ACTIVE LEARNING FACILITATED BY TECHNOLOGY IN STEM LECTURE COURSES IN A COMMUNITY COLLEGE

By

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To my Mima… you are the rock I stand on and reach for the stars
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With increased attention focusing on how to engage students in science courses, reports have called for action to revise curricula and have brought to the forefront the importance of using student-centered teaching practices (Bauerle et al., 2009). Faculty in STEM disciplines that have used active learning strategies to involve students have reported increased levels of student engagement and interest. While reports have shown positive results, many have shared challenges associated with the time investment during class and strain due to content requirements (DiCarlo, 2006; Fata-Hartley, 2011; H. W. Lee, Lim, & Grabowski, 2008). As a response to these concerns, faculty have used technology to facilitate active learning strategies (Cotner et al., 2013; Eichler & Peeples, 2016; Gardner & Belland, 2012; Mayberry et al., 2012).

While many reports have shown the impact of these practices in various institutions, there is little information about their impact on STEM courses at community colleges. Therefore, the focus of this study is to explore how full-time STEM faculty use technology to facilitate active learning and what factors influence their implementation at a community college. This study is framed within the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Venkatesh, Morris, Davis, & Davis, 2003) to focus on participants and factors that influence
their decision to integrate technology. Using a qualitative exploratory approach, STEM faculty members were interviewed using a protocol based on the UTAUT model to collect information on their experiences. An analysis of the data provided examples of how participants integrate technology in STEM courses, and factors such as professional development opportunities by the institution and peer-support that show how some of the concerns associated with implementation of active learning strategies can be addressed. Results presented in this study correspond to challenges and outcomes described in the literature. Overall, this study provides insight into the STEM community college faculty and their active learning practices. Likewise, it describes the effectiveness of the UTAUT model as a framework to provide understanding of participants’ behavior of use and interaction of factors within the model, provides suggestions related to the institution, and concludes with its contribution to the current body of literature.
CHAPTER 1
INTRODUCTION

In an effort to engage students in science courses, calls have been made to revise how science curricula are presented to students (Bergstrom, 2011; DiCarlo, 2006; Gardner & Belland, 2012; Michael, 2006; Woodin, Carter, & Fletcher, 2010). Some recommendations discussed by the *Vision and Change in Undergraduate Biology Education* report funded by the National Science Foundation (NSF), the National Institute of Health (NIH), and the Howard Hughes Medical Institute (HHMI) focus on aspects of the educational process and not just the content of the science curriculum. An emphasis on science-learning competencies has directed attention to specific “ideas” that should be developed and integrated in the curriculum (Bauerle et al., 2009). Likewise, engaging students in the scientific process is a priority of these reports to provide a real-world link between the content of student learning and the process of science. This engagement, the report suggests, should be mediated in an environment that fosters community building and cultural change, and provide students with teambuilding experiences, and multicultural awareness. Finally, the report recognizes that students will not be alone in the discovery process and that some of these undertakings may be new for instructors. Thus, faculty development should accompany these practices to facilitate the process of instruction. Importantly, these recommendations have been made to address all types of science educational contexts.

Over recent years, there has been an increased interest in the areas of science, technology, engineering, and mathematics (STEM) on the world stage. Emphasis has been placed on the disciplines encompassing the natural sciences, technology, and applied science as tools for the advancement of the individuals that pursue these fields and through them, national advancement.
Various reports that focus on the importance of improving STEM education have been published since the 1990s by various agencies (Labov, Singer, George, Schweingruber, & Hilton, 2009).

As the science community considers engagement strategies to facilitate student learning, teaching practices have become the center of attention. While science laboratory courses mimic real-life experiences within an educational and controlled environment (Hall & Vardar-Ulu, 2014), the laboratory co-requisite ofs STEM lecture course are mostly designed as passive students listening to a professor and taking notes (DiCarlo, 2006). These courses emphasize instruction on course content and presentation of theoretical components that are later explored in the laboratory course. As described by Gardner & Belland (2012), “lecture-based instruction in introductory Biology courses do not produce meaningful learning, as the ability to apply knowledge” (p. 466). In many situations, this is a result of instructors not being aware of new available strategies and simply continuing the use of educational approaches that they know (DiCarlo, 2006); this echoes the need for faculty development.

As a means for student engagement, active learning strategies that focus on student-centered learning have been proposed. Various forms of active learning emphasize student engagement and address recommendations by the reports mentioned above. Gardner & Belland (2012), as well as Michael (2006), summarize active learning strategies which aim to not only engage students, but also facilitate learning by positioning the student in command of the process and promoting deeper conceptual understanding through real-world problems (DiCarlo, 2006). However, while active learning practices have been shown to promote learning (Michael, 2006), many practitioners are concerned with the amount of content that needs to be covered as part of the curriculum and the impact on time invested in the classroom when these strategies are implemented (DiCarlo, 2006). Constructivist instruction in the form of active learning strategies
can be more time consuming than passive lecture-based instruction (Tobias, 2009), and practitioners worry that active teaching practices will consume time currently allocated to the discussion of course content (Lowell & Verleger, 2013). For example, Chin & Chia (2004) describe how the implementation of problem-based learning in a Biology course led to mismanagement of time by students, poor group dynamics, and off-task behaviors that resulted in students working on the project at the very last minute.

To address the need for content delivery, off-task behaviors, and time management, practitioners have introduced various technology based approaches to facilitate the delivery of content through different types of media, sometimes enabled by a learning management software (LMS) (DiCarlo, 2006; Gardner & Belland, 2012; Picciano, 2009) and a “flipped classroom” instructional style. “The flipped classroom actually represents an expansion of the curriculum, rather than a re-arrangement of activities” (Lowell & Verleger, 2013, p. 5). Using this method, faculty can increase contact time by moving content that was traditionally covered during face-to-face time to the online space and at the same time, allowing for the use of active learning strategies as in-class activities. Furthermore, other learning approaches, such as blended learning, allow the incorporation of both the online and in-class space as a single instructional unit. As defined by the North American Council for Online Learning, “blended learning combines online delivery of educational content with the best features of classroom interaction and live instruction to personalized learning…” (Watson, n.d.). Hence, students are not learning two different sets of content material, but rather are participating in an educational experience that exploits the benefits of the online space and the face-to-face interaction. Both these strategies incorporate technology as the medium to provide the content and active learning experience in the classroom. The aim of this study was to identify how faculty members facilitated active
learning strategies by integrating technology and what factors influence the integration of technology into their courses within a community college environment.

**Context of the Study**

The institution where this study was performed is one of the largest enrollment institutions within the Florida College System. It is composed of various campuses within the county, and is the the second-largest institution of higher learning in the United States. The institution served over 92,000 enrolled students during the 2014-15 academic year, the clear majority of which were members of minority groups. In addition to an Associate of Arts degree with several pathways, it provides multiple certificates and Associate in Science degrees focusing on workforce training and development, as well as ten bachelor degree programs. Throughout the campuses of the institution, the School of Science oversees various degrees and certificates as well as a Bachelor of Science in Biological Sciences program. The School of Science provides hands-on experiences for students allowing them to acquire practical skills, and through student engagement highlight the role of science in the “real world”.

In response to the call by the Vision and Change document (Bauerle et al., 2009), a group of program officers from funding agencies launched the Partnership for Undergraduate Life Science Education (PULSE) with the goal of stimulating department-level implementation of the Vision and Change recommendations concentrating on student-centered learning (“About PULSE,” n.d.). Regional networks were developed and within regions, fellows were recruited to develop workshops and serve as ambassadors of PULSE to facilitate implementation of the recommendations within their respective regions. The Southeastern Regional PULSE (SERP) is a regional network covering schools under the accreditation of Southern Association of Colleges and Schools (SACS).
The current dean of the School of Science at this Institution is one of the SERP fellows, and this institution has been a participant in this initiative. Teams of faculty members and administrators participated in two summer workshops and presented departmental initiatives focusing on student-centered activities. Some of these activities have included workshops on the use of Process Oriented Guided Inquiry Learning (POGIL) and the use of adaptive learning technologies. Therefore, there is a vested interest by the leadership of the School of Science to promote the use of active learning strategies, and the development and scaling of current practices throughout the science faculty college-wide.

Currently, the School of Science is comprised of 75 full-time faculty members in addition to many adjunct faculty instructors at the different campuses. Of these, 16% are in different stages along the tenure-track, while the remaining 84% of the faculty have already received continuing contract status. Full-time faculty members are assigned a teaching load of five, three-credit hour courses in the fall and spring semesters, as well as two, three-credit hour courses during the summer. Science faculty members may choose to teach any combination of lecture or laboratory courses to fulfill their academic load. Both lecture and laboratory courses may be designated as web-enhanced to signify the use of technology in the class. Faculty members determine the extent or use of technology in their individual courses.

The laboratory course has been the foundation in many science courses for experimentation and application of theoretical knowledge; however, the lecture courses have been characterized by passive student participation (Gardner & Belland, 2012) and lack of deep-learning due to the focus on breadth of content (DiCarlo, 2006). As faculty members attempt to transform science curricula, active learning strategies have been proposed to engage students with content and promote deeper learning (DiCarlo, 2006; Gardner & Belland, 2012; Michael,
These strategies have been met with resistance from some faculty because of the amount of content that should be covered as part of the science curriculum at the expense of time invested in these practices (DiCarlo, 2006; Gardner & Belland, 2012). To facilitate active learning in STEM lecture courses, many faculty have adopted the use of technology without impacting content (DiCarlo, 2006; Gardner & Belland, 2012) and therefore, addressing criticisms about time investment. As DiCarlo (2006) asked, “how do we teach this vast amount of content to students in this limited time?” (p. 290). His answer was a proposal to unpack the curriculum and maximize use of innovative teaching, and the use of teaching resources. Some of his examples propose the use of 3-dimensional computer modeling to show students how specific proteins work at the molecular level and animation that show complex interactions at the microscopic (or smaller) levels.

