 11, 2016). When asked why this was the way it is, Sonya said that:

> I think they would probably say they have more time for things that they want to do, like research. I would assume one of the reasons they would be at a four-year is probably to do research and to publish. It's usually part of their contract that they do research and publish. I would assume they would want to do that I would think that if they don't, they would be miserable. I think their teaching load is easier. I think they probably put grading onto their (teaching assistant) and grad students. (Sonya, interview, November, 11, 2016)

Vinca elaborated on the idea that the four-year faculty only teach in a teacher-centered style: "because of the high student population they only have the ability to lecture…that this has less rigor not more than community colleges" (Vinca, interview, November, 11, 2016). She stated that the student-centered style requires them to be more reflective about the activities through asking questions like, the "activities, are they challenging?

Are they good activities? Are they teaching? How do you assess them? How do you manage time?" (Vinca, interview, November, 11, 2016). Vinca suggested that since the four-year faculty are not trained or know how to use activities to get critical thinking from the students, they automatically judge the use of anything other than the technique that they use as less rigorous. Vinca stated: "Four-year faculty just don't get any training other than the expert on the podium, they don't experience students interacting and therefore look down on the rest of us that do" (Vinca, interview, November, 11, 2016). Sonya summed up the idea of rigor in referring to the teaching and learning of science content, "So, in general, there might be a steeper learning curve to say [teaching] the STEM courses than the non-STEM courses" (Sonya, interview, November, 11, 2016).

In the final part of this section, the student-centered group focused on the struggles they are having with teaching such as students lacking skills and the lack of planning time forcing the student-centered group to use teacher-centered instructional styles. Sonya expressed changes seen as a STEM faculty has been seeing an ongoing trend in the slow erosion of skills that students would begin with at the community college: "It is, part of what I'm seeing is students today in general on average they don't come in with skills that will help make them successful. They honestly have a hard time reading" (Sonya, interview, November, 11, 2016). Vinca lamented the students not having the skills needed and saw its impact on her classes:

> The most difficult part of Bio 2 is piece of cake. It is easy because it's giving you the information and they get it. Bio 1, the more I teach the more I feel bio 1 is complex because you are teaching cell division its mitosis. Actually it's a very hard concept to get they might learn the stages they might learn the names but they don't understand that this is what really makes your cells too. This is what is happening in your cell. When I first started teaching, this was 8 years ago at Lone

> Star, I taught mitosis, and I was very proud of myself. But now, when I try to go teach these concepts like replication and mitosis, I'm nervous because I know what they won't get and I know that by giving them a series of events they will get superficial knowledge. However, I don't think they understand what it really is. (Vinca, interview, November, 11, 2016)

Vinca gives the impression that this is the first time many of these students are seeing the material. She is spending a significant amount of time on the content and not the concepts. "I'm having a hard time getting the students to that critical thinking level? That's my struggle and the more I teach the more I feel that they might not be getting there" (Vinca, interview, November, 11, 2016). The need for time for instructional planning aggravates this issue of the need of the students. Vinca looked at how she was overwhelmed and lacked time for proper planning of the curriculum:

> I have not really incorporated many hands-on activities with Bio 2, the reason being that I feel I'm hard-pressed for time because I have to do so much material in Bio 2 than Bio 1, maybe it will take me a few more semesters to figure out something to build from. (Vinca, interview, November, 11, 2016)

This has led Vinca to use instructional strategies that she does not want to use. Vinca said that "So you find yourself the newer classes where you're just starting to teach, you find yourself more lecture-centered [teacher-centered] for those classes and then as your able to work on them" (Vinca, interview, November, 11, 2016).

To summarize statements in this section, student-centered STEM faculty feel that there is a benefit and have a positive outlook to teaching at a community college. Student-centered faculty see this as tied to the academic freedom they have, they also see it as a means to the end of improving student interactions to improve the whole student. While rated with negative teacher self-efficacy in their survey, this group had a lot more positive things to say in the interviews. Student-centered STEM faculty are also unhappy with the disrespect that they feel they get from four-year universities and the assumptions that they make about their teaching ability. This group worries about the abilities of the students and their ability to be successful in academics. This group was definitely more positive than the teacher-centered group even though their surveys said differently.

Student Engagement

In the TSES survey, student engagement was defined as to how faculty see their ability to reach difficult students, encourage critical thinking, and motivate and support valued learning. It was found to have a statistically significant difference between teacher-centered and student-centered groups. Based on participant responses that were coded within student engagement theme, several catagories were identified between the teacher-centered and student-centered groups. Participant responses included mentions of: (a) defining student engagement as communication, (b) defining student engagement as instructional stratagies, (c) labs being interactive, and (d) student having difficulty. Not all participants responses consisted mentions of student engagement. All teacher-centered and one student-centered participants gave responses toward defining student engagement as communication. No teacher-centered and all three student-centered participants gave responses toward defining student engagement as instructional stratagies. Two teacher-centered and no student-centered participants gave responses toward labs being interactive. Two teacher-centered and one student-centered participants gave responses toward student having difficulty communicating and participating. The teacher-centered and student-centered groups were explored individually in terms of the emerged catagories.

Teacher-centered group.

The teacher-centered faculty responses described student engagement as way such as communication with students, labs were interactive, and expressed how students had difficulty communicating or participating in discussions. The participants for this group were asked how they engaged their students. The descriptions of student engagement described by the teacher-centered group focused on communication both with and from the students. Wheeler started by describing what he did during his course:

> I usually lecture at the beginning of the class. I lecture for about 20-30 minutes and then I stop and then engage with the student going over lecture. What I do is I engage with them right away after when I lecture to see if they were able to comprehend what I had just explained or taught to them. At the same time if I see an opportunity for me to bring out the student to explain to me or to explain to other students how he/she was able to solve this either a complex problem as well as tell them to come to the board and try to explain that. (Wheeler, interview, April 25, 2019)

In his responses, Wheeler suggested that engagement was communication from the instructor with limited dialogue. Captain Planet described her interactions with her students to be like Wheeler's though she did add the use of lab activities in her description, "I like being able to do kind of talk, group work, discussion, go into a lab-type activity and come back out of it and do the whole thing again" (Captain Planet, interview, November, 4, 2016). Captain Planet described daily communication as a way to illustrate student engagement, she, "likes to have the students know what they are going to cover that day" (Captain Planet, interview, November, 4, 2016).

Wheeler also commented on how he communicated with the students outside of class. Showing that the message of communication is not relegated just to in-class interactions:

> At the same time, I communicate with the students on a weekly basis and I assure them I tell them that you will receive a weekly email from me with, with, your grades. To understand where you stand in the course, and in case the student has a question. I have the ability to help them upfront rather than waiting until the last minute. (Wheeler, interview, April 25, 2019)

If Wheeler sees student engagement as communication with students instead of educationally purposeful activities or using effective educational activities, it would make sense that Wheeler would focus on how often he communicates with his students in and outside of class. Wheeler continued to describe:

> One other thing is that when I did with the students before is that the students said, "*I do not know my grade until the last day of the course*". Which is in a way is like, how I am doing what I am supposed to be doing is very difficult. Implementing this technique helped a lot with my students and made them feel a little more comfortable. They are in control more and know what needs to be taken care of in order to pass this course. (Wheeler, interview, April 25, 2019)

Many instructors working at community colleges have access to a learning management system where the students can access grades. To solve a student ownership problem this instructor has taken it upon himself to make sure he communicates grades to the students and sees it as student engagement.

Another aspect of communication discussed considered students outside of the classroom centered on the instructors making themselves accessible for communication with students. Wheeler described an open-door policy he has with his students:

> Also, I make sure to tell my students I have a, it might not be related, but I tell them I have an open-door policy. So, at any time would you like to come. If you would like to have a conversation with me, please do so. Don't think I'm just an instructor here, I go home, or you going to do your thing, we are here and partnered together in this. (Wheeler, interview, April 25, 2019)

Wheeler did say he did see that few students use his open-door policy and that "When I call one of my students, believe it or not, you can tell that they are just a little taken back. Why are you calling me when you can email or text me?" and that he sees that students want less personal interaction (Wheeler, interview, April 25, 2019). This led to his choice of weekly emails with the students:

> As well as what I stated before, weekly I send a weekly reminder to the students. Either through their regular mailing list (email) and at the same time, I utilize one of the learning management software. There is like a canvas for example. I engage with my students through that as well. I see them every lecture, pretty much, so I make sure I connect with them then as well. Tell them if you have questions please let me know, just constantly engaging with them. (Wheeler, interview, April 25, 2019)

So, by his own admission, student engagement is seen by Wheeler as communication with the student either face-to-face or electronic. Geo saw her student engagement as giving her students a choice in what they would do in class leading to having more face-to-face communication is the form of in-class discussions:

> How about we do discussions and I said OK, but you know there are points built into the syllabus, so I need to hear from everybody, it needs to be a very thoughtful response. So, all of the students are participating in the discussion instead of doing the article review, so that's how I overcame one problem where

> the students were dissatisfied and I listened to them and incorporated their comments and I made the solution with the students, not with the students in mind but with the students. I think that gained a lot of rapport for me with the students. (Geo, interview, November, 2, 2016)

Geo continued to equate the discussion of student engagement to communication practices. However, Geo saw two benefits to using this process. This included being able to get student feedback and to make the course materials related to personal experience. Geo gives her students the chance to decide how they are going to be taught by getting anonymous feedback at times during the semester:

> I asked them a question on Blackboard where you could respond anomalously. I said many of you are frustrated about the format of this class. Now please know that I am extremely proud of everything that you've accomplished how would you like to change the format of the class. Make it easier or better whatever or however, I said it and overwhelmingly they said we liked the article reviews we're learning from them it's just a lot to do them on Monday because they don't want to give up their weekend to do it. (Geo, interview, November, 2, 2016)

While trying to be supportive of her students, Geo also expressed the need to hold her students to high expectations:

> So, I found that I set the bar really high and they are exceeding my expectations. I think that's because I am praising them when possible, if someone gives a really good presentation or gives a really good comment, I say, 'You know Sarah I really appreciate that you said that because blah blah blah'. I think that is helping them. I think that students aren't used to having a voice or using it in a classroom. I think that's another reason their enjoying this format. (Geo, interview, November, 2, 2016)

This shows that Geo is trying to make more of a connection to her students through praise and communication. Captain Planet did acknowledge that the bond with the students is important:

> So, we may not be teaching at the same level, but we need to be near enough that the students can survive when they go to the four-year. The big difference is in how we deal with our students and how we approach them. We actually need to be able to establish a bond to them. We have to connect with them to some degree. We have to motivate them more than four-year has to be. Our students are balancing work school and life, oftentimes-multigenerational family responsibilities. We have to be responsive and adaptable to those needs where a four-year professor does not. Sometimes we have to provide emotional support. And a four-year faculty member really doesn’t have to supply that. (Captain Planet, interview, November, 4, 2016)

Instructors in the teacher-centered group are discussing focusing on communication on a surface level with the students. Communication is directed at a judgment system at how each party is doing, both the student and the instructor. The two-way system of communication is one of the ways the teacher-centered participants described student engagement.

In addition to the idea of communication as evidence of student-centered engagement was the inclusion of lab-based practices. Captain Planet asserted that “probably the biggest difference is we've been doing collaborative interactive inquiry-based teaching always because we have the labs are part of what we do” (Captain Planet, interview, November, 4, 2016). This gives the impression that by nature of many STEM courses having labs are student-centered by default and has student engagement built into it. Captain Planet also described in this scenario that she prefers to use small groups of students to facilitate learning:

> The hardest thing is allowing students to work on activities individually or in a small group. I would prefer them to work small groups than individual and the reason is that the real world doesn't always work out, for example when we go to the field where they are taking field readings. Once again, we have that technical aspect of our profession, so you've got to be able to incorporate the academic and technical and there's got to be an acknowledgment of those skill sets. You've got to deal with teamwork and small groups, that's just imperative and because of the emphasis in that field, I'd expect to see some form of communication out, an emphasis on communicating results in some form or fashion. But the big one would be collaborative teamwork, technical skills incorporated into academics. (Captain Planet, interview, November, 4, 2016)

This shows a level of interaction that the teacher-centered group did not discuss in their previous answer of how they engage students. This shift had other impacts on overall satisfaction with the courses. Geo mentioned that she had noticed that her students are happier with a student-centered instructional style:

> We have been outside doing freshwater sampling at the body of water that is on campus here. Now that it is getting a little less miserable outside and now they are in the groove. You know they don't want to come back inside they want to just to stay outside. And it's a very pleasant experience and it's really wonderful to see them working so well with their groups. Many of the students have given me feedback that they would hate the format of the class, but they really like it. So, it seems that students and professors are not willing to change methodology from that teacher-centered learning environment lecture centered sage on the stage, but

> once you make the break then everybody is much happier. (Geo, interview, November, 2, 2016)

Geo expressed interest in changing to a more student-centered instructional style but described barriers to that process. She described how her students felt that the student-centered instructional style she had tried was awkward:

> So, based on what color they were wearing, I made some of them be the sun or Sunbeam or clouds or greenhouse gases or the earth. And I had them walk through the classroom and interact with each other playing the role that had been assigned to them. And they all said oh this is really awkward, and I told them they were more likely to remember it if it was awkward. (Geo, interview, November, 2, 2016)

Even in describing something new, Geo attempted to make connections to the impact on student learning.

The teacher-centered group expressed that student engagement was difficult to achieve with their students. Their responses included some insight into why this was the case. The consensus was that difficulties were fixed on their students. Captain Planet and Wheeler reiterated the topics from above of the students having difficulty with communication, utilizing open door policies, and students initiating communication with the instructor. Geo expressed that she was trying to move to a more student-centered instructional style, and explained that some of these difficulties were based in her student’s low expectations of her class:

> The first couple of weeks were kind of rocky because the students aren’t used to it there is very much the idea that the students gonna walk in like 10 minutes late, and they're going to sit there and fall asleep and get an A in the class for all of the efforts. (Geo, interview, November, 2, 2016)

Geo did not feel that the students were lazy or entitled, referring to how after being at her position for a while she started to understand that many of these students are disadvantaged:

> I see the flaws in that now, now that I've gotten to know our student populations better and mostly like I said before these students are so disadvantaged that many of them cannot afford the book. Many of them don't have printers at home and they don't have a credit card so they can't print on campus. These students have trouble that I can't even wrap my head around as an adult and that really fundamentally gets me because I want to do better for them. (Geo, interview, November, 2, 2016)

A lack of resources and lacking basic skills like "mathematics with just multiplication" and "students have very big problems with articulation" lead to an ongoing challenge for GEO (Geo, interview, November, 2, 2016). Geo thought that this may come the fact that,

> They are sort of in the transitionary period from high school where they are tested to regurgitate the material pick out fairy easy multiple-choice answers and then they get an A. To me, that's not actually understanding the material because in science you have to be able to communicate it, because there is so much in science that is linked to our wellbeing the environments wellbeing, politics, and if you can't convey this material then you don't understand it. (Geo, interview, November, 2, 2016)

This leaves the students unable to access materials in the same way that other four-year students can. Geo saw that her students "in my introductory-level 1000 level environmental science class are reading journal articles and having trouble extracting the pertinent information" (Geo, interview, November, 2, 2016). Geo explained that she would have to encourage her students by telling them:

> Do you have a Ph.D. is this? And they said No. And so, I said are you trying to replicate the study and they said no. And said well then you don't have to know every step of the methodology, there are words in there that you are not going to know that potential google isn't going to know. So, don't worry about it. (Geo, interview, November, 2, 2016)

When she discussed reaching these disadvantaged students she was proud to say that she experiences few student drops, "Surprisingly No, I had one student drop the class who had taken a class with me before and he basically said he didn't want to do all the work" (Geo, interview, November, 2, 2016). This was is in contrast to what she sees in other STEM courses

In summary, teacher-centered STEM faculty define student engagement as communication with students. This is shown through the references to using face-to-face and electronic communication to relay information to the students. Some in this group believe they are student-centered by default because they had labs with the courses. One participant was trying to become more student-centered in her classroom. The focus on difficulties was centered on abilities that are lacking in students. This group focused on engagement being how often an instructor interacts with a student rather than focusing on educational purposeful activities to reach difficult students. They are looking for students to instruct them as to what changes need to happen to get better performance from the students.