As the School of Science faculty at the institution have been encouraged to implement student-centered learning practices, such as active learning, concerns, including those described in the literature regarding time devoted to practices and activities rather than course concepts have been expressed by the faculty. Some faculty members have turned to technology using publisher provided material, while others have adopted flipped-classroom and adaptive learning platforms.

Platforms like MyLab & Mastering provided by Pearson Education and Connect by McGraw-Hill, provide faculty with a catalog of videos, presentations, online practice activities, student response platforms, links to material within electronic versions of the textbooks, and assessments that supplement or enhance courses in Biology, Anatomy & Physiology, Chemistry, and Physics. Other providers like Smart Sparrow have offered adaptive learning platforms for the non-majors’ Biology course and physical science courses. Through project-based learning
models, students navigate a series of lessons with a central theme. As students are asked to complete tasks, they are prompted with feedback that adapts to their needs. Some faculty members have used this platform to enhance their courses, including modules as assignments or as examples for activities that instructors work in-class with students, while other faculty members have used it as a method for blended learning.

Jaffee (1998) stated (as cited by Straub, 2009), “adoption does not equal acceptance” (p. 643). Thus, there is a need to understand how technology is adopted within a population. As faculty in the School of Science increased their use of technology, it was important to understand its integration into the curriculum. The impact of the use of technology on student learning and the practice of teaching for faculty had to be determined. Moreover, it was important to understand why faculty members choose to use certain technologies and what resources would help them implement such technologies to their full potential.

**Purpose of Study**

The goal of this study was to determine how faculty members are using technology to facilitate active learning strategies in STEM lecture courses, and what factors influence the adoption of technology to facilitate these active learning strategies. The main research question was, “how are active learning strategies facilitated with the use of technology in STEM lecture courses taught by full-time faculty?” To explore these questions, the following sub-questions were addressed:

1) How are full-time science faculty members using technologies to facilitate active learning in lecture STEM courses?

2) What factors influence full-time STEM faculty’s integration of technology to facilitate active learning?
Research Design

This study used an exploratory qualitative methodology consisting of an interview focusing on each participant’s experiences and factors implementing technology to facilitate active learning strategies in STEM courses. The objective was to identify the use and role of technology to facilitate active learning in STEM lecture courses, and the factors that influence faculty’s integration into their courses.

This project consisted of a purposeful sample (Creswell, 2013) from self-identified full-time faculty technology users, members of the School of Science. Faculty were asked to volunteer for the interview and sampling aimed to represent each of the STEM disciplines in this study (Biology, Chemistry, and Physics) and to address moderating factors identified by the Unified Theory of Acceptance and Use of Technology (UTAUT) model.

Faculty members were invited to contribute to the study. They volunteered to participate in an interview to further examine their use of the technology and what factors have influenced their adoption and implementation. During this process, extensive field notes and journaling assisted in capturing information that may not have been recorded during the interview process, but was identified during the data collection.

Significance

As faculty members are encouraged by a national and institutional impetus to integrate active learning strategies into STEM courses, faculty may choose to use technology to facilitate this process. As technologies are incorporated into courses, how faculty use technology becomes an important question. This study aimed to explore faculty members’ use of technologies to facilitate the active learning process, and the factors influencing the integration of the technology.
On a personal level, this study allowed me to identify areas where I could target further development and integration of active learning strategies, specifically, improvements of how topics and concepts in STEM are developed with our students. As a promoter of active learning and the integration of technology, my interest is to facilitate these strategies beyond my courses. Thus, areas of deficiency have been identified that will be evaluated in future studies. Likewise, while the impact of these practices has been described in the literature, the specific population that comprises this institution has not. The establishment of best practices at a college-wide level and the exploration of colleagues’ use of technology and their implementation processes facilitated a reflective process within my own practice.

The impact of this study also focused on various levels of faculty support. Based on the findings, professional development could be designed to support faculty implementation of active learning strategies in STEM courses and the use of technology to facilitate the process. At an institutional level, the results from this study reveal the current practices and motivations of faculty members. By understanding faculty current practices, best practices in the specific areas can be identified and shared. Moreover, limitations in the implementation process could be addressed to assist faculty in their use of technology. Likewise, motivations and challenges associated with the use of technology can later inform the institution about successful initiatives and institutional practices. Factors that influence adoption of technology and strategies have been identified by this study, which will be shared with institution’s administration to support faculty where possible; leading to later expansion of the use of technology and active learning to other disciplines.

This study adds to the body of knowledge within the educational field regarding integration of technology in STEM lecture courses, as well as capture the use and needs of a
diverse body of faculty in STEM. This study and its participants serve as a model for addressing integration and development, not only within the natural sciences but also in broader aspects of faculty development. Additionally, this study allows the expansion from individual experiences discussed in the literature to that of an institutional description of practice, adoption, and implementation.

Summary

This chapter focuses on the national call to review STEM lecture courses to include student-centered activities; specifically, I focused on a response to this call to action and my professional role within this initiative. As the School of Science moves forward with this plan, many faculty members have used technology to facilitate these strategies and it is important to assess technology’s use in active learning and the factors that influence its integration. Therefore, this study focused on how full-time STEM faculty members use technology to facilitate active learning strategies in STEM lecture courses and the factors that influence their integration. In the next chapter, I will review the literature associated with the topics addressed in this work.

Definitions

The following terms will be used throughout this study. Included are the working definitions that will be used:

Active learning – a shift in teaching that focuses on the process of learning rather than the act of teaching.

Adoption – institutional acceptance of technology for faculty who either choose not to use it or use it to replace traditional instructional methods.

Implementation – technology that will be used (or is used) to transform teaching practices.
**STEM laboratory course** – co-requisite for many STEM lecture courses where the course mimics real-life experiences within an educational and controlled environment (Hall & Vardar-Ulu, 2014). Students perform activities that expand on the information discussed in the lecture course.

**STEM lecture course** – STEM course where the curricular information is delivered to students and the instructor talks to the students as an audience.

**Student-centered learning** — a focus on the student as an active participant of the practice, rather than a passive receiver in the learning process.

**Teacher-centered learning** – a transmittal model of teaching where the student receives information from the instructor in a expatiate format and is later asked to recall the information given (King, 1993).
CHAPTER 2
LITERATURE REVIEW

This chapter is focused on a literature review that explores a national movement for transformation of undergraduate STEM education. As a response to a call to action, educators have proposed the implementation of student-centered practices that will enhance student achievement and retention in the STEM fields. Active learning is a specific approach that has been described as mirroring the science inquiry process; thus, this strategy has been adopted as a model for student engagement, but it comes at a price. Because the strategy calls for flexibility in teaching and allowing the students time for the discovery process to occur, it comes at the expense of time dedicated to content instruction. To incorporate active learning practices into traditional lecture courses, instructors have used technology to facilitate the learning process and at times, moved the instruction of content outside of the physical classroom. While these strategies have proved fruitful, the literature describes a variety of institutions, disciplines, and student populations that do not represent the faculty at this institution. Therefore, the purpose of this study was to explore how full-time faculty members of the institution’s School of Science use technology to facilitate active learning strategies in their courses; and what factors influence the integration of technology.

With the goal of understanding the role of technology in teaching within larger populations, models of technology integration are discussed in this chapter. Inside these models, frameworks focus on how the technology is dispersed through a population, how the population uses the technology, and the beliefs associated with the implementation of an innovation. These frameworks serve as guides to understand how faculty approach implementation of technology adopted by their institutions. Moreover, they also address the administrative plans to focus on national initiatives.
Lastly, the literature review focuses on the individual as a participant in the process and factors that influence implementation are considered. Among them, barriers are identified that may be external as well as internal sources that are considered by instructors when deciding how they will proceed in the implementation of technology.

**Literature Search**

To review the literature, a search of key terms in databases was conducted. Initial key words used included active learning; student-centered learning; and STEM education. These key words were used to determine what the current state of these practices was and find examples of the implementation as a response to the call to action from documents such as Vision and Change. To identify research on active learning and technology, terms such as technology adoption and integration were included in the search. Frameworks that identified the adoption, implementation, and beliefs associated with the integration of technology were necessary to understand how institutions, and specifically faculty, address innovations. Therefore, terms such as Diffusion of Innovations; Concerns Based Adoption Method, Unified Theory of Acceptance and Use of Technology, and Technology Integration Matrix were used. References from initial articles were also reviewed to delve deeper into specific areas of content and examples within practice.

The topic of student-centered practices, active learning, and the role of technology in their implementation were limited to reports focusing on STEM and higher education. This was done to restrict the literature search to scenarios and teaching environments like those in my professional context. Because there have been various attempts in the K-12 system as well as higher education in the adoption of technologies, the evaluation of the processes, and teacher integration, both K-12 and higher education environments were included for the search.
associated with the implementation of technology. This search included any field where technology had been implemented and models of diffusion were reviewed. Lastly, when discussing factors affecting implementation of technology, a broad search was used to compile information in various teaching settings and to understand potential limitations regardless of the teaching environment. All STEM disciplines were included in the search.

**National Appeal for Transformation of Undergraduate Science Education**

Over the years, there has been an interest in the areas of science, technology, engineering, and mathematics (STEM) on the world stage. General categories driving these efforts are professionals, such as medical doctors and engineers, or skill development for the workforce. The STEM disciplines have focused on generating this interest in order to determine best practices to progress and be prepared for the future, in addition to maximizing student potential (Campbell et al., 2007; Chin & Chia, 2004; Lou, Shih, Ray Diez, & Tseng, 2010; Musante, 2011). Likewise attention to STEM is also centered on hopes of bettering a society as a source of future skilled labor and paving the path for technological discoveries (Williams, 2011). Whatever the driving force, emphasis has been given to the disciplines encompassing the natural sciences, technology, applied science in the form of engineering and mathematics as tools for both the advancement of the individuals and fields and thus, a national advancement.

Wood (2009) generalizes the causes that advance efforts within the United States based on (1) a deep concern about the role of the nation on the world stage because of decreased retention of students in the STEM areas and (2) the developments in education and new understanding on how students learn. Various reports that focus on the importance of improving STEM education have been published since the 1990s by agencies, such as the National Science
Foundation (NSF), National Research Council (NRC), as well as other federal agencies (Labov et al., 2009).

Although the natural sciences are considered independent fields, the focus on STEM as a unifying element has moved them to the forefront and integration of the various disciplines has been the focus of numerous studies (Brien, 2010; Campbell et al., 2007; Kelley, 2012; Lou et al., 2010; Musante, 2011; Paulsen, 2012; Williams, 2011). While there is no unifying concept on how integration must be developed or implemented, the idea of STEM as the answer to the challenges of the future continues to be at the center of conversations not only for the natural and applied sciences but other disciplines (Williams, 2011). To address the challenges of the future, there is a need for an interdisciplinary and collaborative approach (Musante, 2011).

The latest initiative that tackled the need for reform, bringing together the interdisciplinary nature of the disciplines in STEM and new approaches to pedagogy, specifically in Biology, combined the efforts of the NSF partnering with the American Association for the Advancement of Science (AAAS), with additional funding from the Howard Hughes Medical Institute (HHMI) and the National Institute of Health (NIH). Together, these groups began regional conversations that led to a single conference that produced a report combining the efforts of faculty, administrators, and invited undergraduate students (Bauerle et al., 2009). The Vision and Change in Undergraduate Biology Education: A Call to Action document focused on integration models of concepts within the discipline and other STEM fields as discussed by reports and presented by Labov, Reid, & Yamamoto (2010), and the implementation of teaching strategies that focus on students.

Teaching methods that address this approach are varied and there is yet to be a cohesive concept (Tobias, 2009). Some articles focus on the use of out-of-school time in order to
maximize the exposure to the concepts (Paulsen, 2012), by maximizing the time outside of school to expand on what the students learned during the day. Other methods utilize computer and web-based programs to deliver instruction (Clark & Ernst, 2008; Fancovicova, Prokop, & Usak, 2010). This approach allows instructors to move content to the online space and provide more interaction during face-to-face class time, while others focus on the “T” and “E” of STEM as the support in which to integrate concepts (Kelley, 2012; Koehler & Mishra, 2005; Lou et al., 2010). Following the lead of these conversations and methodologies, problem-based learning (PBL) rises as a model of delivery (Chin & Chia, 2004; Clyde, Herreid, Schiller, Herreid, & Wright, 2011; Kelley, 2012; Koehler & Mishra, 2005; Lou et al., 2010; Miller, Mayes, & Smith, 2001; Musante, 2011; Park & Ertmer, 2008; Priem, 2011). Overall, all of these strategies have one overarching focus, the student as the key player in their education.

**Student-Centered Education**

Set on the foundation of the constructivist paradigm, student-centered education aims to refocus the learning process on the student as an active participant in the practice, rather than as a passive receiver. King (1993) contrasts this approach with a transmittal model of teaching where the student receives the information from the instructor in a lecture format and is later asked to recall the information given – “the sage on the stage”. Constructivism cultivates inquiry where students will be encouraged to be curious about questions in their surroundings and thus, the exploration will lead to learning (Duffy & Cunningham, 2001). Students take ownership of learning and are at the center of instruction. Duffy & Cunningham (2001) described general characteristics of constructivism where “(1) learning is an active process of constructing rather than acquiring knowledge, and (2) instruction is a process of supporting that construction rather
than communicating knowledge” (p. 2). Therefore, the instructor is a resource in the student’s journey, rather than the source of the information – “the guide on the side”.

**Definition and Characteristics**

The *Vision and Change in Undergraduate Biology Education: A Call to Action* document defines student-centered courses and curricula as those “that take into account student knowledge and experiences at the start of a course and articulate clear learning outcomes in shaping instructional design” (Bauerle et al., 2009, p. 22). Wood (2009) effectively compares traditional instruction in STEM classrooms with student-centered designs and outlines key aspects that characterize this approach:

- Effective instruction is based on prior knowledge
- No learner is equal or like another
- Learning requires frequent feedback
- Learning requires proper use of self-awareness of knowledge (metacognition)
- Learning is enhanced by collaboration and community
- Learning should motivate and increase student’s curiosity and attention
- Learning is an ongoing process

**Student-Centered Approaches**

Student-centered learning is exemplified by Problem-Based Learning (PBL), where students are given a task, and with appropriate support and guidance, build answers through their need for information and discovery (Chin & Chia, 2004; Park & Ertmer, 2008; Priem, 2011; Schul & Barab, 2007). Groups exploring the integration of PBL in STEM courses have proposed transformations to current approaches in STEM education (Chin & Chia, 2004; Kim & Hannafin, 2011; Lou et al., 2010; Park & Ertmer, 2008; Woodin et al., 2010).

Some methods discussed and reviewed in the literature focusing on student-centered learning demonstrate the collaborative and social nature of the approach, the individuality of the learning process, and the role of the instructor as a guide.
• Guided reciprocal peer questioning – students may work in small groups, and interaction is promoted. Students are provided generic questions that serve as foundations for questions developed by the students, based on the lesson. After questions are constructed, students engage in peer questioning and take turns answering each other’s questions. (King, 1993)

• Jigsaw – students in a group receive part of the learning material and must learn those parts to teach them to other students. Understanding of the lessons is achieved when all parts of the lesson are put together as parts of the learning material. (King, 1993)

• Constructive controversy – large class activity; students are broken into groups, and pairs within the group are assigned opposite sides of a topic of controversy. After discussion is completed, students switch sides and argue the other position. (King, 1993)

• Co-op – students are placed in groups that provide information to the class. Therefore, students cooperate within their groups and later cooperate with the class to produce a final product. (King, 1993)

• PBL – Students exposed to these learning practices are presented with well, or ill-structured problems and asked for answers to solve their challenges. Instructors provide information, tools, and experience, so they contribute to solving complicated problems. (David H Jonassen, 2014; Musante, 2011)

**Active Learning as Student-Centered Practice**

Michael (2006, p.160) cites the work by Barr and Tagg (1995) and Pedersen and Liu (2003) describing student-centered learning as an opposition to teacher-centered, as well as a change in paradigm where the focus shifts from the act of teaching to the process of learning. The strategies mentioned previously respond to national reports promoting a change in the way students learn and the approaches that need to be taken into consideration. Active learning is a student-centered strategy that not only addresses the new approaches in pedagogy, but also responds to calls for the development of inquiry in the students and relevance of the material with real-world problems (DiCarlo, 2006). Therefore, this approach not only addresses the national and student learning needs but also mirrors the process of science inside the classroom.
Active Learning in STEM Classrooms

In the natural science curriculum in higher education, many introductory courses encompass two components that explore different approaches to the practice; these components are usually co-requirements and must be completed simultaneously as a pre-requisite for more advanced courses. The laboratory course has historically been the centerpiece in many STEM courses for experimentation and application of theoretical knowledge. Conversely, the lecture courses have been characterized by passive student participation (Gardner & Belland, 2012) and a lack of deep-learning due to the focus on breadth of content (DiCarlo, 2006). Allen & Tanner (2005) call attention to this when they refer to the laboratory course as the location where science is addressed in a “science as inquiry” format, while the lecture becomes the presentation of the “why.” Passive students become unmotivated, which in turn impacts completion and the retention in STEM fields of specific populations, such as unrepresented groups, women, and ethnic and racial minorities (D. Allen & Tanner, 2005; Graham, Mark J.; Frederick, Jennifer; Byars-Winston, Angela; Hunter, Anne-Barrie; Handelsman, 2013).

The National Research Council (2000) is referenced as stating, “science education research has suggested that students learn science best by asking questions, analyzing data, and creating predictive models and other approaches to better learn the content” (Lee & Jabot, 2011, p. 99). Therefore, the focus on active learning strategies has had the goal of retaining students, increasing participation, learning, and decreasing failure rates in STEM courses (Freeman & Eddy, 2014; B. W. T. Lee & Jabot, 2011; McClanahan & McClanahan, 2002) beyond the laboratory courses by also transforming the lecture courses.