Student-Centered group.

The participants for this group were asked how they engaged their students. The Student-centered group understood that student engagement is using educationally purposeful activities to reach difficult students, encourage critical thinking, and motivate and support valued learning. The description of student engagement described by the student-centered group focuses on their instructional strategies in the course and lab. Instead of repeating this subject again, instructional strategies are reviewed in that section. What is covered here is the are items that coincided with the teacher-centered group: (a) defining student engagement as communication, and (b) student having difficulty. Vinca did couple communication, which she referred to as "interaction", with students as a part of her instructional strategies. She stated that:

> I think there is a lot of interaction at the community college, I have students in my office all the time, I think the interaction around here is more like I was already saying on a personal level they could see you in the hallway and ask a question. I don't think they have that at the four-year, because I had a student that came back that was a UH main campus student and they did bad on one exam and I asked them what was going on and she told me you're the only that asks me that question, they don't ask me that question over there. You do it you don't do it, but I think there is more personal responsibility expected in a four-year university whereas in a two-year you baby them a little bit. (Vinca, interview, November, 11, 2016)

Vinca described the aspect of student engagement similar to Geo and Captain Planet, as a representation of communication with the students though at a more personal level.

Several times when discussing their instructional strategies, the student-centered group referred to difficulties in engagement being with both the instructor and the students. This led to the idea that the problem needed to be identified and resolved in an empirical fashion. Sonya described this way of thinking and acting by giving an example of how she identified a problem and the root cause:

> I realized years ago especially with Anatomy & Physiology 1, the students would get questions wrong because the question might ask for the organ and they would

> tell me the tissue and they wouldn't be wrong because they are telling me the right tissue, but they aren't answering the question, so I try to show them those differences. (Sonya, interview, November, 11, 2016)

This wasn't the only change that she saw that was necessary for her courses. She also described how students were having issues with the vocabulary.

> They will just ignore it or read over and so um I had them keep a notebook where they had to write down every word that they weren't familiar with and they to define it, they had to look up the definition and they had to use it in a sentence. Where did they get those words, from your lecture or just from the book, notebook, any kind of reading, or even me speaking? I tried to define a lot of words, as well some students think I'm just repeating thing, but for others it makes sense um what I realized when I tried that the first-time students would turn in notebooks that had 5 words in it, so I would right in can you describe for me the word homeostasis? They couldn't so I realized that I can't rely on them to write down words they don't know, they wouldn't do it. (Sonya, interview, November, 11, 2016)

Sonya describes not only setting up a solution to the vocabulary problem but also checking in on the process to make sure it is working in the way that she intended and adjusting. Varna also stated that the use of a specific instructional style was able to overcome difficulties on student engagement. Varna stated that she "found that when I taught STEM courses, integrating the subject areas engaged students more fully and allowed them to come to a deeper understanding of the content" (Varna, interview, May 10, 2019). When asked what instructional style she used, Varna discussed the 5E model. Varna explained that:

> I engage students by following a 5E model in my class. We start with a hook or common experience so that all of the students can draw from a common event. Then we dive in and explore the topic in order to build questions and develop a conceptual understanding before talking about the knowns of the topics. Then we take some of the questions, elaborate, and extend the learning through investigations or real-world scenarios before assessing their learning of the content. (Varna, interview, May 10, 2019)

The 5E instructional model is a constructivist learning cycle that consists of five stages (Engage, Explore, Explain, Elaborate, and Evaluate) that was designed by Rodger Bybee (2013). This is typically a K-12 science instructional model and tends to be integrated into ideas such as Project-based learning (PjBL), Problem-based learning (PBL), and Universal Design for Learning (UDL) (Bybee, 2013). This is interesting since Varna did not identify as having a teaching certificate. How Varna found the 5E model is discussed below in the professional development section.

With these two student-centered faculty discussing their instructional styles, they expressed the difficulties they saw with the students entering her courses. Sonya speculated that some of these difficulties come from the K-12 requirements for science courses:

> I think a lot of students coming from high school haven't had a lot of science for a lot of the biology they take in 9th grade and that's it so they may not have had a biology course again until they take one of our courses here. (Sonya, interview, November, 11, 2016)

Sonya believed that the large gaps in exposure to the different content may be responsible for some of the student difficulties.

Sonya saw a pattern with the students. A lack of science courses ends up with students having difficulty with communication, self-learning, and student ownership. Sonya saw that the students "can read a passage but if I ask them to explain in plain terms what they just read. Notetaking and the ability to look up information on their own is lacking. The students just can't do it" (Sonya, interview, November, 11, 2016). Sonya had issues with both of these that "they won't do that, they will ask, and I will try to force them to look it up and they do not like that they will actually say well why don't you just tell me" (Sonya, interview, November, 11, 2016). Sonya described the daily fight to get students to take ownership of their own learning:

> I've noticed that they can't like the dihybrid cross lab that we did yesterday, they have a hard time just doing basic mathematics without telling them the exact here's the formula they use, and they also don't want to read the instructions. (Sonya, interview, November, 11, 2016)

She did say that if the students have scaffolds in their learning through college courses they did better in her courses:

> I would say one thing about the prerequisites, I survey my students at the beginning of the semester and the students who have taken general bio and have made a C or better on their first lecture exam they score anywhere from 15-20 points higher than those who haven't had a general bio. (Sonya, interview, November, 11, 2016)

Through her statements, Sonya had expressed that students are not as prepared for college as they could be experiencing difficulty with communication, self-learning, student ownership, and needed scaffolding.

In summary, student-centered STEM faculty correctly define student engagement as educationally purposeful activities and that they focus on evidence-based changes to improve student outcomes. They do use communication with students though it is integrated with the instructional strategy to find reasons that students are performing poorly so that meaningful instructional changes can be made. Student-centered STEM faculty see student deficiencies as challenges that push change so that they can perform better.

Instructional self-efficacy

In the TSES survey, instructional self-efficacy is defined as to how faculty see their ability to respond to difficult questions, implement alternative strategies, and providing students with appropriate challenges. There was a statistically significant difference between teacher-centered and student-centered groups. Based on participant responses that were coded within instructional self-efficacy theme, several catagories were identified between the teacher-centered and student-centered groups. Participant responses included mentions of: (a) mistaken student-centered definition, (b) content acquisition/gatekeeping, (c) lecture, (d) communication, (e) positive veiws of student-centered instruction, and (f) student-centered activity. Not all participants responses consisted mentions of instructional self-efficacy. All teacher-centered and no student-centered participants gave responses toward mistaken student-centered definition. Two teacher-centered and all three student-centered participants gave responses toward positive veiws of student-centered instruction. All teacher-centered and no student-centered participants gave responses toward goal – content acquisition. All teacher-centered and no student-centered participants gave responses toward lecture use. All teacher-centered and no student-centered participants gave responses toward activity – communication. No teacher-centered and all student-centered participants gave responses toward activity – student-centered. The teacher-centered and student-centered groups were explored individually in terms of the emerged catagories.

Teacher-centered group.

The teacher-centered participants held positive views of student-centered instruction though they described it using a misconception, described goal-content acquisition, lecture use, and communication. Teacher-centered participants shared that presence of lab based activities connected to their STEM courses and make them student-centered instructional styles. Captain Planet mentioned that the student-centered style that she used was collaborative interactive inquiry-based teaching saying that, "student work in groups to answer questions from the lab, they follow the instructions and work together" (Captain Planet, interview, November, 4, 2016). This illustrates a key difference in the perception of student-centered instruction, that activities alone make a course student-centered.

Captain Planet used her definition as the framework for how she designed her courses. She thought that the goals for the course were to teach both academic and technical skills:

> I think so, the fact that we have activities already incorporated. We also have to teach a skill set to the student a manual skill set to go on with the academics. It's a year one, that's listed twice, and some don't recognize that they're related, there's a slide, but it's a six-hour not a three-hour class like the others. (Captain Planet, interview, November, 4, 2016)

Captain Planet described "more practical hands-on tactile and learning a skill set to go with it or it emphasizes the academic learning" and being an integral part of the learning process (Captain Planet, interview, November, 4, 2016). When asked about how she changes her courses, she described an optimization process using student achievement data from her courses to precipitate change.

> Yes, being an engineer, I know what you mean. I do a feedback loop. I do optimization. So, it's going to be we're going to design it, we're going to test it we're going to analyze the results and we're going to optimize and modify as we think is best and then we're going to go through that process again. (Captain Planet, interview, November, 4, 2016)

The optimization she refers to here is linked to her belief that the revision cycle makes the course student-centered.

As a part of this optimization process, Captain Planet stated that she is constantly adapting her course from semester to semester. One of the changes she said she made early on was to request that the lecture and lab be in the same lab room. Captain Planet said her best experiences start with the location and room she is teaching: "The way I like to teach best is where I teach the lecture and the lab in the lab. So that way I can integrate the two experiences more so" (Captain Planet, interview, November, 4, 2016). Having the lecture and lab in the same room allowed for a better flow of instruction:

> We then try to do a lab associated with it and I don't like separating the lecture and lab if I don't have to. I like being able to do kind of talk, group work, discussion, go into a lab-type activity and come back out of it and do the whole thing again...With that said during that three-hour block sometimes allows me to do it to do an entire three-hour hands-on lab type experience like where we go to the field. like when we go to the field, we go do sampling and we do it for the entire day, for the three hours. (Captain Planet, interview, November, 4, 2016)

This allowed Captain Planet flexible use of the course and lab time and allowed for off-campus trips for sampling. She believes that sampling or field trips along with a discussion-based lecture are considered student-centered. When asked to elaborate on this use of laboratory time for activities, it led Captain Planet to describe more cookie-cutter labs where the students followed directions to get to a predetermined answer. Captain Planet described the labs as activity based with lecture integrated throughout the lesson:

> When it comes to labs then I tried to work for whole group hands more hands-on for example how to test for the nitrate, how to test for the nitrite how to test for phosphate, what does it mean by limiting nutrients and how it fits with biogeochemical cycles. (Captain Planet, interview, November, 4, 2016)

This use of cookie-cutter labs bought from the textbook companies was such a problem for Geo because they were not having the ability to engage the students so she "wrote a lab manual specific for the students here because of one of the challenges that we have" (Geo, interview, November, 2, 2016). On the surface, it sounds like the teacher-centered group is designing student-centered activities to be implemented in the classroom and labs that are engaging the students at a deeper level.

Goal setting and achievement for the teacher-center group was stressed by all participants and was the metric that they used to judge whether or not changes were needed in instructional styles. This is what Wheeler said set his courses apart from non-STEM courses. Wheeler saw the difference as the level of competency that the students were required to obtain to pass the course:

> I see a big difference, especially when it comes to the core competency of each course when it comes to STEM. Because keep in mind when it comes to these science courses or STEM courses you have a different type of material you're dealing with… There are a lot of aspects such as making sure the calculation is right for the patient. I don't know if you want to include that in your paper or not. I joke about it all the time, nobody dies from a poorly written English paper or if you answer the wrong history question, but people will be hurt if you miscalculate a drug dose or people might hurt will be hurt if you miscalculate at all. Let's say

> when you build a bridge when it comes to the engineering and you miscalculate how much resistance or the thickness of the concrete. (Wheeler, interview, April 25, 2019)

Wheeler is outright stating that rigor is higher in STEM and that it is more important that students are capable (i.e., have competency) and therefore see it as his job to gate keep his courses to reject the less capable students. For Wheeler, the teaching of the STEM course leads to life or death choices that non-STEM courses do not deal with. Captain Planet saw the difference as two-fold. First, she discussed the differences in vocabulary mastery in STEM courses in comparison to non-STEM courses:

> Uh so, a lot of the English and the social behavioral sciences fine arts and there's some vocabulary that you might have to pick up but it's not a different language it's still English, but whatever you're going into a STEM field or STEM class. It's also like you have to pick up an entirely different language an entirely technical language. You had been able to talk biology I think there's a lot more getting over that obstacle before you can ever start teaching concepts. I don't think you have that big of a barrier in your other traditional, like I said, your social behavioral science classes. (Captain Planet, interview, November, 4, 2016)

She spends a large amount of time "Making sure (the vocabulary) is available to them" and that the students "are using the correct terms so they understand what they're doing" and that the students are "comfortable with the language of the field" (Captain Planet, interview, November, 4, 2016). Captain Planet described teaching both academic and technical skills in the course:

> The biggest difference is really the fact that along with that we're kind of a combination of academic and technical. So, we have the hands-on skill set that we have to teach too is the lab, that's probably the biggest difference is we've

been doing collaborative interactive inquiry-based teaching always because we have the labs are part of what we do. (Captain Planet, interview, November, 4, 2016)

Captain Planet continued to identify the way she teaches as being student-centered and that her courses are so different from non-STEM courses because of the presence of the lab. The perception is created from her description that the presence of the lab is the sole way to have student-centered instruction.

All participants in the teacher-centered group elaborated on what a normal day, lecture and lab cycle, looks like in their classrooms. Geo and Captain Planet saw a purpose in having their students prepared before they entered the classroom, though each had different ways to accomplish this. Captain Planet said that, “Hopefully they have been introduced to it already, looked over the material to get an idea of it, sometimes I’ll even have a pre-assignment for them, so they’ve had to look at it before they come in” (Captain Planet, interview, November, 4, 2016). Geo was more certain of her student preparation because she would, “ask my students to do a reading and then take a reading quiz on Blackboard before they come into class” (Geo, interview, November, 2, 2016).

Wheeler described that to start a good semester he always designed the course with a clear introduction and reviewed expectations with students:

> I always make sure I explain first, I go over the material first before I go to the next step…usually at the beginning of each course I do more, the standard introduction to the course. Who I am and what I try to do, and what's the goal? I lay out the structure or the map for the course to the student. So, I do that approach so that the students are aware of what needs to be done in order to pass the course” (Wheeler, interview, April 25, 2019).

Connecting his preparedness with setting the clear expectations led Wheeler to feeling confidence about his course instruction.

A common thread among the teacher-centered participants was once any preparation work was done outside of the classroom, all courses started with a lecture. Geo described it in her course as, “my physical geology is more of a traditional science classroom as you might expect it’s a lecture followed by a lab” (Geo, interview, November, 2, 2016). She also said that she includes questions for the students in her courses:

> And then I lecture for a couple of minutes at a time. I call students randomly to answer questions throughout the lecture, which is the meaning of the vocabulary words which are from the list I sent to them before the lecture starts, I also punctuate a lecture with what I call concept tests and there are somewhere between eight and twelve concept tests in any given lecture. (Geo, interview, November, 2, 2016)

Concept tests are a different name used for quizzes or questions integrated into the lecture presentation. Geo mentioned using quizzes many times before, during, and after courses.

Wheeler described his courses as, “usually lecture at the beginning of the class. I lecture for about 20-30 minutes and then I stop and then engage with the student going over lecture” (Wheeler, interview, April 25, 2019). Captain Planet had the same lecture in her course though she described the use of activities:

> So, I would estimate that in the semester they spend probably 60% of their time times in the field or in a lab-type activity or a field trip whereas about 40% in lecture mode. But in that lecture mode, you would conclude like the uh group discussion and group activity that I wouldn't consider a lab necessarily. So, I try

> to aim at about 25 percent of my time may be being lecturing maybe. (Captain Planet, interview, November, 4, 2016)

This leaves the impression that only about 10% of her class is lecture on any given day. Out of a three-hour lecture/lab cycle, this leaves approximately twenty minutes of lecture. This coincides with the amount of time Wheeler said he lectures.