Use of active learning strategies has been referenced in the literature for disciplines such as Physics, Chemistry, and Mathematics (Fata-Hartley, 2011; Freeman & Eddy, 2014). Initial
presentations of the strategy were developed in small classrooms (D. Allen & Tanner, 2005), but other studies have followed that assess the impact of active learning in larger classroom environments (Eichler & Peeples, 2016; Freeman & Eddy, 2014; Mayberry et al., 2012). These later studies are important for non-STEM majors and introductory STEM courses, which have traditionally been taught in large settings (D. Allen & Tanner, 2005). A study by Freeman and Eddy (2014) conducted a meta-analysis of studies that showed students in STEM classrooms using active learning strategies were 1.5 times less likely to fail than students in a traditional instruction class. More importantly, the authors demonstrated that the strategies impacted medium (50-110 students) to large (more than 110 students) classes.

While results have shown the positive impact of active learning on students, change is sometimes met with apprehension. Faculty have expressed concerns associated with the time invested in the use of these strategies, finding that the activities take longer periods of time than traditional instruction (DiCarlo, 2006; Fata-Hartley, 2011; Gardner & Belland, 2012; B. W. T. Lee & Jabot, 2011). Many faculty therefore struggle with choosing between a breadth versus a depth approach to instruction (Fata-Hartley, 2011). Moreover, students have also shown initial hesitation when requested to participate in work they are not used to and that may require additional effort when compared to traditional instruction (D. Allen & Tanner, 2005). Contrary to initial responses, when surveyed after completing active learning courses, students have expressed higher learning gains and higher departmental mean evaluations when compared to those in traditional courses (B. W. T. Lee & Jabot, 2011). Likewise, researchers have reported statistical significance when comparing lesson assessments of a traditional course with one that uses active learning (Fata-Hartley, 2011), while in other reports students show increases of half a standard deviation (Freeman & Eddy, 2014).
Gardner & Belland (2012) present a conceptual framework that describes active learning in Biology instruction. In their work, they present specific strategies used in these classrooms that echo the core approaches of student-centered learning by focusing on collaboration and the role of the instructor as a guide. These are:

- **Problem solving** – presents the student with real-world experiences through which they can identify important information and organize it (Gardner & Belland, 2012; Woodin et al., 2010).
- **Collaboration and discussion** – allows students to articulate rational of decisions they are making during the problem solving process (Gardner & Belland, 2012; King, 1993).
- **Animations** – demonstrate phenomenon in accurate and engaging ways. Students are able to visualize and sometimes manipulate what may be occurring at a microscopic level (Gardner Belland, 2012).
- **Technology-Enhanced Activities** – allow for students to engage other students and provide in-class assessments to measure student understanding. Other approaches allow for content management, and provide web-based assignments (Gardner & Belland, 2012).

As described by Gardner & Belland (2012), technology not only serves as a tool for engagement and student-centered practices, but can also facilitate the work by a faculty member in providing assessments or managing class material. This in turn allows for the repurposing of time that was traditionally allotted to classroom practices to other instructional goals.

**Active Learning Facilitated by Technology in STEM Courses**

In the book Teaching Machines, Marshall McLuhan is referenced as stating; “new types of media initially replicate the forms that preceded them until they can establish themselves as a medium that exploits their unique features” (Ferster, 2014, p. 18). While the book’s author continues to state that technological advances in education have followed the didactic method, practitioners have used technology to go beyond the “sage on the stage” and have used technology to facilitate their move towards the “guide on the side.”
**Integrating new technologies in instruction.** In the by work Cotner, Loper, Walker, & Brooks (2013), a traditional room was modified, arranging groups of 9 students with connections to technology such as an LCD screen, laptop computer connections, whiteboard space, microphones, and access to projection screens. Using ACT scores as predictors of student achievement in the class, students that were exposed to the modified technical learning environment and used active learning strategies outperformed expectations, while the control group without the technology did not. Moreover, instructors noted that their role had changed during the course to that of a learning coach or a facilitator (Cotner et al., 2013).

The use of technology may go beyond the incorporation of hardware into teaching. Other practitioners use similar accessibility to technology such as the LCD screens and other hardware tools to transform the way the instruction is delivered. Nogaj (2013) describes the transformation of a lower division Molecular Biology course from traditional instruction to one using active learning strategies incorporating technology to facilitate instruction. Students completed the course in a studio room with technology adaptations as described by Cotner et al. (2013), and combined active learning strategies with didactic methods of instruction. The didactic portion used modified Power Point presentations that did not include all the information for the lesson to promote student engagement with the material to complete the missing information. The room was designed to facilitate conversation and collaboration, and students were given the time during class to stop and share information or ask clarifying questions to each other. Active learning strategies included model building with Play-Doh, computer work, watching videos, and answering questions; here technology in the room facilitated group work and promoted collaboration among students. When compared with the traditional course, students performed equally or better, and were receptive to the newer learning strategies (Nogaj, 2013).
Rather than focusing on how technology facilitates student collaboration in a classroom, the work by Mayberry et al. (2012) describes how various instructors modified their teaching strategies to include the use of an iTouch. The device was used during this study to access resources, participate in class, and to produce student-generated content such as video recording of problem solving or visual representation of course topics. Some of the technology addressed in this study included the use of Web 2.0 strategies as recordings and uploading of videos to YouTube, microblogging through Tumblr, and communication tools like email and a course blog; other tools included the Google Suite for collaboration and pooling. Additionally, instructors also integrated many of the recordings and documents to be shared through the institution’s learning management system (LMS). Because of the availability to transfer course material like presentations into the online space, instructors described that their time during class was extended to focus on other activities (Mayberry et al., 2012). Moreover, participants note that student views of videos on YouTube were mostly recorded prior to an assessment but that viewings also increased at later times during the course, thus becoming permanent learning resources (Mayberry et al., 2012).

**The flipped classroom.** Some faculty have incorporated various technology approaches to reach larger classroom settings as those frequently used for STEM courses. The flipped classroom is a teaching strategy that combines various strategies to maximize the time students participate in active learning by incorporating the advantages of technology both inside and outside the classroom. Eichler & Peeples (2016) combine resources to define the flipped classroom as one that “…moves the content learning to a student centered out-of-class setting, usually using online learning technologies, and integrates problem solving activities into the lecture component” (p. 198). This type of approach can also be considered blended, where
blended learning is a fluid description that encompasses various forms of content delivery. The general consensus is that in blended learning, content is delivered between 30% to 70% online (I. E. Allen, Seaman, & Garrett, 2007; Graham, 2005, 2013; Watson, n.d.). This differs from other forms of content delivery where the course is supported or enhanced by online content less than 30% (web-enhanced) or, content that is delivered online more than 70% (distance education/online course) (I. E. Allen et al., 2007; Graham, 2005, 2013).

In their work Eichler & Peeples (2016) compared a general Chemistry course that used flipped strategies with another that did not. Both courses used additional resources as graduate assistants, student-response systems (clickers), online resources, technology-based homework, and quizzes to assist and assess student learning; both courses were evaluated with the same midterm and final exams. In the flipped classroom, students had to complete assignments that included video presentations, interactive tutorials, and quizzes. Once in class, instructors used clicker questions to evaluate student’s understanding and allow for “just-in-time” mini lectures to expand on the material (Eichler & Peeples, 2016).

When comparing both courses, authors found that the final scores were equivalent; neither the flipped classroom nor the traditional instruction outperformed the other. However, findings revealed that students in the flipped classroom showed better understanding of the specific class material through the in-class assessments (Eichler & Peeples, 2016). Researchers noted that the lower cognitive load associated with the use of online assignments better prepares students for the class than an approach which provides larger amounts of material in one sitting, such as in the traditional lecture. Furthermore, the similarity between the results of the teaching modalities is assumed to be associated with the effects of active learning strategies used in the control population, thus having a greater impact on long term learning (Eichler & Peeples, 2016).
Moreover, course evaluations showed students responded favorably to the introduction of technology and the use of innovation.

**Use of technology at a large scale.** While reports discussed show the effectiveness of active learning and how it can be facilitated by technology to address faculty concerns (Eichler & Peeples, 2016), they describe individuals or small groups of practitioners, not the use of technology by a department or a discipline. These individuals can be considered innovators or early adopters in their institutions and as such, may not be representative of the faculty at an institution. Furthermore, the general population of faculty members may not share characteristics with these innovators or early adopters, and are sometimes left to proceed with innovations on their own (Favero & Hinson, 2007; Garza Mitchell, 2011), or they may be less tech savvy than their own students (Favero & Hinson, 2007). These factors may limit the use of active learning practices or technology by all members of a group and reduce the strategy’s impact. Therefore, it is important to understand the integration of technology and the factors that facilitate active learning. Beyond their use, comprehending the use in the classroom focusing on student-centered practices, will allow for the distinction between best practices and evidence for Marshall McLuhan’s observation, employing the new technology as replacement of traditional teaching-centered approaches (Ferster, 2014).

**Adoption and Implementation of Technology**

In the past few years, there has been a strong emphasis on the diffusion of technology by government, private institutions, and individuals, leading to greater access to technology for teachers and students, at home and in school (Cuban, Kirkpatrick, & Peck, 2001). When describing the role of technology in the teaching-learning process, Whitehead, Jensen, and Boschee (2003) cite Gülbahar (2007, p. 944) describing it as a process that may lead to
“increased student writing, enhanced cooperative learning, enhanced integration of curriculum, greater application of learning style strategies, increased applications of cross-age tutoring, increase teaching communication, enhanced community relations, and enhanced global learners.”

All these characteristics not only enrich the learning process, moving towards student-centered practices, but also incorporate active learning strategies and cross-curricular communication as described by the Vision and Change report (Bauerle et al., 2009).

While access to hardware and software may be crucial for exposure, technology alone does not enhance pedagogy (Georgina & Hosford, 2009). In fact, if faculty are not provided with the right tools or training, many will return to their traditional practice and not use technology (Reid, 2014). Therefore, a distinction should be made between the access and use of technology, and the transformation in teaching practices that is achieved through the use of technology (Georgina & Hosford, 2009). For the purposes of defining this difference, the term “adoption” will be used to signify the institutional acceptance of technology for faculty that either use technology to replace traditional instructional methods with the technology, while still maintaining traditional teaching strategies. The term “implementation” will be used to refer to technology that will be used (or is used) to transform teaching practices.

**Models Describing Technology Implementation**

Frameworks that describe the process of adoption and implementation help to describe the population of faculty rather than focusing on individual practitioners, as evidenced in the literature. Importantly, these frameworks also serve as evaluation tools to determine the dissemination of the technology into faculty’s teaching practices. The frameworks described here show different aspects of the adoption and implementation process, focusing on how an
innovation is disseminated within a population, the use of the innovation by specific individuals, or the behaviors and beliefs leading to the implementation.

**Diffusion of Innovations.** Proposed in 1962 by Everett Rogers, Diffusion of Innovations “provides a theoretical framework for analyzing faculty technology adoption patterns” (Zayim, Yildirim, & Saka, 2006, p. 214). Rogers described the process by which an innovation, defined as something new for a particular group, is communicated through various networks (Rogers, 1995). Rogers’ framework describes how a process diffuses through the network rather than the reason for the diffusion (Straub, 2009). As an example, Zayim et al. (2006) used this model to describe the characteristics of the members of a population to determine features between adopters and non-adopters of technology within a medical faculty.

Through the elaboration of the diffusion model, Rogers defines stages for various components of the diffusion process (Rogers, 1995). During the decision-making process, the users may look for the information necessary to determine the usefulness of the innovation. Attributes of the innovation allow the users to determine the innovation’s functionality. Rogers describes the individual users and classifies them into various groups depending on their inclination towards acceptance or not of the innovation. Individuals within these classifications can be defined by characteristics associated with their aptitudes to change and risk (Rogers, 1995; Zayim et al., 2006). As mentioned in earlier sections, Rogers would categorize the participants of the implementation study’s innovators or early adopters. Together, these individuals would comprise approximately 15% of the total population, leaving the rest of the population in the early/late majority along with those that do not adopt the innovation.

**Concerns Based Adoption Model (CBAM).** With the goal of school improvement, education institutions introduce innovations and new procedures in the hope that such changes
will lead to improvement in student outcomes. CBAM serves as a tool to help describe and measure the components of an adopted initiative. While the Diffusion of Innovations framework focuses on the dissemination of the innovation, CBAM focuses on the process of adoption (Keengwe, Kidd, & Kyei-Blankson, 2009). Therefore, CBAM will look at the innovation adoption process as a mandate to consumers and the change leading to the implementation (Straub, 2009).

The CBAM framework identifies 3 major components that best facilitate the adoption process (Straub, 2009):

- **Stages of Concern** – Describes the concerns the adopters may have throughout the implementation process. These concerns may include personal, management, or concerns related to the impact of the innovation.

- **Levels of Use** – Describes the level at which the adopters are employing the innovation. These levels may range from just thinking about using the innovation, using the innovation in a mechanical way, or refining the innovation to achieve maximum results.

- **Innovation Configurations** – Determines the forms the innovation may have when being implemented by the various adopters.

As faculty members are assessed within the CBAM framework, their participation in the process of adoption is categorized and evaluated. As the user becomes more familiar with the innovation, they change over time (Favero & Hinson, 2007). Therefore, this model focuses on understanding the individual and their role in the adoption and implementation process. By understanding faculty’s levels of use, specific interventions may be proposed that allow for the movement of the user towards further implementation of technology in their classrooms.

**Unified Theory of Acceptance and Use of Technology (UTAUT).** Based on a study by Venkatesh, Morris, Davis, & Davis (2003) assessing the most common theoretical frameworks focusing on an individual’s adoption and use of technology, the UTAUT framework is the collection of the significant characteristics forming a unified model (Straub, 2009). “At the core,
the UTAUT model uses behavioural intentions as a predictor of the technology use behaviour” (Thomas, Singh, & Gaffar, 2013, p. 72). Therefore, the model focuses on the perceptions and beliefs of the user as it relates to the innovation. Additionally, modulators such as age, gender, education, and intention to participate also have an impact on the adoption of the innovation and are included in the model (Thomas et al., 2013). At the core of the model, 4 major constructs from the different models guide the understanding of the behavior: performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh et al., 2003).

Rahim et al. (2013) reviewed 174 research articles that use the UTAUT model to explain user acceptance of technology. While the review describes various areas of use, critics have brought to attention the multiple variables, and inconsistencies within the relationships (Thomas et al., 2013). Regardless of the criticism, researchers have used the framework where they have been able to confirm, while contradicting some of the relationships established (Thomas et al., 2013). Therefore, the model can be used to assess the behavior associated with a user’s adoption and integration process.

**Evaluation of the Implementation Process**

The general models of diffusion discussed previously can explain how an innovation is disseminated within a population (Diffusion of Innovations), the characteristics associated with the implementation of the innovation by specific users (CBAM), or the behaviors and beliefs associated with the individuals leading to the implementation (UTAUT); but these frameworks do not establish the degree of actual use associated with the innovation, or how the innovation is being used. Perception of use may vary, and various levels of use may be determined ranging from non-use to expansion or refinement of the innovation (Barron, Kemker, Harmes, &
Therefore, by establishing an evaluation process in which the use by the practitioner is determined, the level of integration of the innovation can be established.

**The Technology Integration Matrix (TIM).** Based on a K-12 system, the Technology Integration Matrix aims to assist teachers in enhancing their practices by integrating technology (Florida Center for Instructional Technology, n.d.). TIM uses both elements that characterize the learning environment and levels of integration into the curriculum. The characteristics of the learning space are those describing constructivist environments focusing on active, collaborative, constructive, authentic, and goal oriented practices. Likewise, the axis that describes the integration of the curriculum navigates a continuum from entry level, adoption, adaptation, infusion, and transformation. Similar to the levels of technology integration discussed by Barron et al. (2003) and established by the Apple Classrooms of Tomorrow project (Apple Computer Inc, 1995), as the matrix increases in the stages of integration to the curriculum, the practice becomes more student-centered. Furthermore, as discussed by the same article and echoing the benefits of integrating technology to teaching methods generally, teachers integrated technology on the basis that it afforded them more time to engage in other activities (Allsopp, Hohlfeld, & Kemper, 2007; Barron et al., 2003; Eichler & Peeples, 2016; Mayberry et al., 2012).

A recurring theme in the literature is that, if faculty members are not trained in the implementation process, many are left to implement it by themselves; and if they are not self-motivated, they may not complete the process (Allsopp et al., 2007; Favero & Hinson, 2007). Moreover, failure of learning the effective use of technology may induce a cycle of non-adoption (Straub, 2009). Therefore, TIM is a tool that goes beyond the evaluation by the CBAM framework of an instructor, but rather TIM serves as a professional development tool to assist in
the development and progression of the individual toward student-centered methods of instruction (Allsopp et al., 2007).

**Factors Influencing Implementation of Technology**

As the process of adoption by institution moves into the implementation process, it has been observed that the role of faculty training is crucial to maintaining the momentum generated by innovators or early adopters. In 2010, the non-profit organization Educause presented their list of challenges faced in teaching and learning. These challenges included (Garza Mitchell 2011):

- Creating learning environments that promote active learning, critical thinking, collaborative learning, and knowledge creation
- Developing twenty-first-century literacy among students and faculty (information, digital, and visual)
- Reaching and engaging today’s learners
- Encouraging faculty adoption and innovation in teaching and learning with instructional technology
- Advancing innovation in teaching and learning (with technology) in an era of budget cuts

Years later, we find ourselves still focusing on similar aspects as active learning and the implementation of technology for teaching and learning purposes. Therefore even though there has been support and investment in resources, technology is still not being fully integrated (Zayim et al., 2006).

**Barriers for Technology Implementation**

Zayim et al. (2006) discuss the technology adoption process by a medical faculty. In their work, they do not focus solely on the aspects that help the diffusion process, but rather explore barriers as perceived by the users. Some of these objections have been mentioned previously, while others were mentioned in the larger challenges for the field. Specific comments can be
summarized into general categories focusing on the lack of hardware for faculty and students; lack of support to supervise student use; no structure for faculty rewards (incentives); inadequate financial support, and lack of training.