Each of the teacher-centered interviewees made some mention of using activities for their students much like Captain Planet. In describing the different types of activities that they were using in the classroom, Captain Planet said that she,

> Will bring that to a small group activity. That would still be considered lecture, and so I would say something like go look at the biogeochemical cycles try to determine what the effect on them would be great but then in the class discuss what you found and come up with the one greatest effect it has. (Captain Planet, interview, November, 4, 2016)

While Geo described her instructional style as a series of activities interspersed with a traditional lecture:

> I try to keep it sort of a more traditional classroom for physical geology, but I try to include more active learning techniques. Occasionally we do group work and think pair share and sort of act out situations, for example, the other day we did the greenhouse effect which is something students have had trouble with in the past. (Geo, interview, November, 2, 2016)

Wheeler described much the same pattern but with more discussion rather than activities:

> I do all kinds of activities, lectures, even group activities. We do a little competition between groups; you know where I break the students into groups. At the same time, I ask a couple of the students to be, after I introduce a new skill and introducing the new material the following week, I'm going to assign some of

> you to be a teacher for that course. So, we can see if they have the ability to articulate and connect with the students as well. That would give me an overall understanding...What I do is I engage with them right away after when I lecture to see if they were able to comprehend what I had just explained or taught to them. And at the same time if I see an opportunity for me to bring out the student to explain to me or to explain to other students how he/she was able to solve this either a complex problem as well as tell them to come to the board and try to explain that. (Wheeler, interview, April 25, 2019)

In addition, Geo seemed to be the only teacher-center participant that used any other activity. Geo described using the reading of peer-reviewed articles in her course:

> So, can you believe that in my introductory-level 1000 level environmental science class my students are reading journal articles that are published peer-reviewed journals? (Geo, interview, November, 2, 2016)

The surprise in which she said this statement shows that she has encountered many individuals and colleagues that expressed they did not believe that introductory students have the capability to understand or read the articles. Geo gave examples of the types of articles that she had used:

> So, for example when we cover the atmospheres, we're talking about atmospheric circulation, pollution, ozone, ground-level ozone and basically the class has six groups of three to four students, and they are teaching each other what is in each article. And it's really great because it's also gotten those soft skills including presenting in front of a classroom, group work. Which are valuable for employers and in the lab, I usually do more collaborative group work activities. (Geo, interview, November, 2, 2016)

She sees this activity as out of the norm for most STEM courses, and she seems to feel the need to justify the use of the articles in the classroom.

These descriptions of activities amount to three key themes for this group. The first is that activity is synonymous with communication. Each participant discussed different strategies with Captain Planet using discussion, Geo uses think-pair-share, and Wheeler uses student to teacher questioning. The difference is who the communication is with, either fellow students or the instructor. The second theme is that the students are not responsible for asking questions, investigating, and analyzing or interpreting. The instructor is still responsible for communicating information to the students and confirming that they understand through the "activities". As with the student engagement section, Wheeler really stressed the fact that he communicates with the students to let them know how they are doing in the course and what they need to pass. Wheeler seems to put very high importance on this one aspect of teaching. That he is a conveyer of information rather than a resource to the students: "It is important that I am clear on my explanations, my lecture time is the only chance I have to be sure they understand what I have said" (Wheeler, interview, April, 25, 2019). This leads to the third theme, that the process is tied to the student gaining knowledge or content rather than problem solving or learning to critically think independently.

The belief that these activities are student-centered connected how the teacher-center group perceives student-centered instructional styles. Geo acknowledged the trend in STEM courses to change to more student-centered instructional strategies and this sets STEM courses apart:

> For example, an English professor could lecture for the entire time just as simple as a STEM teacher could, but I think the trend in education is moving towards a more learner-centered inclusive active style, but I think it depends on the teacher.

> I don’t see any reason why the methodology couldn’t be very similar. Of course, if the subject is English vs Geology then you know a review of papers, a discussion of student performance of submitted work would not be appropriate in a geology classroom. That doesn’t mean that you can’t have group work environment where the students are all working on a separate project but are helping each other to complete the same project but I would say the differences would come from the professor not necessarily from the subject material. (Geo, interview, November, 2, 2016)

She had such a positive viewpoint that she then started discussing how she was going to start integrating some flipped classroom designs into her classroom:

> My plans for the future because right now I have them read and I always question the efficacy of that and the efficiency of that it is unrealistic to ask them to sit down and read three or four hours for a chapter and we cover a chapter a day. So, what I would like to do is take my lectures and record them at the educational technology facilities. (Geo, interview, November, 2, 2016)

Some of the reasoning behind this was the availability of technology and assistance to create the kind of curriculum materials needed to make the change:

> I'm not sure if you're aware, we have state of the art facilities to record professors teaching. And essentially you just teach to an empty classroom and they record and caption it and so my thought was I could export my lecture material into blackboard, have the student watch the lecture and take notes from lecture and they can pause it. That way we can get away from the book resource, which many of them don't have the finances to purchase. Then come into class and do group work. (Geo, interview, November, 2, 2016)

Geo connected resources that were available for teachers to use, but her responses did not include how the recording of the instruction would be different than lecturing real-time.

With Geo acknowledging a positive opinion of the change to student-centered instruction, Captain Planet and Wheeler expressed their views of the use of student-centered pedagogy in the classroom. Wheeler had a similar viewpoint to Geo, stating that:

> So, student-centered, what does that mean for my own perspective is the ability to provide our students with either activity, or assignments, or assessments that are geared to their understanding. As an educator, we have to understand that we cannot just continue teaching the same material or the same way that we used to teach 5 years or 14 years ago. (Wheeler, interview, April 25, 2019)

This leaves the impression that he believed change is good but the change that he was referring to was not related to a specific instructional style.

Captain Planet also discussed the use of a flipped classroom and her viewpoints on how it is used in STEM. As a proponent and practitioner of a student-centered instructional style, her opinion of flipped classrooms was surprising. She started her statement sounding positive of the practice and then turned negative to the practice:

> I was very excited about the idea of flipping the classroom. What we have found in STEM by talking to colleagues that have done this is that it is only somewhat successful. There is so much of that technical language, the vocabulary, and technical skillset, which they have to pick up and that is very difficult for the students to prepare to do this adequately at home by themselves. So, if you're going to flip, it’s got to be a modification of the flip where a lot of the more difficult concepts are still taught in the classroom. That tends to be the consensus and you don’t share that until you are talking to your colleagues... I’m not sure

> which because what was happening is we had a few that piloted the fully flipped classroom. They weren't able to identify at the time whether or not it was because they aren't picking up the vocabulary or if it was not important, they thought that they had the concepts. Then they failed, not that they failed the grade, but they failed to be successful because they didn't really have the vocabulary or was it because they couldn't understand what the terms meant so they couldn't understand the concepts. I'm not sure where the students failed yet, I haven't been able to able to talk to the faculty so I don't know if they have enough data to tell. All they know is a full flipping where they send them home to learn and then came back in and just did activities to try to reinforce those concepts didn't work very well in several fields in STEM in our department. (Captain Planet, interview, November, 4, 2016)

Captain Planet focuses on the lack of ability of the students to pick up the vocabulary and is unclear in her next steps to shift to a more student-centered instructional style.

For instruction efficacy, the teacher-centered group believed that the lecture style had the most impact on student learning. It was mostly a consensus that content acquisition is important enough that the teacher-centered group used it to gate keep the course on whether the students achieved. The instructional style used heavily was communication in activity and lecturing, instructors are responsible for the transmission of content, and student gaining knowledge or content is the achievement metric. Most all teacher-centered participants had an understanding that the push was to change STEM courses to a more student-centered instructional style. The group believed that they had already changed or were changing to a student-centered style. Viewpoints of a student-centered style were found mixed between positive and negative when closely examined.

Student-centered group.

The student-centered faculty described their instructional self-efficacy related to their instructional styles. The student-centered participants shared positive views on student-centered instruction, described activities that were student-centered. All student-centered participants stated that they believed that educationally purposeful activities in their STEM courses make them student-centered instructional styles and was closely tied to their instructional self-efficacy. The approach used shared some components with the teacher-center participants. Although they focused on how those concepts fit into student-centered pedagogy, Sonya believed some of the student engagement centered on content acquisition such as vocabulary:

> I think a lot of us who teach STEM courses, we feel that there is so much content that we have to get the students to learn that we can just delve in. To read this, then come in, and let's do an activity, because I think the common thought is most students will not be able to understand the concepts there so I think it is different. If you go to an English class, they can read a story and start to discuss it, where with our classes it is a little bit tougher. We would have to, to have more a traditional lecture, show them where the supplies are, and then time permitting do some activity. (Sonya, interview, November, 11, 2016)

Sonya went on further to justify the sense of frustration with students unable to access some of the content based on student's prior experiences. Sonya described the use of science vocabulary as a barrier for many students when approaching a STEM course due to students lacking in science preparation in high school:

> They [the students] have at least an English, Mathematics, and a History almost every semester. At least until the 11th grade ... so that's a big part of it, they don't remember a lot of what they have studied in the 9th grade. For some, the 9th

> grade may have been 10 years ago, and so I guess with a lot of our science courses especially Biology not only are they learning how things work but they have to learn the names. It's like taking a foreign language in addition to a science course. Yes, considering that most of the terminology is based on Latin or Greek. Yah so they pretty much are taking a foreign language so if you would describe a typical lecture and lab course section that you would be teaching and if you teach multiple sections. We can pick one to go with and then you can if you feel the need to describe it. (Sonya, interview, November, 11, 2016)

Varna was the only one out of both groups that said that she focuses on concept integration from all subjects. She said that the unique part of STEM courses is the integration:

> I don't think I see enough of a difference, I think that all courses should include engaging work for students, but STEM courses should focus on the integration of those studies to illustrate the real-world connections that exist in those content areas. (Varna, interview, May 10, 2019)

Vinca was able to summarize these statements with an example of what her instructional goals for her courses would look like:

> Yes exactly, I had a student who came to me from bio 1 who said to me, oh I have a cousin who has a Ph.D. and he said your exam made us learn a lot, I said go find a teacher that gives you an easy exam. You're in a biology 1 for the major course, my job is not for you to get an A and leave, my job is for you to really learn. If you feel this is too much that I'm asking, pick a teacher and I can write a letter asking them to accept them. Two weeks later she came back and said she had signed up for bio 2 and I asked why you did that, you didn't need 2 biology

> courses. She said 'but I learned so much and I want to do the next part of the course'. (Vinca, interview, November, 11, 2016)

This statement is seen stated many different ways for the student-centered group. Their focus is on student learning rather than making a grade. In another word, they are focusing on the whole student's development; emotional, intellectual, and social. While getting the content or vocabulary is necessary for understanding concepts, it is not the complete focus of the student-centered group like it was for the teacher-centered group.

The interviews continued by asking about the best teaching practices for which they described a student-centered pedagogy. Varna described what she is trying to accomplish with her students: "I think that relevancy, real-world connections, problem-solving, engagement, high interest, transparency (in terms of grading), and clear expectations impact student achievement in my courses" (Varna, interview, May 10, 2019). This focus was seen in several different ways in the others in the group. They described these as course scheduling, in ways to better prepare students, lecture design, lab design, and assessment. Scheduling was an important subject for Sonya. Sonya described the need to cover so much material as an overwhelming obstacle:

> It is and appears to be, as I keep going along semester to semester it appears to be more lecture heavy than activity heavy. We seem to be falling behind the last two semesters so it's almost like a catch up game. I'll try to do an activity, ok, so go read this I'm not going to cover this, but they come in the next class period with lots of questions or they just didn't read ahead. Because I want them to still learn the content, I'll cover it but that puts me behind in my schedule... So if we are not finished with the unit information and this is the last class to finish that before the test, I will have warned them, 'you have to read ahead and you may have two or more questions on the material I haven't yet covered but most of it will be

> material we've covered'. In other cases since I try to build into the schedule at least one class period between the time we finish the unit and we have the lecture exam, it's usually material they should have already studied and learned so a lot new. (Sonya, interview, November, 11, 2016)

Participants are expressing that more content is needed to be covered in courses and are feeling pressure on the usage of time.

As pressuring increases on utilization of time, the planning for lecture and lab becomes paramount. Vinca discussed what she is thinking about when designing her courses and how she must lead the students by example and teach them soft skills that allow them to succeed:

> In a bio 1 class I would go introduce a concept, and bio 1 is heavy on big important concepts the way we teach bio 1. Let's say I'm teaching photosynthesis, I would start with a video and ask what did they see, then they would say I saw leaves, I saw glucose, I saw carbon dioxide, and I would just list them all on the board. Then have them knit the information into a story, a very basic story and then I would delve into it and once I'm going into it, say I have to explain electron transport chain, that's where action comes into play... In a bio 2 class, more of the students are better prepared. They are there because they have to be, they already know how to study so I don't have to worry about concepts getting into them. Bio 2 is a lot of material so I have to teach them the skills they need to learn the material. For example, if they are doing a phylogenetic tree, how do they break it down? How do they build the tree, for them to understand the animals they have to understand the phylogenetic tree and how it works, after that everything is a piece of cake. So, I repeat the phylogenetic tree many times,

> every class we start with building the tree. (Vinca, interview, November, 11, 2016)

Sonya stated how she assigns course work outside of class and then checks for concept understanding at the beginning of class:

> Sometimes (the students) have to go and prepare and study and come into class and they'll have a Kahoot quiz at the beginning of class where they use their student id number as their nickname and that way, I can track it back to the student. (Sonya, interview, November, 11, 2016)

This focus on design is interesting and in contrast to how teacher-centered faculty focus on curriculum design.

The best teaching practices described for lecture was seen to be more varied than the teacher-centered group. The one-piece that was the same through both groups is the use of traditional PowerPoint lectures. A key difference in the student-centered group is how they are used with students. Sonya described the use of lectures in environmental classes:

> Lecture; there are a lot of lectures. I have prepared PowerPoints, I don't typically don't use the canned PowerPoint provided by the publishers. I tailor them to what I need cover, I customize them, put in links that take them to the web, I use YouTube, I use Khan Academy, anything I think that will help the students learn better. I try to stop or pause and answer the student's questions in the middle of the lecture to see if they are understanding it, as much as I can. I'll use Kahoot, that's one of my favorites new tools to use, in the classroom and the students become very engaged with Kahoot because they can use their cell phones and tablets. It shows them a graphical representation of how many got it and how many didn't. If a lot of them are getting it wrong, it gives me the opportunity to

> go into the content and describe why they got it wrong. If they got it right we reiterate, yes that they got it right. So that helps them, I don't know, it gives them a little more confidence for the ones that get it so that helps. (Sonya, interview, November, 11, 2016)

Along with the lectures, this group discussed alternative forms of instruction that they used. Sonya described how this could include worksheets, activities, role-play, and interactive notebooks:

> I will have the students work on a worksheet that I've developed pertaining to something I maybe haven't covered in detail but I've probably introduced. They've had to go read and fill in this answer sheet or this worksheet and then they come in and do an activity. One of those has to do with DNA replication, transcription, and translation. So I go out and buy poster board stickers, I put them in groups, and then they have they get a strand of DNA. They are responsible for using that poster board as a cell and showing me using the stickers that represent the nucleotides replication, transcription, and translation. (Sonya, interview, November, 11, 2016)

Vinca described similarly that she "most likely would do an activity with the clickers with a sort of a flipped classroom" (Vinca, interview, November, 11, 2016). She also described a role-play activity she had been implementing in her course:

> I ask students to come up, and let's say markers are electrons, student are actually role-playing the electron transport chain. We identify the student as photosystem 1 or photosystem 2, there are a bunch of students, and there is an ATP synthase. So, what I see helps them is when they are coming to an example, when they are trying to play, they will just the names of the students. They will say 'oh Justin

> was ATP synthase that day' and they will go by the story. (Vinca, interview, November, 11, 2016)

Along with the activities, Sonya saw a need for students to have a handle of terminology and created an interactive notebook that she termed a terminology notebook:

> One of the things is and one thing I've tried is to actually have the students keep a terminology notebook because that is one place that they're lacking. They don't have the terminology and they refuse to look it up... They will just ignore it or read over so I had them keep a notebook where they had to write down every word that they weren't familiar with. Then they define it, they had to look up the definition, and they had to use it in a sentence… What I realized when I tried that the first time, students would turn in notebooks that had five words in it, so I would write in can you describe for me the word homeostasis? When they couldn't, I realized that I can't rely on them to write down words they don't know, they wouldn't do it. (Sonya, interview, November, 11, 2016)

This is her creative way to have her students take responsibility for their own learning. This gives her students individualized learning plans for their own terminology that they do not know.

The labs were not discussed as extensively as the teacher-centered group. However, both Sonya and Vinca discussed their students needing assistance. Sonya discussed giving her students indirect assistance:

> So, lab typically is, I usually have taken the PowerPoints that have taken the histology or cats and I've taken lots of pictures of the cats with pictures they have identified, they don't do a lot of data capture labs, it's more here is look at it. (Sonya, interview, November, 11, 2016)

While Vinca discussed getting her students direct assistance:

When we go to the lab, of course, the lab is hands-on the students are doing their thing. I start the lab, I generally make the student read the prelab questions that we have on campus and as they are reading it I'm helping them answer the questions. I sort of weave the information in there and they start working I am with them going around helping them out, but then we do a post-lab where we synthesize the information and then I leave. That is how a general bio 1 goes. (Vinca, interview, November, 11, 2016)

These differences were either due to the difference between courses (anatomy and physiology and General Biology I) or between lab manual availability. General Biology has a lab manual written by the faculty and A&P does not. Though when asked neither Sonya or Vinca could decide on a reason for the difference.

Finally, this group was the only group to discuss the use of formative assessment to make decisions on change in instructional style. Teacher-centered faculty only discussed the use of summative assessment to get student grades and surveys to figure out what instructional changes were needed. Sonya was a big proponent of the use of formative assessment:

> Sometimes (in lecture) they'll even have paper quizzes, so just whatever I've passed out in class and I do different versions of those and that's usually right before a lecture exam so that I and they can see how well they understand the content... Right so (in the lab) I try not to waste too much time on that, but I go through that pretty quickly and then they are set loose to identify to look at everything they need to look at. That's usually the first few days of a new unit, after that, I'll take 15 minutes usually to quiz them so I usually prepare PowerPoint quizzes with pictures asking questions that they will see again on the

> lab practical so they can get used to the wording. (Sonya, interview, November, 11, 2016)

Vinca was the opposite of Sonya where she used Kahoot at the end of the course. "They do quite a bit of informal you know the formative ones ... but they do Kahoot they draw something at home and bring it in" (Vinca, interview, November, 11, 2016).

In summary, student-centered STEM faculty find themselves using the same techniques as the teacher-centered faculty as well as more varied techniques. The student-centered group equated instructional style to being student-centered. In describing best practices for instruction, scheduling, student preparation before class, and the lecture were integral parts of instruction though lecture must be paired with an integrated activity. Activities were described as a variety of events that are facilitated by the instructor but were student led. Finally, adapting instruction should be based on formative assessments with the students.

Classroom Management

In the TSES survey, student engagement was defined as to how faculty see their ability to reach difficult students, encourage critical thinking, and motivate and support valued learning. It was found to have no statistically significant difference between teacher-centered and student-centered groups. Based on participant responses that were coded within classroom management theme, three catagories were identified between the teacher-centered and student-centered groups. Participant responses included mentions of: (a) no problem with classroom management, (b) enforcement of classroom rules, and (c) did not discuss or talked about instructional stratagies. Not all participants responses consisted mentions of classroom management. Two teacher-centered and one student-centered participants gave responses toward no problem with classroom management. One teacher-centered and one student-centered participants gave responses toward enforcement of classroom rules. One teacher-centered and two student-centered participants gave responses that did not discuss or talk about instructional strategies.

Teacher-centered group.

The teacher-centered group expressed having no difficulties with classroom management and described enforcement of classroom rules. Geo describes not having any difficulty with classroom management saying that, “as far as classroom management I’ve never really had a problem with that because for whatever reason students have always picked up on that I really am there for them and that I respect them” (Geo, interview, November, 2016). Geo explained that she believed the reason she did not struggle with classroom management was due to relationships with the students:

> I try to learn their names early on and they also know that I’m brutally honest and so the students ask me can I leave lab early because I’m done and I say I won’t take it personally as long as you don’t take it personally when you get an F on the test. (Geo, interview, November, 2016)

Building positive relationships with students allowed the teacher-centered faculty to avoid conflict or other classroom management issues.

Wheeler similarly believed that he did not struggle within his classroom in terms of management: “Quite frankly, I don't have a lot of challenges” (Wheeler, interview, April, 2019). He described the structure of the master schedules and the connections to life outside of school creating issues with attendance as a management issue: “I would say, and it's not a challenge is more working with the student, is if you have a morning course, and the students are not on time due to either working late or they have trouble in the morning or if they can’t get to school on time” (Wheeler, interview, April, 2019). This seems to classify his classroom management challenges on how to get the student to class on time. The concern expressed was not that the student missed class but that, “it is more like, so let's say that if I have an exam on that day if I am not notified by my students, I am not aware of what's going on with them" (Wheeler, interview, April, 2019). His concern was not with the student missing the exam, but with the student making sure to communicate with him: "So, I encourage my students that to make sure that make sure to communicate with me upfront of whatever is going on so please I can act with you accordingly" (Wheeler, interview, April, 2019). This was a thought that Wheeler previously expressed when describing student engagement in terms of communication equating to student engagement and now classroom management. In summary, the teacher-centered group did not see any significant problems with their classroom management.

Student-centered group.

The student-centered group similarly expressed having no difficulties with classroom management and the enforcement of classroom rules. In the student-centered group, Vanca and Vinca did not discuss their classroom management styles but connected classroom management to their instructional activities. These were discussed in the instructional self-efficacy section. Sonya felt she little difficulty with her classroom management: "Definitely (laughing) definitely I have very high classroom management with getting them into a routine" (Sonya, interview, November, 2016). She described the need for her routines for the activities she does in the classroom and lab: "I'm kind of strict with certain rules, especially labs, but they get pretty good after the third week of observing those rules and they learn what to do and the routines" (Sonya, Interview, November, 2016). Sonya described the need for routines to make the activities run more smoothly. In summary, the student-centered group also believe that they do not have any problems with classroom management.

Research Question Six

Research question six, *What factors contribute to a STEM faculty's instructional style selection?* was answered by utilizing grounded theory to determine emerging themes. An open and axial coding process was used to analyze the interview responses of the participants. The statements included in the study were from participants who responded to the survey and volunteered to be interviewed individually. The qualitative analysis identified three major themes: (a) defining STEM education, (b) preservice, and (c) professional development.

Defining STEM Education

STEM education is a term frequently used in educational literature. This study examined how the different instructional style groups defined STEM and how they described how STEM education courses should be taught. This section will examine the teacher-centered and student-centered participant groups responses separately.

Teacher-centered group.

In the teacher-centered group, STEM was defined as content areas of science, technology, engineering, and mathematics. Captain Planet defined STEM as, "The traditional science technology engineering and mathematics...minus nursing and the arts in STEAM" (Captain Planet, interview, November, 4, 2016). Geo similarly expressed, "the technical definition is the science, technology, engineering, and math" (Geo, interview, November, 2, 2016). Wheeler included the health sciences as he described STEM: "STEM courses that have to do have to do with science and has to do with health as well" (Wheeler, interview, April 25, 2019). Interesting to note is Wheeler made the point to emphasize that health is considered part of STEM that was unique from the other participants. Wheeler explained his reasoning for including health sciences in his STEM definition: "STEM everything has to do with the health science that is gearing to teach our students" (Wheeler, interview, April 25, 2019). Wheeler detailed that STEM teaching is a, "focus on competency through graduation and clinical rotation" (Wheeler, interview, April 25, 2019). Geo differed from the group in describing STEM education as focusing more on critical thinking:

> I really think a deeper understanding of the subject requires the concepts of critical thinking skills and analytical skills. So especially dealing with science technology and engineering we're talking about using the scientific method to observe patterns in nature, come up with a hypothesis for those patterns and then try to understand them more deeply. Then, of course, math and coding. You're solving solutions and really using those critical thinking and analytical skills. (Geo, interview, November, 2, 2016)

The teacher-centered group clearly described that STEM is a set of categories that fits certain degree paths and that there may be a focus of critical thinking for students.

Student-centered group.

In the student-centered group, STEM was defined as an integrated approach that combined the subject matters with a style of education. Sonya defined STEM as, "education that is just centered on math and science... engineering and technology...though science may have more of the focus" (Sonya, interview, November, 11, 2016). Vinca integrated the method of teaching STEM into her definition: "science education related to science, technology, engineering, and math ... and the focus is there more experimental based" (Vinca, interview, November, 11, 2016). Varna had a unique explanation and specifically included statements against STEM being individual subjects but rather an intentional combination: "STEM Education, I would define it as a cross-curricular way of learning that encompasses elements of science, technology, engineering, and mathematics, but that also includes a problem-solving approach. It is not about learning about these topics in isolation" (Varna, interview, May 10, 2019). All the student-centered responses indicated a focus on the integration of the subject areas combined with an instructional lens.

Pre-Service

In this study, pre-service refers to formal training or education that prepares an educator to enter the profession and become a faculty member or being placed in front of students. Unlike K-12 education, there is no formal requirement at the local or national level that requires certification or training in higher education, only degree requirements and/or matriculated hours of experience in coursework. STEM courses require a level of integration of multiple subject and are usually not a degree subject in itself. Participant responses about pre-service experience indicated that there were no differences between teacher-centered and student-centered participants regarding this topic. Similar themes arose from their responses including: (a) a negative view of learning about teaching, (b) the lack of pedagogical courses available in higher education, and (c) very little experience or notice before being put in a classroom. Both groups expressed that there is little to no training for STEM faculty, or faculty in general, before their first teaching assignment. Both groups are discussed together in this section.

No formal training other than a degree from an accredited institution is required to teach at the college/university level. Several participants described experiences where they felt that there was a negative view from the institutional level at learning about teaching. Geo described how little preparation she had before going into her own classroom as well as a sense that learning about teaching was not promoted at her institution:

> I have had no formal training in how to teach. But during grad school, I would always sneak away to the teaching portion of conferences if I could because you

> know presentations on geochemistry is not the teaching section but when I could I would sneak away to that session to learn some stuff. (Geo, interview, November, 2, 2016)

Captain Planet shared similar feelings and reasoned that this sense of the forbidden came from STEM faculty at four-year universities:

> Heavens no, heavens no, they actually look down on the education process. They look down on education degrees. The fact is that I told you I almost have a master's in education. I'm two or three classes away from it and I was actually told at one point in time to not get an education degree and not have it on my credentials because it would not help me get a college or university position. In the four years, what I have observed the instructional methodology, how we educate the students is just now becoming the topic of concern and that is only among some faculty. There at the four-year university, if they're at the research institution, they're there to do research and it's in their field, not in education. (Captain Planet, interview, November, 4, 2016)

Geo and Captain Planet echoed similar ideas, that learning about how to teach more effectively was frowned up and not encouraged, it was assumed that you knew enough about how to teach from holding your degree in your field.

Many of the STEM faculty expressed that there were no courses on specific pedagogy available and that their experiences on pedagogy relied on the mentors that were assigned. Wheeler described his relationship with his mentor as giving him an "opportunity to grow in this field" though he had no specifics on how the mentor helped him accomplish that (Wheeler, interview, April 25, 2019). Sonya was more specific about her mentor, and explained methods the mentor suggested and participated in:

> I actually was lucky enough to observe my mentors, and I was able to go into their classes to observe how they did it. I got to see 3 or 4 different ones, so I saw different styles, and I decided on combinations of those styles that I thought would work for me. I've tried different things, it took probably 3 years or so once I became full time for me to try activities, which a lot of them didn't do. I just wanted to engage students a bit more and then taking professional development and finding out about new activities and new ways of doing things, it's still a work in progress and it's still changing. (Sonya, interview, November, 11, 2016)

All participants in both groups described a mentor that used a teacher-centered instructional style (i.e., lectures) to a great extent. Sonya only had exposure to mentors with a lecture-based style saying she, "witnessed for the first few years it was little more [than a] standard lecture" and she had to actively look for other mentors with other teaching styles to observe (Sonya, interview, November, 11, 2016).

The lack of pedagogy preparation available continued prior to participants being placed in a classroom. Little to no training was provided before instructors were placed in a classroom. The participants described this as a "trial by fire" in their first teaching assignments (Varna, interview, May 10, 2019). Geo detailed the frustrations and anxiety that resulted from having so little preparation prior to going into the classroom:

> My first semester as a grad student at the university the day before the semester started, they said you're teaching lab. I was like, uhhhhh. So it was, and I very much felt alone and scared and responsible for things that I shouldn't have been responsible for. Then the first time that I taught lecture at the university as a grad student it was, like, three days before class started. You're teaching this and so you know the lectures that I taught were straight from the publisher. There was

> very little you know bells and whistles, active learning techniques or things that were integrated into the classroom. When I came to my current community college, I spent the summer before making these lectures, I just went through the book, and I followed the book. I think the students liked that because my best students would have the book open and would be flipping pages. I'll be talking about the things I had seen in my travels, showing them my pictures that I've taken, and talking about the concepts. They'll be sort of cross-referencing with the book and pulling vocabulary words out or you know doing whatever they're doing. (Geo, interview, November, 2, 2016)

Varna described how the lack of preparation resulted in her relying on the, "classroom experiences as a child and my experiences in the education system influenced my instructional strategies" (Varna, interview, May 10, 2019). She had positive experiences that sparked a desire "to create courses that engaged me the way my old instructors did while I was a student" (Varna, interview, May 10, 2019). Geo also described how her own experiences in school influenced her instructional choices: "the frustrations that I faced when I was in school were the feeling that I was talking about things that didn't directly relate to my life" (Geo, interview, November, 2, 2016). Both participants expressed using their own personal experiences to connect with how they should teach their own college courses even without any pedagogical support.

Professional Development

Acknowledging that both groups determined that there was very little preparation for academic teaching in their university programs prior to entering the classroom, there were differences in the professional development that was available through their community colleges and the groups approach to overcoming the lack of professional learning. Each group will be explored separately in this section.

Teacher-centered group.

The reliance on the experienced gained from the content degree programs continued to be relevant concerning professional development. The teacher-centered group was clustered into concerns that centered around: (a) the lack of professional development specific to STEM, (b) available professional development focusing on human resource related topics, (c) the lack of relevance to their teaching practices. Multiple participants reiterated the idea that there was a lack of professional learning specific to STEM courses. Captain Planet described the lack of professional development specifically designed for STEM courses:

> No. No. There's none. I have found like I have offered some of the professional development and because I’m stem faculty, I will use what I learn to STEM and then try to apply it or help others apply in their class that is not STEM. But unless you are STEM faculty teaching there’s not a STEM emphasis. (Captain Planet, interview, November, 4, 2016)

Geo and Wheeler acknowledged this lack of professional development through similar statements, but Wheeler focused more on how he was trying to apply current professional development to fit with his STEM courses:

> Specific training... I don't have ... I have basic training and I tried to attend all kind of student center training that current employer provides, and at the same time, I do my due diligence and I tried to do my research trying to see if there any webinars or any new activities out there I can benefit from them. (Wheeler, interview, April 25, 2019)

All participants confirmed that their institutions did offer some form of professional development even if it was not related to the STEM courses.