- Additionally, other barriers are discussed by Reid (2014) which can be described as second order barriers, those that are described as personal:
  - **Effective use of technology** – While faculty in general have increased technical skills, they have not reached the level necessary to master the technology implementation. As mentioned by Favero & Hinson (2007), sometimes faculty are less tech savvy than their students.
  - **Resistance to change** – Mars and Ginter (2007) are referenced as saying that “[r]esistance is greater when faculty believe the technology is focused on increasing market share rather than improving teaching and learning (Reid, 2014, p. 398-399). Moreover, as a general population, faculty are described as highly resistant to change (Reid, 2014).
  - **Self-efficacy and background** – Faculty will be more willing to incorporate technologies they feel most comfortable with, but not those that require a major change. Likewise, those that are not in categories of innovators or early adopters by Rogers will usually be characterized by not being adventurous and mostly conservative (Rogers, 1995). Likewise, because they may not have instructional experience that included technology, they will replace current practices with technology without modifying the process (Ferster, 2014). Finally, the faculty’s assessment of their own technical expertise will limit their exposure.
  - **Perception of technology’s effectiveness** – Based on their own perceptions, many faculty members will not accept the data regarding the benefits of technology implementation citing limited rigor compared to traditional courses.
  - **Participation in professional development** – While the opportunities to participate in professional developments are sometimes available they may not be sufficient. Instructors need to master skills and knowledge to integrate technology into their courses.

As these barriers are presented in the literature, other factors are also combined with those described by Reid (2014). When considering motivation for faculty to implement technology that may have been adopted by administrators, Davis (1989) discusses other perception factors to be considered: perceived usefulness as the measure of how technology that facilitates the job or task, and perceived ease of use as the effort that must be exerted. These two categories can be included as expansion on Reid’s self-efficacy and background category.
While there are various examples of the barriers associated with the implementation process, the characteristics are not necessarily transferable to all institutions. Specifically, community colleges share features that distinguish them from 4-year institutions. The features that represent the student and faculty population, like factors associated with funding and governance present modulating factors that influence previously described situations. Thus, the next section will center the on the specific context of community colleges as the learning background for this study.

The Community College Environment

Reports have indicated that the first community college was established in 1901, originally serving populations transferring to 4-year institutions or for the workforce (Boggs, 2012). Gentry, Lawrence, & Richards (2016) state that "[r]ecent research suggests that almost half of all students who have completed bachelor's degrees during the 2013-2014 academic year had previously completed coursework at two-year institutions" (p. 536). At the same time, many community colleges have transformed themselves in the past century, and now offer baccalaureate degrees in applied fields, teacher education, and nursing (Boggs, 2012). Nonetheless, the many institutions have kept at their core to “(1) offer a terminal degree in a subject area, (2) provide the first two years of a four-year curriculum in preparation for transfer to a four-year institution, and (3) train students in technical or vocational degrees” (Boggs, 2012, p. 536).

Therefore, at the center of the community college is the goal of providing greater access to higher education (Boggs, 2012; Gentry et al., 2016). This affords access to diverse groups of students, mostly characterized as non-traditional. Defined by the National Center for Educational Statistics, some of the characteristics of the non-traditional student are those that have delayed
enrollment in postsecondary education by a year or more after high school graduation or attended only part-time; having dependents other than a spouse; being a single parent; working full-time while enrolled; being financially independent from parents; and, students that did not receive a standard high school diploma but earned some type of certificate of completion (“Nontraditional Student - Definition and Data,” n.d.). Moreover, the Center for Community College Student Engagement (2014) describes the characteristics of community college students as those that “attend classes and study while working; caring for dependents; and [are] struggling to balance personal, academic, and financial challenges.” While this is a large segment of the population and the average age is 28, interestingly 46% of student populations were reported in 2007 to be 21 years or younger (Boggs, 2012).

With such a diverse student body, specific features and challenges accompany the task of teaching and engaging these students. Given the focus of this study, the following section will be redirected towards the faculty that serve in community colleges.

**Community College Faculty Members**

Twombly & Townsend (2008) present a study where they focused on the community college faculty because they state that the body of work around this population is less extensive than that of the studies focusing on their university counterparts. In their review, they describe the community college faculty population as regional and not nation-wide. Thus “the localized nature of research makes it difficult to generalize findings across institutions and states or to assume the transferability of findings in the case of qualitative research” (Twombly & Townsend, 2008, p. 11).

Twombly and Townsend (2008) describe community college faculty as equally distributed between male and female, and as 80% predominantly white. When considering their
day-to-day work, faculty members predominantly focus on teaching with an average teaching load of five 3-hour courses per semester. These courses are predominantly lower division courses and there is little support for research. Twombly & Townsend further state that when considering faculty development and satisfaction, the work on development has focused on the institutions rather than the individual, and research has shown high satisfaction with their work. The description of the faculty concludes with the governance process, where the authors describe the existence of external factors such as state and national policies on topics of accountability and the growth of additional degrees, which have not been fully explored.

Given the diversity of the student population as non-traditional students compared to traditional students and the factors influencing the faculty (intrinsic and extrinsic), how topics such as STEM are addressed in this environment and the response to active learning become significant for this study. While active learning strategies have been used in various disciplines, it is important for this work to explore how community colleges have used these strategies in their teaching practices, specifically in STEM fields. The following section will explore these efforts in a specific course and as a comparison of active learning strategies between institutions.

**STEM and Active Learning in Community Colleges**

Efforts to engage students in deeper understanding and the implementation of the recommendations in the Vision and Change report have led faculty members to use active learning strategies. In a study by Edward, Mary, & Herzog (1997) the reaction of students in an Anatomy & Physiology course in a community college was assessed during a six-week course where the active learning strategy was introduced at the half-way point of the course. Students’ reactions were initially apprehensive and some complained throughout the study; however, most students found benefits in the use of the strategies by the end of the course (Edward et al., 1997).
In keeping with studies cited earlier, problems of class size and its impact on transferability, as well as initial student uneasiness are present in all learning environments. Moreover, the impact of active learning strategies is generally regarded as positive, with the view that the integration of these methods in traditional teaching approaches and assessments should be seriously considered.

Specifically addressing a call for change in introductory courses, D’Avanzo, Anderson, Hartley, & Pelaez (2012) discuss a faculty-development model that aims to change introductory Biology and Ecology courses. By using diagnostic question clusters, the researchers intended to assess student understanding of Biology concepts and to use active learning to support student learning. For this study, researchers compared various types of institutions including community colleges. Likewise, the universities and 4-year colleges that participated included one that was a historically black university, and three that were minority-serving institutions. In their conclusions, one of the key elements they describe is that there is no evidence of difference in the performance between institutions, when measuring faculty-engagement and student performance (D’Avanzo et al., 2012).

These reports show that while both students and faculty may have very individual characteristics compared to other institutions, using active learning strategies students’ general response to the use of a new teaching approach and the impact on student engagement and performance is comparable, regardless of the institution.

**Literature Review Summary**

The literature review presented in this study has explored the response to a national drive for transformation in STEM undergraduate education, along with the impact that this movement has had in the use of technology to facilitate implementation strategies. Wood (2009) describes
the causes that move forward these efforts within the United States as (1) a deep concern about the role of the nation on the world stage because of decreased retention of students in the STEM areas and (2) the developments in education and new understanding on how students learn. Therefore, it is important to understand the best practices and those which have been identified as making an impact in the classroom, to focus on student engagement and achievement.

Student-centered strategies have been identified as practices that increase student involvement with the content, bring their attention to STEM courses, and engage students in science-like practices. These approaches help students construct their learning while the instructor serves as a guide. Specifically, active learning has been implemented in STEM courses focusing on the development of student’s inquiry and trying to go deeper in the “why.” Reviewed reports describe how the use of active learning practices has helped STEM instructors engage their students and deepen their understanding of the subjects.

Various approaches have been described as effective, but they have also been met with criticism associated with the time investment and the impact on curriculum. Thus, faculty have explored the use of technology to facilitate active learning strategies and to address said critics. The implementation of technology like hardware, manipulatives, interactive technologies, and flipped classrooms, have been identified as strategies to engage with students. Moreover, literature reviews have also addressed the use of technology in large enrollment courses, representative of the traditional introductory STEM courses. Therefore, this research presents the use of technology as an alternative to address faculty’s concerns while still implementing student-centered strategies, focusing on active learning.

Although the literature presented shows the positive impact of technology facilitating active learning practices, they focus on individual class but did not study impact at an
institutional level. To impact larger populations, understanding the implementation of technology at an institutional level is necessary. Thus, this study evaluates models that describe implementation of technology. A focus on different aspects and participants of the diffusion process is central for each of the implementation models. As this study focuses on the faculty members’ perspectives regarding implementation, the UTAUT model serves as a framework to understand their beliefs and factors influencing their implementation process. Moreover, factors described in the literature are explored influencing faculty’s decisions about technology or barriers to the implementation process. Understanding implementation at the individual level will provide insight into the institutional process.

The last section in this literature review was an exploration into the characteristics of the community college environment, focusing on both students and faculty, in addition to student engagement efforts that show that there are no identifiable differences in the struggles of faculty at these institutions and others. Thus, it is implied that the strategies that have been successfully implemented in other educational environments may also be effective in the community college to engage STEM students, and help faculty members facilitate active learning practices in these courses by using technology. At the same time, while various examples at 4-year institutions and community colleges regarding the use of technology, the implementation process, and active learning in STEM courses have been described, the characteristics of population demographics and size of the institution that serves as context for this study provide important information previously not described.
CHAPTER 3
METHODOLOGY

The goal of this study was to explore the use of technology by full-time faculty members to facilitate active learning strategies in STEM courses, along with factors that influence their integration of technology. In this chapter, the methodology used for the study is presented, starting with the purpose, research questions, professional context where the research was performed. This is followed by a description of the students and faculty populations, the theoretical framework and research design. The chapter ends with a discussion of rigor, limitations, and ethical considerations associated with the study.