While acknowledging that some professional development was available at their institutions, some participants described how it was based on human resource topics or degree mapping rather than relevant issues to STEM education. Captain Planet described the prescribed focus of her professional development being on diversity in the classroom and the use of strategic planning in most current professional development that is being provided with little attention to different instructional practices:

> Right now, the emphasis seems to be on diversity training. We're doing some mapping. We're looking at going more to a guided approach by getting their degrees. So, we're mapping degrees for them, so I guess I've gone to some training or meetings on that. Many times in the past, it's been a lot like here is professional development on collaborative learning, here's professional development on problem-based learning. So, we may have individual skill sets or you know instructional methods being presented or more like diversity. (Captain Planet, interview, November, 4, 2016)

Geo mentioned generalized professional learning opportunities through a learning management system, Cornerstone, which has been used for online professional development to cover basic human resource or campus-based topics: "there might be some stuff in Cornerstone" (Geo, interview, November, 2, 2016).

The lack of relevance from institutional level professional development was one component of what emerged from responses, but also the faculty level initiated professional learning lacked a clear instructional focus that was viewed as irrelevant. Geo described her experiences with a faculty-interest group professional development that she had volunteered to go to the previously:

> In the second semester, you break out into the faculty-interest or focused-interest groups or FIGs and I signed up for one, group-based or team-based learning, and I

> thought this was going to be great, because what do we do in science classrooms? We do group-based learning. So I was really disappointed by the delivery of the content, as I think everyone was in that FIG, so if the professional development was well thought out and worth my time then absolutely I would be all over that. If it sort of half-assed I guess, for lack of a better word, I don't have time for that so it needs to be a very quality product for me to be interested in voluntarily doing that because honestly, I have so much to do I don't have much free time. (Geo, interview, November, 2, 2016)

Geo expressed a real sense of disappointment in quality and applicability of this type of professional development offered, she appeared to expect that a group of faculty members would talk about instruction instead of content only. She described her disappointment through an experience when the FIG was covering the topic of team-based learning techniques:

> I can tell you the problem with the fig from last year but essentially, it's delivery of today's content it's being, in a FIG you have to be aware of the members and take their specific iterations to heart because there is only six of us so the content could be tailored... So, we learned team-based learning techniques through the knowledge transmission method (traditional lecture). Which doesn't make much sense and the materials were out of date. It was photocopies of photocopies from 1991. My god and we all felt that was not a lot of time or effort put into the material. We all were just watching the clock waiting for the clock to strike 4:30 so we could all leave. But of course, the FIG is required. (Geo, interview, November, 2, 2016)

Geo’s frustration seemed to be focused on the expectation that the student-centered instructional strategies should be modeled in the professional development to increase their applicability.

Captain Planet agreed that the professional development opportunities needed to be more relevant to teaching strategies, but expressed more independence in her own ability to adapt from her learning style in way that was more flexible from modeling the way she wants teaches her classes:

> Why I say the way I was taught influences the way I teach, at the same time I can tell you I don’t teach the way I was taught. I was taught in a very traditional lecture that didn’t go to lab things were presented to me, very few questions in a lecture. I am very well adapted to that so I’m ok if people present professional development to me in that format. It’s comfortable to me however I actually preferred professional development done that way, however, we have a broad spectrum of faculty and many of our younger faculty have not had as traditional of a message as me. So, for that reason yah, I think there should be at least a portion of the professional where you practice what you are preaching or teaching to the audience, and then that covers all generations the multigenerational aspect of learning. (Captain Planet, interview, November, 4, 2016)

While Captain Planet felt that she was more flexible in her learning experience, she understood that modeling those instructional strategies were best practice in professional development sessions to show how they can be applied in the classroom.

The lack of formal relevant professional development created situations where faculty had to rely on themselves, or from learning from other faculty members. Captain Planet suggested this in describing how her instructional style was just as influenced by colleagues and being self-taught as a mode of professional development:

> They are influenced by what their colleagues do, if they are discussing it with their colleagues they are influenced if they've taken any instructional classes or professional development they are influenced. Almost to the point that I would say I was self-taught even though people influenced me, I had to figure out what worked with my classes and what worked with me... I have read, I actually have almost a master's in education, and I have been teaching even at the college level since I was 18. So, I learned primarily from colleagues but the biggest way I learned was I try something in my class and then I would look at the outcomes, did my students get it? If they didn't, what kept them from doing it, what do I need to change? (Captain Planet, interview, November, 4, 2016)

For both Geo and Captain Planet, the professional development offered at their institutions were not effective at promoting student-centered practices and required them to seek additional learning.

Wheeler described a different situation with a relevant professional development system for STEM being in place to support faculty. He described many professional development options and the ongoing support that were available from his institution:

> Yes. So, we have a very good support system where I work. We have a department within our instructional services. They are focused and they are there only to help the faculty improve their teaching style or help them with any new ideas or any training they are asking for. So, and we do have offices throughout the district as well in case you need help right away. We have technology that would help you with that. (Wheeler, interview, April 25, 2019)

Wheeler described how the national level certification requirements for the health field contributed to the sense of relevance around his professional development. The ongoing professional development that was available to him and he was encouraged to engage in the learning and transfer the experiences to his classroom:

> We have ongoing professional development. That is part of National certification all of the medical licensing exam... We can either go and general teachings, for example, is classroom management or curriculum competencies, course syllabus alignment such as canvases or we are at the standards that we are supposed to be. At the same time if I need to focus only on our field I can. What the new trends or what's going on in the medical field. Also, I have the ability to do so... [This professional development included] webinars, conferences, professional networks, and networking with your peers. Always, always, be on the lookout for any new trends there are in the education. One of the new things right now is, I'm doing this every morning, I tried to read Inside Higher Ed. I subscribe to it, I get notification emails, and I try to read it as much as I can. Peer review articles just to see what is going on in academia? (Wheeler, interview, April 25, 2019)

Out of the three interviewees, Wheeler described the most support by his institution in terms of promoting professional development.

Student-centered group.

The student-centered group discussed professional development with frustrations similar to the teacher-centered group emerging. The student-centered faculty focused on (a) the lack of any professional development, (b) the lack of relevancy of the content, (c) the lack of STEM education specific professional development, and (d) the lack of connections with instructional strategies to STEM education which all made it difficult for the student-centered group to have positive descriptions of their institutions professional development programming.

Similar to the teacher-centered group, the student-centered faculty described how little professional development was available but focused more on how the lack of relevant professional development affected their instruction. Varna described her experiences with professional development to be overall lacking and general in nature and pushing her to look toward learning that was K-12 centered to grown professionally:

> Mostly from personal experience, in teacher prep courses they did cover elements of classroom management. As a science teacher, I was always more heavily influenced by lab-based courses. I think authors like Harry Wong, Page Keeley, and Robert Jones also influenced me... There is professional learning that takes place every year, but it is general in nature and is usually up to me to go out and find learning based on what I was currently teaching and wanting to learn about. (Varna, interview, May 10, 2019)

Varna continued to connect the lack of relevancy in how the learning could be applied to her individual classroom. She described some of professional development she received and the support afterward as, "too theoretical, there were big ideas that were great conceptually but not a clear-cut way to implement in the classroom" (Varna, interview, May 10, 2019). Vinca and Sonya supported the idea that professional development was lacking in terms of both availability and relevance. Vinca (2016) stated that her institution was "short on professional development for STEM faculty" and Sonya (2016) describes the absence of professional development as a recent development: "No I think there is less being offered than there used to be at one point. There used to be a choice of several different sessions and things to do and now there aren't that many".

When discussing STEM-based professional development specifically, all the student-centered participants acknowledged there was none. Vinca described how her experiences with STEM professional development were different and more relevant at other institutions:

> Honestly, at my institution, I didn't have any professional STEM thing happen except this journal club we do, but at another institution, I worked at, they have this adjunct certification program that was a 6-week program that I went into. I learned a lot there. I learned about students, their learning, teachers. (Vinca, interview, November, 11, 2016)

Sonya echoed this sentiment and expressed frustration at the lack of connections she was able to make to her specific content:

> They may honestly and I try to keep up with all the PD, but I haven't seen anything specifically for STEM. Ok, so just general education stuff on classroom management. And they've even done away with the professional development that I think gives us tools in the classroom now their broader like book clubs and things like that, so I think we definitely need to look more at maybe department professional development. (Sonya, interview, November, 11, 2016)

Not being able to engage in relevant learning within their departments was a source of frustration expressed by the participants.

Participants described outside sources professional development since there wasn't much available for them. Vinca explained how she personally pursues learning related to STEM despite the low availability at her institution: "So I have gone to two or three conferences and then whoever comes there they could be two-years or four-years, the years according to me will be the colleagues who teach like me" (Vinca, interview, November, 11, 2016). Sonya described seeking professional development through making observations of other faculty members:

> I have tried everything from teaching square, where they put us into groups of four, we go sit in on everyone else's class and observe at least one, and then we provided constructive feedback that was meant to help and we also took from those things that we liked. What we saw that was an advantage that was one of the better ones early on... Yes that here about seven years ago, I got to see a chemistry class, and English class. I got to see a speech class and it was nice, it wasn't all STEM so it was good to see the variety, what worked in their classes, what they did to encourage students. I've done learning by Kahoot, that was probably one of my favorites. I've gone to professional development sessions where we learned about tickets in the door. (Sonya, interview, November, 11, 2016)

The student-centered participants continued to express frustrations about the overall lack of availability of professional learning for STEM courses.

Summary of Findings

Surveys were sent to the STEM instructors of a community college. Nine instructors responded with six who were chosen for interviews. The population was skewed both female and Caucasian. The participants were evenly divided between master's and doctoral level faculty with most being science instructors. The quantitative analysis resulted in significant difference between instructional style groups for overall teacher self-efficacy, student engagement, instructional self-efficacy, and no significant differences between the two groups in classroom management.

The qualitative analysis illustrated that there were similarities and differences in the participant responses to interview questions. Four themes were identified for RQ 5 in participant responses: teacher self-efficacy, student engagement, instructional strategies, and classroom management. From these themes' participant responses were coded and categorized further into subcategories under each theme. Qualitative responses further supported quantitative results that indicated that there were some significant differences in instructional strategies between the teacher and student-centered groups. Key differences between teacher and student-centered groups could be found in the perception of traditional lecture, activity-based instruction, the hardest part of instruction, how classroom management is taught, professional development available, and criteria of quality professional development. Some misconceptions in the teacher-centered groups surrounding STEM and student-centered were identified based on participant responses but gave insight into how these could be addressed at the institutional level.

Conclusion

Chapter 4 discussed the results of demographics, quantitative questions one, two, and three, qualitative themes classroom climate, instructional style, and previous experience. This study contributes to the field of educational research by addressing what differences do teacher and student-centered STEM instructors have. This study serves to contribute to a new area of educational research and to provide foundational work to build future studies. The quantitative analysis resulted in multiple significant differences between instructional style groups. The qualitative analysis illustrated that there were similarities and differences in the participant responses related to theme derived from the literature review. Chapter five will summarize the results of the study, relate implications of those findings to the field of education, and suggest recommendations for future research.

CHAPTER V:

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

The purpose of this study is to examine the relationship between teacher self-efficacy and the instructional style of community college STEM faculty. This study was completed during the spring of 2019 when 39 STEM faculty from two community colleges in southeast Texas were solicited to participate. Six STEM faculty were interviewed about their views of their development of teacher-centered or student-centered instructional styles. STEM faculty were solicited to complete the survey instruments and participate in interviews. Two-tailed independent t-test, open, and axial coding were used to analyze the data collected. This chapter includes a summary of the findings, implications, and recommendations of the findings.

Summary

The research questions address whether there was a statistically significant mean difference between STEM faculty in the teacher-center vs. the student-centered instructional style groups. Research Question One asked if there was a statistically significant difference between teacher self-efficacy and instructional style. Quantitative analysis using a two-tailed independent t-test demonstrated that there was a significant difference between the instructional styles and teacher self-efficacy of STEM faculty indicating that student-centered faculty have lower teacher self-efficacy than their teacher-centered counterparts. These results are different from the results of other research, demonstrating that the way STEM faculty approach teaching is through their beliefs, skills, and knowledge of either research or teaching. These heavily influence their pedagogical choices and that those with higher teacher self-efficacy would choose a student-centered instructional style (Albrecht & Fortney, 2010; Ebert-May et al., 2015; Eick & Reed, 2002; Hirschy et al., 2015). High teacher self-efficacy is seen to have traits associated with a student-centered instructional style such as being able to plan, organize, motivate students, give better feedback, identify how lessons are integrated, and choose more challenging pedagogical techniques that look for higher levels of critical thinking (Chesney, 2017; Gormally, et al., 2014; Morris & Usher, 2011). This is not what was found in this study. Student-centered STEM faculty have significantly lower teacher self-efficacy than teacher-centered STEM faculty. Student-centered STEM faculty have become comfortable with being uncomfortable in their classrooms. A possible explanation can be seen in how university STEM faculty treat community college STEM faculty. Community college STEM faculty are viewed as lesser than their university counterparts due to the reduced value for teaching and increased value for research by universities and mission statements at community colleges that focus heavily on teaching students (Morest, 2015; Twombly & Townsend, 2008). This was expressed by many of the interviewed faculty with the community college faculty describing interactions with four-year faculty being described as them being arrogant and looking down on community colleges and that they show little respect for the students or faculty at community colleges. Differences between community college and university faculty that are passed off as a deficiency in community college faculty reduce teacher self-efficacy further as they are treated as less capable (Morest, 2015; Twombly & Townsend, 2008). Student-centered community college STEM faculty are so different in their instructional style than their teacher-centered university STEM faculty, they are treated even more inadequate than their teacher-centered counterparts leading to a lower teacher self-efficacy.

The overall teacher self-efficacy score was broken down into three subcategories, which were analyzed in research questions two, three, and four. Research Question Two asked if there was a statistically significant mean difference between teacher self-efficacy in student engagement and instructional style. Quantitative analysis using a two-tailed independent t-test demonstrated that there was a significant difference between the instructional styles and teacher self-efficacy in student engagement of STEM faculty. These results are different from other research results that demonstrating a move to student-centered pedagogies because of increases in student engagement that were established as a critical predictor for college completion, transfer, and explicitly for the diverse students in STEM programs (Alicea et al., 2016; Anderson et al., 2011; Barthelemy et al., 2015). One would expect that the purveyors of the student-centered style would have higher teacher self-efficacy in student engagement. In this study, it was found to be the opposite. A possible explanation for this is explained in research question five under student engagement.

Research Question Three asked if there was a statistically significant mean difference between teacher self-efficacy in instructional self-efficacy and instructional style. This was the second subcategory of overall teacher self-efficacy in research question one. Quantitative analysis using a two-tailed independent t-test demonstrated that there was a significant difference between the instructional styles and teacher self-efficacy in the instructional self-efficacy of STEM faculty. Teacher-centered STEM faculty have higher instructional self-efficacy than student-centered. These results are like other research results demonstrating that the dominant teaching paradigm for higher education is a teacher-centered instructional style (Barr & Tagg, 1995; Bernstein-Sierra & Kezar, 2017; Divoll, 2010; Fishback et al., 2015; McConnell et al., 2017). Some faculty see their role in higher education to either explicitly or implicitly find individuals like themselves that are born to be scientists, therefore the top tier of all students, and to eliminate the rest (Gasiewski et al., 2012). This leads to the explanation of why attrition rates are that overall 45% for both four-year universities and two-year community colleges for STEM degree programs for incoming freshmen with two-year community colleges contributing an attrition rate of their own of 86% at the end of two years (Riccitelli, 2015). Both professional and institutional epistemologies currently are congruent with learning pedagogies and principles that focus on the instructor delivering instruction and transmitting content (Howard, & Taber, 2010). This ideology supports that many teacher-centered STEM faculty would have higher instructional self-efficacy because the institutional expectation is that faculty are using teacher-centered instructional styles. This leaves student-centered faculty with less self-efficacy because their teaching style is not supported in the evaluation systems.

Research Question Four asked if there was a statistically significant mean difference between teacher self-efficacy in classroom management and instructional style. Quantitative analysis using a two-tailed independent t-test demonstrated that there was not a significant difference between the instructional styles and teacher self-efficacy in classroom management of STEM faculty. Both groups believe that they have high teacher self-efficacy in their classrooms.

Research Question Five explored what factors contribute to higher and lower teacher self-efficacy in STEM faculty. A total of six participants were interviewed and responded to semi-structured questions about different aspects of instructional style. The qualitative analysis demonstrated that participant responses could be classified into four major themes: (a) teacher self-efficacy, (b) student engagement, (c) instructional strategies, and (d) classroom management. Each theme was further broken into subcategories based on individual responses. Participant responses supported quantitative data describing differences in overall teacher self-efficacy and the subcategories student engagement and instructional self-efficacy between STEM faculty in the two instructional style groups. Some key distinctions between the two groups could be expressed through the STEM faculty's perceptions of student capabilities, institution support, time and resources, definitions of student engagement, definitions of student-centered instruction, and instructional goals.

In the word cluster analysis, beliefs become evident for each group in the connectedness from word association with teaching. Both groups were seen to have the same connections with teaching as what is seen with the research with teacher-centered STEM faculty connect teaching to lecturing (Ayar & Yalvac, 2016; Bonet & Walters, 2016; Coil, Wenderoth, Cunningham, & Dirks, 2010) while student-centered connect teaching to action or activity (Anderson et al., 2011; Bonet & Walters, 2016; Coil et al., 2010; Cooper et al., 2015). Teacher-centered STEM faculty also see their role as a central to connecting, conveying knowledge to students, and having them attain mastery of the material. Teacher-centered STEM faculty look to grades and mastery while student-centered want holistic approaches to learning. This reveals a reductivist approach to learning for teaching-centered interviewees where knowledge is obtained in isolation from activities and the college professor becomes the transmitter of knowledge or the "sage on the stage" (Divoll, 2010; Unruh, Peters, & Willis, 2016). Student-centered interviewees perceived the opposite in that learning is a holistic approach where there is a quality activity, knowledge is more than just content, and the classroom is considered a community where emotion is considered in the learning process. They did think that it is imperative for instructors to be responsible for creating an environment or positive reinforcement that supports student motivation (Lumpkin et al., 2015; Peters, 2013).

A question arose as to why overall teacher self-efficacy scores did not replicate previous results of student-centered STEM faculty having higher self-efficacy than the teacher-centered STEM faculty. When exploring this topic with the teacher-centered group the reasoning they gave for this belief was a generally positive outlook to working at a community college due to the focus on diversity in student populations, the focus on student success, and interactions with students. This was overshadowed, in the interviews, by many negative perceptions of their career when interviewees reported they could have done better for the students because of the lack of time for course preparation and general self-doubt in their capabilities. Ultimately, the teacher-centered instructional style leaves faculty unable to provide instructional feedback or use evidence-based teaching methods and leaves a performance gap between what they are doing and what they should be doing (Ebert May et al., 2011; Gormally et al., 2014).

The student-centered group mirrored many of these statements but overall were much more positive in their statements saying that the environment as more personal with the students because the difference in the number of students in the classroom allows the instructor to be more social (Alicea et al., 2016). This group described much the same seen in the research, a shift from the student focus on the acquisition of content knowledge and basic skills to an active learning curriculum that focuses on problem-solving experiences (Divoll, 2010; Feldman et al., 2009; Lumpkin, Achen, & Dodd, 2015; McConnell et al., 2017). A distinction that the student-centered group added was that they worried about their ability to reach students and help them think critically (AAAS, 2011; Brownell & Tanner, 2012; Dubinsky, Roehrig, & Varma, 2013; Fishback et al., 2015; Henderson et al., 2010; Henderson, Beach, & Finkelstein, 2011). It was recognized that student-centered STEM faculty have more introspection of their capabilities in reaching students and getting them to critically think about the subject. Once students are engaged, the student-centered instructors can then drive high expectations and hard work from students (Barthelemy et al., 2015).

This led to the greatest distinction between the two groups. Student-centered STEM faculty focused on descriptions on educating the whole student through social, emotional, and intellectual needs (Alicea et al., 2016; Can & Kaymakci, 2015; Corkin et al., 2014; Fraser, 1989; Peters, 2009, 2013). Their goal was the development of critical thinking and the ability for students to graduate with the skills needed to take control of their learning. They did this by leading students to be proficient at self-re-evaluation, integrating relevant personal histories, developing models, construct explanations, engaging in arguments using evidence, and developing science process skills (Anderson et al., 2011; Bonet & Walters, 2016; Coil et al., 2010; Cooper et al., 2015). Teacher-centered STEM faculty described a more task-oriented mindset that is focused on transferring content knowledge to the students and testing those students on their ability to memorize the content (Gasiewski et al., 2012; Scott, McNair, Lucas, & Land, 2017). Teacher-centered faculty did see it as their function to either explicitly or implicitly find individuals like themselves that are born to be scientists, and therefore of the top tier of all students, and to eliminate the rest (Gasiewski et al., 2012). This focus leads to teacher-centered STEM faculty to a punitive mindset of eliminating those students that are not able to make the grade in the course (Gasiewski et al., 2012). Hence, the idea that this mindset creates a gatekeeping course that prevents students from pursuing STEM careers.

Support from the teacher-centered faculty is lacking for their students and the expectation is that they find support outside of the course (Alicea et al., 2016; Gasiewski et al., 2012). The students are either expected to find their own assistance and if they do not, they fail the course. This gives the impressions that as long as the teacher-centered faculty lecture, ask questions, and assign work to be graded they have done their job and the success of the students matters little. This continues a pattern where, “The culture of science says, not everybody is good enough to cut it, and we’re going to make it hard for them, and the cream will rise to the top” (Riccitelli, 2015, p. 56). The numbers of students leaving STEM degrees are increasing with individuals believing that are not good enough to stay in a STEM degree (Hoffman, Starobin, Laanan & Rivera, 2010).

Some faculty believe that students should take more responsibility to teach themselves and that that they shouldn't have to entertain their students using vast amounts of valuable teaching time when there is so much content in a course that they need to get through (Fishback et al., 2015). This leads to a question if research finds that student-centered approaches are associated with critical thinking and enhanced STEM learning superior to teacher-centered approaches (AAAS, 2011; Anderson et al., 2011; Bonet & Walters, 2016; Brownell & Tanner, 2012; Ebert-May et al., 2011; Ebert-May et al., 2015; Gormally, Evans, & Brickman, 2014; Henderson et al., 2010; Mulnix & Vandegrift, 2014; NSTC, 2013). Are the teacher-centered instructional styles setting up women, academically underprepared, first-generation, nontraditional learners, and underrepresented minority groups for failure (Baiduc et al., 2015; Barthelemy, Hedberg, Greenberg, & McKay, 2015; Coil et al., 2010; Fauria, & Fuller, 2015)?

STEM instructors demonstrated a second key difference between the two groups when discussing the theme of student engagement. The two instructional groups described student engagement though different lenses. In this study, we defined student engagement as the time and energy students invest in educationally purposeful activities and the effort institutions devote to using effective educational practices became an important distinction between the two groups (Alicea et al., 2016). Both groups showed a lower than average teacher self-efficacy in the student engagement categories reported on the TSES (teacher-centered 6.45, student-centered 5.23) when compared to Conti's adult educators (7.2) (Conti, 1983). Exploring this topic was found to be more complicated because higher education institutions considers student engagement from perspectives of both inside and outside the classroom (Alicea et al., 2016; Anderson et al., 2011; Barthelemy et al., 2015). Higher education surveys also describe student engagement as synonymous with other vocabulary words such as engagement, integration, involvement, and social belonging (Alicea et al., 2016). It became apparent through interviews that the teacher-centered group was using the term student engagment but defining it as synonymous with communication. The teacher-centered group stated that student engagement was tied to how often they communicated with the students, either with in-class questions during lecture, sending emails, or phone calls to discuss issues with grades.

While the student-centered group saw student engagement as students invested in educationally purposeful activities which lead to descriptions of their instructional styles used in the classroom (Alicea et al., 2016). Higher education research into student engagement mirrors K-12, though while K-12 uses classroom observation methodologies, higher education focuses on using instructor and student surveys and interviews (Alicea et al., 2016). The differences in the methodology may provide one explanation to why studies lead to different conclusions in the literature than what K-12 has found.

Of note, was that Captain Planet, a teacher-centered STEM instructor, reported a significant background in education and she used the communication definition. Why she was using a definition not supported by education was not able to be answered. When considering these two differing definitions, the teacher-centered group would seem to have an easier time meeting the requirements of their definition of communication. Simply by generating an email or asking a question during class to a student was enough to qualify as high levels of student engagment for the teacher-centered group. There is a disconnect in how the two groups approach student engagement and may lead to an explanation of why there is a difference in student engagement subcategory scores on the TSES.

Considering that student engagement is established in research question two as a critical predictor for college completion or transfer for diverse STEM students, it is interesting that the teacher-centered instructional group is using a different definition of student engagement than the established definition from literature (Alicea et al., 2016; Anderson et al., 2011; Barthelemy et al., 2015). Many university classrooms use a traditional teacher-centered instructional style and students do not cognitively process a question and participate in answering it, so learning does not take place (Gasiewski et al., 2012). Support services that are segregated from classroom experiences have a deep positive impact on students at residential universities and can be used to predict persistence (Alicea et al., 2016; Bonet & Walters, 2016). While support services are provided at community colleges, students are non-residential or transient who go part-time and spend little time on campus (Alicea et al., 2016; Bonet & Walters, 2016). This makes it difficult for this type of student to utilize these support services as often. Community college students do not see as great of a benefit support services and do not socially integrate into the community college culture like students enrolled in a university do (Alicea et al., 2016; Bonet & Walters, 2016). This leads to community colleges with high numbers of teacher-centered faculty to be unsuccessful in raising student achievement due to the implementation of instructional styles that need support services that transient student populations cannot utilize (Alicea et al., 2016; Bonet & Walters, 2016). It is not surprising that the community college retention rate of 54% lags behind the university retention rate of 73% of students from the first to second year (Riccitelli, 2015).

When asked about student engagement, the student-centered group described their instructional style, and how it affected student learning and achievement. They also reported using instructional models developed in K-12 and adapting them to their courses such as the 5E instructional model. This constructivist learning model consists of five stages (Engage, Explore, Explain, Elaborate, and Evaluate) that was design by Rodger Bybee and integrated into in Project-based learning (PjBL), Problem-based learning (PBL), and Universal Design for Learning (UDL) (Bybee, 2013).

Many community colleges have in theory but not practice changed their mission statements from a mission of high-quality instruction to high-quality learning (Barr & Tagg, 1995). When the focus is on learning, the method (student learning) and product (student achievement) are separated allowing for adjustments in instructional style to what works best at improving graduation rates (Barr & Tagg, 1995). This shift in mission has fallen behind recommendations in K-12 who have noted that inquiry-based instruction in STEM courses have empirical evidence that it is better for student achievement at all education levels (Barr & Tagg, 1995; Divoll, 2010; Hayward, 2016; Howard, & Taber, 2010; Lumpkin et al., 2015; Mesa et al., 2014; Peters, 2013; Smallhorn et al., 2015). Part of this trend may be that faculty do not have access to the best practices curriculum and must either use an in-house developed inquiry-based curriculum or borrow from K-12 developed curriculum. This is seen in the student-centered groups descriptions of using K-12 pedagogy like the 5E model, interactive notebooks, clickers, or flipped classrooms. This leaves many student-centered faculty developing curriculum alone and without support of what best practices look like for higher education (Chesney, 2017).

Another theme that revealed some key distinctions between the two groups was how they described instructional self-efficacy. For this theme, it was also found that the teacher-centered group had a higher teacher self-efficacy in instructional self-efficacy. Both groups believed that they teach their courses in some student-centered instructional style. They also understood that there is currently the call for undergraduate STEM reform through new course design focused on strengthening critical thinking skill development by changing from a teacher-centered instructional style to a more student-centered approach (AAAS, 2011; Brownell & Tanner, 2012; Dubinsky et al., 2013; Henderson et al., 2010; Henderson et al., 2011). The teacher-center group equated the inclusion of a lab with the lecture course in community college science courses to teaching in a student-center instructional style. Even though by definition this is still the traditional teacher-centered instructional style with its heavy inundation of content knowledge with activities focused on completing worksheets, homework, and conducting laboratory activities from a lab manual in the traditional “cookbook” fashion (Ayar & Yalvac, 2016; Bonet & Walters, 2016; Coil, Wenderoth, Cunningham, & Dirks, 2010). The teacher-centered group equated best practices for instruction as discussion or questioning, student preparation, and lecture as an integral part of instruction. Activities were discussed in the sense that most described activity as communication that is led by the instructor. When the teacher-centered group was asked about what they thought about moving to a student-centered instructional style the answers were mixed.

As seen in the chapter two section Student-Centered Learning, change to student-centered learning has been happening since 1995. Research into student-centered instructional style has shown positive student motivation (Lumpkin et al., 2015; Peters, 2013) and empirical evidence for higher student achievement at all education levels (Barr & Tagg, 1995; Divoll, 2010; Lumpkin et al., 2015; Hayward, 2016; Howard, & Taber, 2010; Mesa et al., 2014; Peters, 2013; Smallhorn et al., 2015). This is not how community college STEM faculty are teaching their courses. Undergraduate courses are focused on studying worksheets, completing homework, and conducting laboratory activities that are heavily inundated with content. The important is placed on instructional that covers the complete syllabus that faculty are provided by either a colleague or the institution (Ayar & Yalvac, 2016; Coil, Wenderoth, Cunningham, Dirks, & Grossel, 2010). This traditional lecture formatting predisposition is created early in the STEM faculty careers with many reporting being “thrown into the fire” with just a PowerPoint presentation that was given to them by another faculty member to rely on (Morris & Usher, 2011). This pattern continues due to science Ph.D.’s only including the science content and having an absence of any pedagogical training, leaving many STEM faculty without even basic awareness of pedagogical techniques (Gormally et al., 2014).

The most interesting response was from teacher-centered faculty Captain Planet. On the surface, she started out seeming very positive and receptive to the change. She described a background in education, having taken some masters level courses, but ultimately receiving a master’s and Ph.D. in a biological science. She expressed that she knew about the push in educational research for community colleges to shift to a student-centered instructional style to increase critical thinking from the students institutions (AAAS, 2011; Alicea et al., 2016; Baiduc et al., 2015; Brownell & Tanner, 2012; Dubinsky et al., 2013; Henderson et al., 2010; Henderson et al., 2011; NSTC, 2013; Whittaker & Montgomery, 2014). Captain Planet believes that the way she is teaching would be identified as a student-centered or inquiry-based instructional style. However, her practices, when described, focused on the content acquisition of knowledge (terminology/academic skills) and basic skills (technical skills) instead of an active learning that focuses on problem-solving experiences (Divoll, 2010; Feldman et al., 2009; Lumpkin, Achen, & Dodd, 2015; McConnell et al., 2017). She showed a knowledge of what pedagogical terms to use in her descriptions of the instructional styles but when asked to describe the activities to match her inquiry-based instruction and student engagement she did not use accepted educational definitions or descriptions. This was the same with the other teacher-centered members. This leads to the question are teacher-centered STEM faculty not aware of the definitions or have learned to use the terminology in context, so it appears that they are more student-centered on paper. Either way, this may explain why there is a discrepancy between descriptions of student engagement between student and faculty on the CCSSE (Fishback, 2015).