**Purpose of Study**

The goal of this study was to determine how faculty members use technology to facilitate active learning strategies in STEM lecture courses, and what factors influence the adoption and integration of technology. The main research question was, “how are active learning strategies facilitated with the use of technology in STEM lecture courses taught by full-time faculty?” To explore these questions, the following sub-questions were addressed:

1) How are full-time science faculty members using technology to facilitate active learning in lecture STEM courses?

2) What factors influence full-time STEM faculty’s integration of technology to facilitate active learning?

**Context of Study**

The institution that served as a focus for this study is a large enrollment institution within the Florida College System composed of 8 physical campuses and a Virtual College within county, and one of the largest institutions of higher learning in the United States. This institution served over 92,000 enrolled students during the 2014-15 academic year, consisting primarily of
members of various minority groups. In addition to an Associate of Arts degree with several pathways, multiple certificates and Associate in Science degrees focusing on workforce training and development, as well as ten bachelor degree programs are offered. Covering 7 campuses of the institution, the School of Science provides various degrees and certificates as well as a Bachelor of Science in Biological Sciences. The School of Science aims to provide hands-on experiences for students to acquire practical skills, increase student engagement, and improve student understanding of the usefulness of science in the “real world”.

**Students.** The population is ethnically diverse; 7% White non-Hispanic, 18% Black non-Hispanic, 71% Hispanic and 4% from other ethnicities. While the institution provides bachelor degrees, the student population displays characteristics of two-year community college students (Center for Community College Student Engagement, 2014). Many of the students of the School of Science seeking STEM degrees are identified as underrepresented minorities from low-income families, as well as first time college students.

**Faculty.** The School of Science is comprised of 75 full-time faculty members in addition to many adjunct faculty instructors at the different campuses. The full-time faculty is 64% male and 36% female. Regarding time at the institution, 49% of the faculty members have taught at the Institution nine years or less, 34% have taught between ten to nineteen years, 11% have taught between twenty and twenty-nine years, and 7% of the faculty have taught at the Institution for thirty or more years. Of these, 16% are at various points along the tenure-track, while the remaining 84% of the faculty have already received continuing contract status.

Full-time faculty members are assigned a teaching load of 5 three-credit hour courses in the fall and spring semesters, and 2 three-credit hour courses during the summer. Science faculty may choose to teach any combination of lecture or laboratory STEM courses to fulfill their
academic load. Both lecture and laboratory courses may be designated as web-enhanced to signify the use of technology in the class. Each faculty member determines the extent and use of technology in the individual courses.

**Technical Resources.** Institutional resources are available to all employees and students to provide an environment in-line with the institution’s vision for teaching, outreach, and lifelong learning. Through the Office of Information Technology, the institution bridges all campuses providing services, security, and management. In collaboration with the Center for Institutional and Organizational Learning (CIOL), various training sessions are provided to faculty and staff providing learning opportunities and access to available technologies. Some of the technologies accessible for faculty members include: Blackboard as learning management system; interphases with publisher provided material; access to Turnitin; NBC Learn; Panopto, and access to cloud services from Microsoft Office 360. Technology integration workshops and specific training sessions focusing on mention tools, in addition to others, are available through CIOL. Likewise, best-practices workshops and discussions, including those focusing on technology use, are offered during professional development days during college-wide convocations.

In addition to software availability, hardware components are present in all classrooms and science laboratories across the Institution. Each learning area is equipped with an instructor station hard-wired for Internet access and access to college and campus-wide networks are available. Moreover, all classrooms and science laboratories are equipped with projectors connected to room controls that provide access to overhead projectors, audio and visual players (VCR and DVD), input for external devices through VGA adaptors, and in recently remodeled campuses HDMI inputs. In science laboratories, microscopes are also connected to the room control for projection of samples through the room’s system. Computer laboratories are also
accessible for classes and the libraries on each campus provide computers for Internet access. Moreover, Internet may also be accessed through a college-wide open access wireless service.

Theoretical Framework

As described by Venkatesh, Morris, Davis, & Davis (2003), adoption of technology by an individual is the intersection of various factors that form the individual’s perceptions and beliefs about an innovation. Other modulators such as age, gender, education, and intention to participate also have an impact (Thomas et al., 2013). Thus, an understanding of how faculty members use technology to facilitate active learning strategies in STEM lecture courses will likewise be subject to these factors. Thus, this study is framed within the Unified Theory of Acceptance and Use of Technology (UTAUT) model.

As faculty members choose to implement technology, core aspects of the UTAUT model played an integral role—especially behavioral intentions and use (Venkatesh et al., 2003). The way a faculty member intended or planned to use the technology was influenced by aspects such as (1) performance expectancy (will the technology work for my class?); (2) effort expectancies (will this be more work for me?), and (3) social influence (am I the first to use this? This works for others; will it work for me?). Likewise, the behavior associated with a faculty member’s actual use is influenced by the factors that help the implementation of the technology (does the institution provide professional development/training? Will someone help if I have questions?).

Modifying factors also impact core aspects and influence intentions and use. As all the factors came together, the belief associated with the technology takes shape and this impacts the implementation process. Analysis outlined within the UTAUT model allows for framing and interaction of these factors. Furthermore, understanding the belief of participants allows for the
development of better practices in the advancement of active learning strategies facilitated by technology in STEM lecture courses.

Exploration of a faculty member’s use of technology and factors that influence their adoption and integration, provide insight into what determines their practice. While some technology adoption models focus on the dispersion of the innovation within a population, others focus on actual use of the innovation; UTAUT focuses on the participant and what they bring to the process of adoption and integration. In this study, the UTAUT model was used to understand faculty members’ approaches and perceptions of technology use and to identify factors related to that use.

**Research Design**

This study used an exploratory qualitative approach consisting of interviews to uncover (1) how faculty use technology to facilitate active learning in STEM lecture courses and (2) what factors influence their integration of technology in their practice.

First, a stratified analysis of the members of the School of Science was performed. Modulating factors such as gender, STEM discipline (Biology, Chemistry, and Physics), and years at the institutions (seniority) were used to determine the faculty’s distribution. Using identified parameters, faculty members representative of the category distribution were asked to identify as “using technology in their classrooms” and later invited to participate in the study. Participants that accepted the invitation were scheduled for an interview that focused on the use and factors that influence participant’s implementation of technology. To address the research questions, Table 3-1 shows the alignment between the research sub-questions, the instrument and the information gathered.
<table>
<thead>
<tr>
<th>Research question</th>
<th>Data source</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>How are full-time science faculty members using technologies to facilitate active learning in lecture STEM courses?</td>
<td>Interview</td>
<td>Thematic analysis; review of faculty technology integration into curriculum.</td>
</tr>
<tr>
<td>What factors influence full-time STEM faculty’s integration of technology to facilitate active learning?</td>
<td>Interview</td>
<td>Thematic analysis; identification of emerging codes and categories.</td>
</tr>
</tbody>
</table>

**Data Collection and Sampling**

To explore full-time STEM faculty’s use of technology and the factors that influence implementation, stratified sampling (Parsons, 2005) followed by convenience sampling (Etikan, 2016) were performed to identify faculty members to invite to contribute to this study.

**Sampling**

Using parameters established by the UTAUT model (Venkatesh et al., 2003), stratified sampling was performed on members of the School of Science based on years teaching at the college, gender, and discipline. Parameters of the UTAUT model of gender and experience were used to represent the strata of the School of Science. The age parameter described in the UTAUT model was not used because of the heterogeneity of the full-time faculty. Moreover, faculty members’ identification as technology users implied a voluntariness of use.

**Years of experience at college.** For this study, experience was defined as the time the faculty members had been teaching at the institution instead of the experience with the technology. Thus, faculty selection was based on years of experience as full-time faculty members. The identified distribution shows that 49% of the faculty members have taught at the Institution nine years or less, 34% have taught between ten to nineteen years, 11% have taught between twenty and twenty-nine years, and 7% of the faculty have taught at the Institution for
thirty or more years. Therefore, the selected faculty members were representatives of each of the categories. Moreover, because 16% of faculty members are in different time-points of the tenure-track, the category of those teaching less than 9 years included participants that have not yet received continuing contract status.

**Gender.** Faculty members in the School of Science were identified to be distributed 64% male and 36% female. For this study, it was determined that the gender distribution would be represented by 3 male participants and 3 female participants. Potential participants were approached using these parameters.

**Convenience sampling.** Participant selection followed by a convenience sampling, where identified participants would serve as representatives of the various strata. Once individuals were identified, they were approached sequentially based on strata and asked to identify as technology users. If they acknowledged being technology users, they were then invited to participate. One faculty member teaching more than twenty years was approached and agreed to participate. Four potential participants were approached that had taught at the institution between ten to nineteen years; two agreed to participate. Finally, the last three participants approached with nine or less years at the institution agreed to participate, two of these participants had not received continuing contract status (as of the time of the study). Faculty members from the School of Science were then scheduled to participate in an interview through an email (Appendix A).

**Data Collection**

Participants were invited to contribute to this study through an interview that focused on use of technology and factors that influence the implementation of technology. After participants agreed to contribute (consent form – Appendix B), an interview was scheduled probing for their
use of technology and factors that influence their adoption and implementation of technology (interview protocol – Appendix C). The interview protocol was based on the UTAUT model, which focused on (1) how faculty members are using technology and (2) what factors influence the adoption and integration of technology in lecture courses.