The student-centered group associated their instructional style correctly to being student-centered. In describing their best practices for instruction, it was mostly a consensus that scheduling, students needed preparation before class, the lecture is an integral part of instruction though it must be paired with activity. This reflected research that reaching the whole class is accomplished through providing students with a supportive environment through a collaborative space where students work towards a common goal with teacher lead guidance (AAAS, 2011; Anderson et al., 2011; Bonet & Walters, 2016; NSTC, 2013). Activities were discussed in the sense that most described activity as a variety of activities that are facilitated or guided by the instructor such as video, clickers, flipped classroom, Kahoot quiz, students' questions, worksheets, role-play, case studies, and interactive notebooks. Coupled with these activities was a discussion of how adaptations to instructional style must be based on formative assessment of the students and not end-of-course surveys (Kezar et al., 2015). These adaptations were not well planned and disconnected from the learning plans faculty had, which could be linked to the lack of pedagogical professional development to align curriculum components.

The final theme of classroom management shows few differences between the two groups. Both groups had higher than normal teacher self-efficacy in classroom management. Neither group believes that they have concerns with classroom management. This could be due to having adults in their classrooms. The students wish to be there and are paying for the privilege. Therefore, these faculty may not see the same issues that would be discussed in a K-12 environment.

Research Question Six explored what factors contribute to a STEM faculty's instructional style selection. The qualitative analysis demonstrated that participant responses could be classified into three themes: (a) defining STEM education, (b) pre-service, and (c) professional development. Each theme was further broken into subcategories based on received responses. Some distinctions between the two groups could be found in the discussion of the perception of defining STEM, preservice experiences, and professional development. The teacher-centered group used a siloed approach of defining STEM as just Science, Technology, Engineering, and Math, which does not fit with current research. It doesn't fit with the current definitions of what is and is not STEM education at many government entities such as NCES, ED, NSF, NSTA, BLS, U.S. Census Bureau, and the GAO. In the student-centered group, a more nuanced definition focuses on the integration of the subject areas in a student-centered instructional style was used. This fits with current research that STEM education in both K-12 and college environments and has become synonymous with a student-centered pedagogy (Bybee, 2013, Gasiewski et al., 2012). This includes collaborative active learning strategies that encourage students to increase critical thinking by writing, thinking, and talking about their learning on the road to mastering concepts to solve real-world problems (Bybee, 2013, Gasiewski et al., 2012). Adding technology and engineering style problem solving to a science and mathematics problem is another method to shift learning to a more student-centered style (Bybee, 2013; Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012). While National Science Education groups addressed critical thinking and collaboration through new standards and context-based pedagogy, college standards have been lagging in their student learning outcomes (AAAS, 2011, Bybee, 2013, NSTC, 2013).

In exploring the theme of pre-service experiences, there was mostly consensus between both groups of the lack of preparation in both pre and in-service. There is little to no formal training in pedagogy for many STEM faculty and that influences outside of the university academic setting are having influence because the university academic setting actively looks down on pedagogy (Morest, 2015; Twombly & Townsend, 2008). Many times, these faculty are thrown into the fire for their first teaching experience with a set of PowerPoints and told to present the material (Gasiewski et al., 2012; Morris & Usher, 2011; Scott et al., 2017). The interviewees gave some variation of the use of lecture is primarily used and encouraged from the administration. This is seen in the physical environment STEM faculty teach in. Typical teacher-centered classrooms (theater-style fixed seating facing a podium with either a board for writing or a projection screen) for showing that a PowerPoint lecture is the expectation set by the administration and not a collaborative space for group work where students can sit together (Alicea et al., 2016; Chiu & Cheng, 2016). Many faculty expressed that they just tried to recreate the traditional lecture-based course from PowerPoints provided due to new faculty being left little to no preparation time and the physical environment being more conducive to a lecture presentation (Gormally et al., 2014). This leads to a classroom climate that is unfriendly to student-centered instructional styles.

In exploring the theme of professional development, there was some similarity to research. Professional development with the teacher-centered group was not held in high esteem and that they would not go out of their way to attend it. It is a perfunctory task that is completed and then walked away from minimal (Howard, & Taber, 2010; Twombly & Townsend, 2008). Wheeler did have a better view of it and did discuss attending regularly. Though he did express that is was a part of the national certification for medical licensing. The student-centered group saw professional development as very necessary, though it was quite lacking at their institutions. All three had to look outside their institutions for professional development. This fits with the research that faculty development or professional development is rarely connected to college mission statements and are ad hoc, lack institutional support, rarely evaluated for intended change, and are voluntary and therefore participation is minimal (Howard & Taber, 2010; Twombly & Townsend, 2008).

Implications

Examining the results led to many more questions that need to be explored about instructor attitudes, beliefs, and their impacts on student achievement in community colleges and universities. Instructor self-efficacy is playing an important role in the choice of instructional style for STEM faculty at community colleges. With research demonstrating that STEM reform has been focused on changing instructional styles from teacher-centered to a student-centered instructional style for more than twenty years. This reform has failed to catch hold in a meaningful way.

The first implication was that evidence uncovered during this study showed that while teacher-centered instruction is predominantly used, it is a detriment to the colleges and universities using it (Barr & Tagg, 1995; Bernstein-Sierra & Kezar, 2017; Divoll, 2010; Fishback et al., 2015; McConnell et al., 2017). Attrition rates are only moving slightly with community colleges having a lower attrition rate than universities by more than twenty percentage points (Riccitelli, 2015). This is explained through teacher-centered faculty's viewpoints of using their course as a "gatekeeping" course and is further exacerbated in that learning is only happening for those few students that are being interacted with through questions during the traditional lecture format (Gasiewski et al., 2012; Hoffman et al., 2010; Howard, & Taber, 2010).

The second implication showed many of the teacher-centered STEM faculty expressed that the presence of the lab where they used a structured low/ no inquiry lab to get a specific answer was enough to qualify themselves as student-centered. Analyzing all this evidence leads to the conclusion that for most of the students, learning is not happening in the classroom/lab and the fix that universities are using to keep retention rates high is to supplement their faculty's lack of student engagement with support services (Gasiewski et al., 2012). Community college students cannot participate in these services so in utilizing the same research and solutions that the universities do results in failure. Interventions need to be focused on the one place many students spend the most time at community college STEM courses, the classroom, and the lab.

The third implication was this study shows that there is a significant mean difference in overall teacher self-efficacy, student engagement, and instructional self-efficacy between the teacher-centered and student-centered STEM faculty. However, the results are surprising is that teacher-centered STEM faculty are more confident than student-centered STEM faculty. Missing from the TSES survey are any questions to help answer why the type of answers were given. This creates an issue when using the survey as a diagnostic instrument on its own. In many cases, it was found through interviews that the teacher-centered group misconceptions for student engagement and student-centered instruction did not fit with current definitions. If student engagement has been established as a critical predictor for college completion and transfer and explicitly for STEM programs and the diverse students in those programs (Alicea et al., 2016; Anderson et al., 2011; Barthelemy et al., 2015), then this could explain discrepancies between faculty and student survey results on the Community College Survey of Student

Engagement (CCSSE). It could also explain why there is a reported increase of student engagement on the CCSSE and no resulting increase of retention rates for students. This leads to an issue with the reliability of any survey sent to teacher-centered STEM faculty. If an additional section for the TSES or CCSSE could be added with open-ended questions that ask the participant to define definitions, describing a typical day in the class/lab, descriptions of activities that are used on a regular basis in the classroom/lab, and what professional development they have taken would lead to better understanding of survey results.

The forth implication is understanding why STEM reform in the last twenty years has stalled is paramount to solving the student achievement gap in STEM. In exploring this study, it is apparent that the system of faculty development is broken for full-time faculty. The breaks in the system of development can be found at all stages of a STEM faculty's career. In a STEM faculty's academic career, the focus for all Ph.D. candidates is on developing scientific research skills, not on pedagogical development. However, many of these Ph.D. candidates find themselves in teaching positions like teaching assistants, adjunct faculty, or tenured faculty. All our interview participants describing a situation where they were thrown into trial by fire with little to no preparation. STEM faculty have had no formal training in how to teach and that they can feel alone and scared and responsible for things that they shouldn't have been responsible for. Recommendations to solve this problem are to either start having at least one course in educational pedagogy development in all Ph.D. programs. Alternatively, for community colleges, they could start having faculty with an Ed.D. on staff in each department and using them as a pedagogy expert to help the other faculty develop best practices curriculum preferably that is student-centered instruction.

A fifth implication is professional development after the STEM faculty are employed by the community college is broken. Knowing that STEM faculty are deficient in educational practices, many professional development programs at community colleges are rarely connected to college mission statements, are ad hoc, lack institutional support, rarely evaluated for intended change, and are voluntary (Howard, & Taber, 2010; Twombly & Townsend, 2008). Minimal participation in voluntary programs leads to little change in the current educational culture at many institutions. Many interviewees told of how they had some professional development when they first started. Teacher-centered STEM faculty expressed that they were too busy, did not have the time to participate, or did not see value in the material that was being presented.

Student-centered STEM faculty saw professional development provided by the institution as useless to them because many would either focus on the logistics or technical details and lack classroom applications. There was a little opportunity during the professional development to engage in questions or reflections on implementation. Professional development also was viewed as lacking the current best educational practices or relevant practices to STEM and was outdated based on participant experiences. Teacher-centered faculty this trend when the described the professional development in department or team-based learning.

The lack of availability resulted in the student-centered group searching for professional development outside their institution. Their departments attempted to start their own professional learning communities but found that the educational practices were not discussed. During the professional learning time, the faculty focused on current content acquisition in what they called a journal club and referred to it as professional development. Both faculty groups described the use of mentors as a form of professional development though it seemed the mentors were untrained due to a heavy reliance on peers observing the mentor teaching and expecting the mentees to replicate it.

Implications one through five leave the impression that the institution does not value student-centered instructional styles and that the administration may miss an opportunity to implement the standard that the college mission and vision statements refer to of improving student learning. One of the issues that administration would need to address is how they are inadvertently setting the standard to use teaching-centered instructional styles based on the classroom structures in new construction and remodeling projects. Teacher-centered classrooms (theater-style fixed seating facing a podium with either a board for writing or a projection screen) are not designed to reduce barriers between instructor and students in order to facilitate the collaborative learning and activities needed with a student-centered instructional style. Serious considerations much be made in adjusting project designs to create environments that match the desired instructional styles (Alicea et al., 2016; Chiu & Cheng, 2016).

The institutions continue to reinforce this teacher-centered instructional style choice by housing the professional development department within the human resources department instead of the education department. Human resource departments have the primary focus of compliance and are less concerned around topics such as instructional style and student engagement. Many professional development opportunities focus on policies and procedures for the institution with topics such as active shooter response, campus carry, FERPA, diversity, Title IX, harassment prevention, etc. instead of pedagogical implications of instruction.

Implications one through five cannot be remedied individually, but a coordinated solution needs to address these needs simultaneously. Classroom environments and professional development should be strategically planned and organized, supported by the institution, and evaluated to measure the intended change. Classrooms should be designed to reduce the barriers between instructor and students to facilitate collaborative learning and other student-centered activities as a way to promote this instructional shift (Alicea et al., 2016; Chiu & Cheng, 2016). As new construction or renovations are undertaken on campus a conscious decision needs to be made to move away from theater-style fixed seating and move toward a more adaptive environment friendly to technology and moveable tables and chairs to reduce barriers between faculty and student as well as promote a student-centered instructional style.

The institution must also set the example that student learning is paramount, that all faculty are expected to adopt student-centered instructional styles in their classroom and labs and create mandatory professional development plans as part of institutional contracts. The institutional focus and message should be that all faculty are expected to continually improve their practices with choice given on the exact methods this could occur. A needs assessment can help determine the criteria for multiple entry points of a professional development plan with faculty sorted based on pedagogical knowledge and produce artifacts to justify how they exhibit desired practices. Professional development should be an ongoing occurrence during the fall and spring semesters with multiple opportunities to engage in learning from multiple contexts. This process should be supported by the institution through an established budget allotment for professional development, time releases for faculty to attend professional development, and integrating education departments to help address pedagogy. Critical pieces currently missing in the professional development cycle are methods to evaluate and monitor the effectiveness of professional learning. Faculty such as trainers, mentors, and supervisors would benefit from understanding these processes from the lens of their different departments.

The sixth implication concerns the evaluation systems that institutions currently use to inform data driven decisions regarding instruction and policy change. This study found that the evaluations of faculty are conducted through surveys: end-of-course surveys, CCSSE, and others. While survey responses are showing that student engagement is increasing, attrition numbers are not decreasing at the same rate (Riccitelli, 2015). If student engagement has been established as a critical predictor for college completion, transfer, and explicitly for the diverse students in STEM programs, then the increase in student engagement should manifest in an increase in attrition rates (Alicea et al., 2016; Anderson et al., 2011; Barthelemy et al., 2015). This is not what is currently observed in institutions leading to two possibilities: either a gap in the research is exists, or the surveys are not providing an accurate assessment of student engagement. A factor to consider that could be contributing to these findings may be that teacher-centered STEM faculty are defining student engagement and student-centered instructional styles in ways that do not align with current research.

Combined with a lack of trained observers and trainers around student engagement and student-centered instruction, these practices are leading to discrepancies in the quantitative and qualitative data and creating an unfounded belief that student engagement is improving when it is not. Institutions then attempt to enact changes that are not based on valid data and can continue to skew the perceptions of students and faculty members. A similar consideration would be that a limited number of administration members have experience in observing and document pedagogical practices. They may observe practices that demonstrate compliance versus engagement and be unaware of the connection due to their limited exposure to classroom teaching. It is recommended that a program evaluation to explore the underlying causes of this discrepancy be utilized that engages in quantitative and qualitative practices supported by current educational literature.

The final implication is that both the teacher-centered and student-centered groups expressed a significant amount of concern over the perception of university faculty and towards their perceived ability to instruct students. There was a continuous connection made to comments from professional conferences, to personal conversations that dismissed the students, faculty, and environment of community colleges. Re-establishing this relationship will become a necessary priority as community college enrollment and credit transfers become more common. Aligning the curriculum and support structures to ensure strong transitions for students as well as build the professional skill sets of both groups will be essential as diverse student populations increase enrollment. Further exploration of these different connections and determining what the root causes of these negative perceptions and influences are could aid community college STEM faculty who are trying to innovate or move to a more student-centered instructional style feel higher degrees of teacher self-efficacy. This exploration could facilitate discussions with institutional administration as well as other stakeholders as an effort to illustrate the expectations and benefits of the student-centered instructional styles. This open level of communication could increase acceptance and ease apprehension from faculty, students, and stakeholders when using alternative instructional models.

Limitations

In this study, there are several limitations to take into consideration. First, the primary external validity issue is generalizability. Findings cannot be generalized to other community colleges or other faculty who are not STEM due to the purposeful sampling technique and sample size of the research study. This purposeful sampling technique may also cause certain faculty to more readily willing to respond to surveys and volunteer for interviews, so the sample may not be representative of the community college STEM faculty in southeast Texas. There was no follow-up with surveys and interviews from administrators. This study was limited to community college STEM faculty. Administrators may not have the same results on surveys and interviews therefore this study may not be generalized to administrators.

Second, internal validity issues resulting from the inability to control for compounding variables are also present in this study. One compounding variable is faculty giving honest answers on the PALS and TSES surveys. On the PALS, faculty may have a bias and report they adhere to collaborative teaching-learning mode more than they do. On the TSES, faculty may also have a bias and report they feel more confident in student engagement, instructional strategies, and classroom management than they do.

Third, internal validity issues would be with instrumentation. The language on both the PALS and TSES may not be clearly understood by community college STEM faculty and may cause answers that are not representative of the sample.

Fourth, the selection bias would be another compounding variable. If one group of faculty is over-represented in survey responses, it may bias the results toward the answers of that one group.

The fifth limitation would be that all the research components were conducted only one time. This short time period may not yield significant impacts of findings and will not show long-term changes in faculty perceptions.

Sixth, a mythological issue with the interviews was due to sampling two different community colleges. Issues with obtaining IRB permissions caused two of the interviews to happen three years apart. To mitigate a teacher-centered and student-centered STEM faculty was chosen from the second community college for comparison.

Recommendations for Future Research

Several recommendations are suggested for future research. Despite the limited size, this study provided insights into the relationship between teacher self-efficacy and the instructional style of community college STEM faculty. The first recommendation is to develop future studies that could replicate the study and expand to several different sized community colleges, which would provide additional data to validate the findings of this study. Expanding the data pool to include more STEM faculty than just science or engineering and would allow comparison to be made about teacher attitudes and beliefs related to instructional style choice. Further, in expanding to other community colleges, the study could also be linked to student achievement and student engagement from current and archival data.

A second recommendation for how this data could be used in future studies would be to administer the surveys in a pre/post fashion with student-centered instructional professional development delivered to both faculty and administration to analyze if the addition of professional development results in changes to teacher beliefs and teacher self-efficacy. This would allow institutions to assess the effectiveness of their professional development on influence the deep-seated beliefs that have proven to be barriers to STEM reform. Through including administration in professional development related to their roles in evaluating educational programming, it would clarify meaning of student-centered instructional styles and give them an clear idea of what they are looking for during interactions with faculty and students.

Finally, the instruments could be modified and broken into subcategories to analyze the impact on specific factors within each of the belief categories. This would allow a wider range of use and standards to be created within each of the categories of teacher self-efficacy, student engagement, instructional strategies, and classroom management for determining faculty professional development needs. Institutions could also then use this data to assess changes in needed professional development training, mentoring, observational protocols, and policy to make effective changes to lead to higher student achievement.

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APPENDIX A:

PRINCIPLES OF ADULT LEARNING SCALE (PALS)

Always	Almost Always	Often	Seldom	Almost Never	Never
A	AA	O	S	AN	N

Question/Item	A	AA	O	S	AN	N
1. I allow students to participate in developing the criteria for evaluating their performance in class.	○	○	○	○	○	○
2. I use disciplinary action when it is needed.	○	○	○	○	○	○
3. I allow older students more time to complete assignments when they need it.	○	○	○	○	○	○
4. I encourage students to adopt middle class values.	○	○	○	○	○	○
5. I help students diagnose the gaps between their goals and their present level of performance.	○	○	○	○	○	○
6. I provide knowledge rather than serve as a resource person.	○	○	○	○	○	○
7. I stick to the instructional objectives that I write at the beginning of a program.	○	○	○	○	○	○
8. I participate in the informal counseling of students.	○	○	○	○	○	○
9. I use lecturing as the best method for presenting my subject material to adult students.	○	○	○	○	○	○
10. I arrange the classroom so that it is easy for students to interact.	○	○	○	○	○	○
11. I determine the educational objectives for each of my students.	○	○	○	○	○	○

Question/Item	A	AA	O	S	AN	N
12. I plan units which differ widely as possible from my students' socio-economic backgrounds.	○	○	○	○	○	○
13. I get a student to motivate himself/herself by confronting him/her in the presence of classmates during group discussions.	○	○	○	○	○	○
14. I plan learning episodes to take into account my students' prior experiences.	○	○	○	○	○	○
15. I allow students to participate in making decisions about the topics that will be covered in class.	○	○	○	○	○	○
16. I use one basic teaching method because I have found that most adults have a similar style of learning.	○	○	○	○	○	○
17. I use different techniques depending on the students being taught.	○	○	○	○	○	○
18. I encourage dialogue among my students.	○	○	○	○	○	○
19. I use written tests to assess the degree of academic growth rather than to indicate new directions for learning.	○	○	○	○	○	○
20. I utilize the many competencies that most adults already possess to achieve educational objectives.	○	○	○	○	○	○
21. I use what history has proven that adults need to learn as my chief criteria for planning learning episodes.	○	○	○	○	○	○

Question/Item	**A**	**AA**	**O**	**S**	**AN**	**N**
22. I accept errors as a natural part of the learning process.	○	○	○	○	○	○
23. I have individual conferences to help students identify their educational needs.	○	○	○	○	○	○
24. I let each student work at his/her own rate regardless of the amount of time it takes him/her to learn a new concept.	○	○	○	○	○	○
25. I help my students develop short-range as well as long-range objectives.	○	○	○	○	○	○
26. I maintain a well-disciplined classroom to reduce interference to learning.	○	○	○	○	○	○
27. I avoid discussion of controversial subjects that involve value judgments.	○	○	○	○	○	○
28. I allow my students to take periodic breaks during class.	○	○	○	○	○	○
29. I use methods that foster quiet, productive desk work.	○	○	○	○	○	○
30. I use tests as my chief method of evaluating students.	○	○	○	○	○	○
31. I plan activities that will encourage each student's growth from dependence on others to greater independence.	○	○	○	○	○	○

Question/Item	**A**	**AA**	**O**	**S**	**AN**	**N**
32. I gear my instructional objectives to match the individual abilities and needs of the students.	○	○	○	○	○	○
33. I avoid issues that relate to the student's concept of himself/herself.	○	○	○	○	○	○
34. I encourage my students to ask questions about the nature of their society.	○	○	○	○	○	○
35. I allow a student's motives for participating in continuing education to be a major determinant in the planning of learning objectives.	○	○	○	○	○	○
36. I have my students identify their own problems that need to be solved.	○	○	○	○	○	○
37. I give all my students in my class the same assignment on a given topic.	○	○	○	○	○	○
38. I use materials that were originally designed for students in elementary and secondary schools.	○	○	○	○	○	○
39. I organize adult learning episodes according to the problems that my students encounter in everyday life.	○	○	○	○	○	○
40. I measure a student's long term educational growth by comparing his/her total achievement in class to his/her expected performance as measured by national norms from standardized tests.	○	○	○	○	○	○
41. I encourage competition among my students.	○	○	○	○	○	○

Question/Item	A	AA	O	S	AN	N
42. I use different materials with different students.	○	○	○	○	○	○
43. I help students relate new learning to their prior experiences.	○	○	○	○	○	○
44. I teach units about problems of everyday living.	○	○	○	○	○	○

APPENDIX B:

TEACHERS' SENSE OF EFFICACY SCALE (TSES)

Question/Item	Nothing		Very Little		Some Influence		Quite a Bit		A Great Deal
45. How much can you do to control disruptive behavior in the classroom?									
46. How much can you do to motivate students who show low interest in school work?									
47. How much can you do to get students to believe they can do well in school work?									
48. How much can you do to help your student's value learning?									
49. To what extent can you craft good questions for your students?									
50. How much can you do to get children to follow classroom rules?									
51. How much can you do to calm a student who is disruptive or noisy?									

Question/Item	Nothing		Very Little		Some Influence		Quite a Bit		A Great Deal
52. How well can you establish a classroom management system with each group of students?									
53. How much can you use a variety of assessment strategies?									
54. To what extent can you provide an alternative explanation or example when students are confused?									
55. How much can you assist families in helping their children do well in school?									
56. How well can you implement alternative strategies in your classroom?									

APPENDIX C:

DEMOGRAPHIC QUESTIONS

58. Gender

Male	o
Female	o

59. Age

18 – 24	o
25 – 34	o
35 – 44	o
45 – 54	o
55 – 64	o
65+	o

60. What degree do you have?

M.S.	o
M.A.	o
Ed.D.	o
Ph.D.	o
Other	

61. Which Stem track do the courses you teach fit into?

Science	○
Technology	○
Engineering	○
Math	○

62. What is your race/ ethnicity?

American Indian	○
African American	○
Hispanic/Latino	○
Caucasian	○
Asian	○
Pacific Islander	○
Two or More	○
Some Other	○

63. How long have you been teaching STEM courses in community college in years?

64. Which Institution are you currently employed with?

Alvin Community College	○
College of the Mainland	○
Galveston College	○
Houston Community College	○
Lee College	○
San Jacinto Community College	○

65. Do you currently hold a teaching certificate?

Yes	○
I do not hold a teaching certificate	○

APPENDIX D:

SURVEY COVER LETTER

November 25, 2018

Dear STEM Faculty and Deans:

Greetings! I hope you had an enjoyable Thanksgiving Break. I am Jeremy Unruh, Adjunct faculty at San Jacinto College - South, and current doctoral student at UHCL. Before Thanksgiving, you received an email detailing a study I am conducting on the relationship between teacher self-efficacy and the instructional style of community college STEM faculty.

This email includes the link to the survey at the bottom. Filling out the surveys is ***voluntary,*** and your support would be helpful in completing the survey. You will also be given the opportunity to volunteer for semi-structured interviews to give more details that were not captured in the survey. This survey will take approximately 15-30 minutes to complete, the interview will take approximately 30 minutes, and all responses will be kept completely ***confidential***. No obvious undue risks will be endured, and you may stop your participation at any time.

Please remember that many studies on how community colleges should change are based on data from four-year universities. Your voice on how unique community colleges are is imperative to direct these initiatives.

Your cooperation and your willingness to participate in this study are greatly appreciated and invaluable. I have attached the IRB approval from your community college and my CPHS approval from UHCL for you to review. You will find the link to the survey hyperlinked below.

If you know of a colleague that has unique insight into this subject or just would like to help in this research study, please forward this email to them. I appreciate any help you can give.

If you have any further questions, please feel free to contact Dr. Brenda Weiser, EdD., (Weiser@UHCL.edu) or me (Unruh@uhcl.edu). Thank you!

If you know of someone who has direct insight into this study, please feel free to forward this email to them. The link works for anyone who has it.

The Survey

STEM Instructional Style Survey

Sincerely,

Jeremy Unruh, M.S.
Adjunct Biology Professor
San Jacinto College
(713) 301-4956
Unruh@uhcl.edu

APPENDIX E:

INFORMED CONSENT

Informed Consent to Participate in Research

You are being asked to participate in the research project described below. Your participation in this study is entirely voluntary and you may refuse to participate, or you may decide to stop your participation at any time. Should you refuse to participate in the study or should you withdraw your consent and stop participation in the study, your decision will involve no penalty or loss of benefits to which you may be otherwise entitled. You are being asked to read the information below carefully and ask questions about anything you don't understand before deciding whether or not to participate.

Title: EXAMINING THE RELATIONSHIP BETWEEN TEACHER SELF-EFFICACY AND INSTRUCTIONAL STYLE OF COMMUNITY COLLEGE STEM FACULTY

Student Investigator(s): Jeremy Unruh
Faculty Sponsor: Brenda Weiser, EdD.

PURPOSE OF THE STUDY
The purpose of this study is to examine the relationship between teacher self-efficacy and the instructional style of community college STEM faculty.

PROCEDURES
Interviews will explore faculty perceptions of what factors contribute to a STEM faculty's instructional style selection. At the onset of the interview, the interviewer will read aloud the Informed Consent Notification. Special emphasis will be paid to confidentiality, audio recording the interview, and that participation is voluntary, and they may stop participation at any point during the interview. The interviewer will ask if there are any questions about the procedures and both will sign to show consent. During the interview, questions will be asked to explore what factors contribute to a STEM faculty's instructional style selection.

EXPECTED DURATION
The total anticipated time commitment will be approximately 10-30 minutes

RISKS OF PARTICIPATION
There are no anticipated risks associated with participation in this project.

BENEFITS TO THE SUBJECT
There is no direct benefit received from your participation in this study, but your participation will help the investigator(s) better understand instructional strategies, classroom climate, self-efficacy and what ways they are developed.

CONFIDENTIALITY OF RECORDS

Every effort will be made to maintain the confidentiality of your study records. The data collected from the study will be used for educational and publication purposes, however, you will not be identified by name. For federal audit purposes, the participant's documentation for this research project will be maintained and safeguarded by the Faculty Sponsor for a minimum of three years after completion of the study. After that time, the participant's documentation may be destroyed.

FINANCIAL COMPENSATION

There is no financial compensation to be offered for participation in the study.

INVESTIGATOR'S RIGHT TO WITHDRAW PARTICIPANT

The investigator has the right to withdraw you from this study at any time.

CONTACT INFORMATION FOR QUESTIONS OR PROBLEMS

If you have additional questions during the course of this study about the research or any related problem, you may contact the Student Researcher, Jeremy Unruh, at phone number 713-301-4956 or by email at Unruh@uhcl.edu. The Faculty Sponsor Dr. Brenda Weiser, EdD., may be contacted at phone number 281-283-3522 or by email at Weiser@UHCL.edu.

SIGNATURES:

Your signature below acknowledges your voluntary participation in this research project. Such participation does not release the investigator(s), institution(s), sponsor(s) or granting agency(ies) from their professional and ethical responsibility to you. By signing the form, you are not waiving any of your legal rights.

The purpose of this study, procedures to be followed, and explanation of risks or benefits have been explained to you. You have been allowed to ask questions and your questions have been answered to your satisfaction. You have been told who to contact if you have additional questions. You have read this consent form and voluntarily agree to participate as a subject in this study. You are free to withdraw your consent at any time by contacting the Principal Investigator or Student Researcher/Faculty Sponsor. You will be given a copy of the consent form you have signed.

STEM Faculty printed name: ____

Signature of STEM Faculty: ____

Date: ____

Using language that is understandable and appropriate, I have discussed this project and the items listed above with the subject.

Printed name and title:____

Signature of Person Obtaining Consent: ____

Date: ____

THE UNIVERSITY OF HOUSTON-CLEAR LAKE (UHCL) COMMITTEE FOR PROTECTION OF HUMAN SUBJECTS HAS REVIEWED AND APPROVED THIS PROJECT. ANY QUESTIONS REGARDING YOUR RIGHTS AS A RESEARCH SUBJECT MAY BE ADDRESSED TO THE UHCL COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS (281-283-3015). ALL RESEARCH PROJECTS THAT ARE CARRIED OUT BY INVESTIGATORS AT UHCL ARE GOVERNED BY REQUIREMENTS OF THE UNIVERSITY AND THE FEDERAL GOVERNMENT. (FEDERALWIDE ASSURANCE # FWA00004068)

APPENDIX F:

INTERVIEW QUESTIONS

1. How would you define STEM education?

Possible follow-up questions:

   a. Who influenced this definition?
   b. Do you see a difference in how STEM courses are taught compared to Non-STEM courses?
   c. What characteristics do you believe impact student achievement in your courses?
   d. How would you describe the perfect STEM student?

2. Whom influenced your instructional strategies?

Possible follow-up questions:

   a. When did you learn your classroom management and instructional styles?
   b. What professional development has been provided?
   c. What criteria would you use to judge if the professional development should be used in your classroom?
   d. Describe a professional development provided by your institution that was no use to you. Why couldn't you use it?
   e. Does your institution offer professional development designed by and for STEM faculty? Can you give me a brief description?

3. What is the hardest part of classroom management for you?

Possible follow-up questions:

   a. Describe a problem that occurred in one of your classes and how did you solved it?
   b. What support was offered from your institution to solve that problem?

4. How does your institution support you in the classroom?
5. How do you engage students?