**Interview Protocol.** While other methods of technology adoption and implementation describe the use of the technology, they do not describe the intentions of the user towards the technology or factors associated with its use. As the empirical combination of various models for technology acceptance and use, UTAUT identifies three factors that directly influence the intention to utilize technology: performance expectancy, effort expectancy, and social influence (Evers, 2014). Furthermore, it identifies two factors focusing on the user’s behavior, facilitating conditions and behavioral intention. Table 3-2 shows the various components of the model with the associated definitions for each factor.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance expectancy(^1)</td>
<td>The degree to which an individual believes that using the system will help him or her to attain gains in job performance.</td>
</tr>
<tr>
<td>Effort expectancy(^1)</td>
<td>The degree of ease associated with the use of the system.</td>
</tr>
<tr>
<td>Social influence(^1)</td>
<td>The degree to which an individual perceives that it is important and others believe he or she should use the new system.</td>
</tr>
<tr>
<td>Facilitating conditions(^2)</td>
<td>The degree to which an individual believes that an organizational and technical infrastructure exist to support use of the system.</td>
</tr>
<tr>
<td>Behavioral intentions(^2)</td>
<td>A person’s perceived likelihood or subjective probability that he or she will engage in each behavior.</td>
</tr>
</tbody>
</table>

\(^1\)Direct relationship to behavioral intentions  
\(^2\)Direct relationship to actual user behavior

This study used a modified form of the interview protocol presented by Evers (2014), which examined the intention of healthcare professionals to use an application for telemedicine. Research conducted by Evers (2014) showed that models used to explain factors influencing intent or actual use were not able to explain these intentions. Thus, researchers used a UTAUT
based model for their interview protocol. Modifications to this protocol were done to adapt for the current study, such as the substitution of the telemedicine application with active learning. Likewise, the protocol presented by Evers (2014) asked about the role of the participant regarding the development of the application, while in this study the questions were modified to ask the participant about the adoption and integration of technology.

The protocol allowed for open responses from the participants to questions addressing the factors presented in Table 3-2. The interview process was between 25 to 40 minutes and it was audio recorded. The questions for the interview are presented in Appendix C, the interview guide.

**Researcher journal.** During the process of data collection, a researcher journal was kept tracking observations and trends identified throughout the different stages of this study. The journal allowed for reflection during the data collection process to present experiences, bias, and thoughts throughout the study (Creswell, 2013). Entries were made during the interviews, coding and data analysis; in addition to informal conversations with peers or colleagues regarding the study. Journaling and continuous revision of these entries allowed for a reflective practice throughout the duration of the study.

Notes gathered during the interview, coding, and analysis portions of the study were included. Finally, all reflections regarding the process were also included serving as a journal of my individual experience part of the study.

**Data Analysis**

Interviews with faculty members were analyzed to describe the use of technology and helped identify factors that influenced faculty when adopting and integrating technology. The interview protocol analysis focused on open coding (Creswell, 2013), later organized into
categories identified in the participant’s interviews, regarding the use of technology in addition to factors that influenced the adoption and integration process and correlated with those identified in the literature.

Interview transcripts were reviewed for accuracy in transcription and to increase familiarity with participant’s responses. Open coding of the transcripts produced abstract codes that were organized using coding software to facilitate the identification of codes in each document, and used to review for consistency throughout the various interviews (Creswell, 2013). Peer coding (Saldana, 2012) was used as comparison to corroborate identified codes, and identify any previously undetermined codes. Comments, annotations, and perceptions were collected in the research journal as a record of the experiences and included as part of the analysis when necessary. Codes were organized and examined into categories to consolidate the data and reviewed to ensure that all identified codes were included. Once all codes were considered and categories were established, general categories were examined using all the participants’ interviews to identify common uses and factors that influence the adoption and integration of technology in STEM lecture courses at the Institution.

**Professional Role**

As a faculty member in the School of Science, I was part of the team that participated in the SERP-I workshop and served as a leader at my campus to promote the integration of active learning strategies. I was also part of the team that presented the progress at the 2015 Association of Southeastern Biologists conference and served as alumnus during the 2016 SERP-II workshop and facilitator for the new members of the institution’s team. Likewise, I have spearheaded the piloting of the use of BioBeyond, provided by Smart Sparrow, as a platform for blended learning
in a non-major’s Biology course, and served as one of two faculty presenters during the 2016 School of Science faculty retreat.

BioBeyond and Habitable Worlds are adaptive learning platforms provided by the company Smart Sparrow. Both these platforms have been designed by the InSpark Teaching Network, a partnership between the Center for Education Through Exploration at Arizona State University and Smart Sparrow, with grants from the Bill & Melinda Gates Foundation and NASA (Smart Sparrow, n.d.). As part of the platform, students pay a one-time fee of $25 per semester to access the course’s units and lessons. Because of my participation and the interest of the Dean of the School of Science to implement this technology at a college-wide level, an implementation and diffusion grant was awarded during the 2016-2017 academic year by the InSpark team to extend the use of the platforms to other campuses and courses.

As part of this grant, my role is as faculty leader and bridge between the company and the faculty members facilitating adoption and use in the courses. The funds for the grant were allocated to cover the student’s access to the platform; thus, I did not receive monetary remuneration for my participation. No research component was included as part of the diffusion and implementation grant, but an application to the institution’s Internal Review Board has been approved to review the impact of the platform on the student population as part of the evaluation of the overall impact of the platforms for their grants; I assisted in the de-identification of the data by the evaluating team. I have provided faculty with my syllabus during my pilot course and assisted with technical aspects regarding navigation of the platform and integration with the learning management system (LMS).

My professional role at the institution is tied to this study from various aspects. As a faculty member in the School of Science, I have integrated technology in the classroom and have
served as a resource to colleagues. Because I am a member of the full-time faculty, some participants have a direct relationship with me as a colleague. Therefore, some participants may have felt the necessity to answer providing responses they assumed I was expecting. Moreover, I have also participated in teams that are active in the support in use of active learning strategies. Altogether, my involvement with active learning initiatives may have discouraged some faculty members from participating because their learning strategies are not those I have supported. Moreover, the use of technology in STEM courses and how participants use these tools or strategies in class could have affected the study, becoming a limitation with impact on participation and data gathered. The invitation to participate, the informed consent form, and my introductory conversation during the interview made it explicitly known that participatory outcomes would not affect their jobs or my relationship with them in any way.

Altogether, I believe that active learning facilitates student learning and that technology can facilitate this approach. These beliefs constitute a bias within the study. While active learning has been promoted as a learning approach, this is not the only strategy that may be used to engage students in STEM. Moreover, effective active learning may occur in classrooms without the use of technology.

Rigor

Attention to rigor when collecting the data allowed for validation and dependability of the data analysis (Barnes et al., 2013). The modified protocol from Evers (2014), was discussed using a Think Aloud interview with a faculty member non-participant of the study, to determine the clarity of the questions and that what was intended was being asked (van Someren, Barnard, & Sandberg, 1994). The data from the interview was subjected to coding by a peer-reviewer. This process allowed for the corroboration of codes originally identified and the inclusion of
others that had not been classified. Likewise, it served to identify repetitions that served to validate the identified codes. Moreover, the determination of categories and codes from interviews were also subject to peer-review, thus increasing the rigor and minimizing bias. Finally, journaling during the data collection and analysis portion was used to determine any bias included in the process. Review of the journal served to collect thoughts during the interviews that were later used to determine if analysis and interpretation were biased analysis or actual events and descriptions annotated. Moreover, ideas collected during the analysis process were also included in the research journal and reviewed to determine any possible bias associated with the analysis. Through the scrutiny of the qualitative data, generalizations that describe the participants that comprise the School of Science STEM faculty were achieved.

**Limitations**

This study contained several limitations relating to design. Differences among the faculty participants impacted the potential for triangulation of the data between the interviewees. The levels of technology use and integration by each participant in addition to their understanding of active learning strategies, and how they are implemented into their practice also provided restrictions. Moreover, the small number of participants compared to the population of the School of Science confines the analysis to these specific faculty members. Furthermore, participation in this study began with individuals that self-identified as a technology users. Thus, data from other faculty members that may not consider themselves technology users, but use technology in their practice was not available. Additionally, member check of the codes was not performed during this study. Therefore, interpretation of the participants’ comments gathered during the interviews were not verified to corroborate participants’ agreement with the analysis.
Summary of Methodology

During this chapter, the purpose of the study (its context and its participants) is discussed. The instrument used for the collection of data is explained, as well as the analysis that followed. Finally, the rigor, limitations, and ethical considerations associated with the study are further explored.
CHAPTER 4
RESULTS

The goal of this study was to determine how faculty are using technology to facilitate active learning strategies and what factors influence the integration of technology. To facilitate this understanding, an exploratory qualitative analysis was performed to answer the research questions. This chapter presents a description of the participants in the study, what type of technology full-time faculty use, and what factors influence the integration of technology in STEM lecture courses.

Introduction of Participants

The institution in this study is composed of eight physical campuses and the Virtual College within the local State county. Covering seven campuses within the institution, the School of Science oversees various degree and certificate programs as well as a bachelor of science in biological sciences. Full-time faculty members in the School of Science may choose to teach any combination of lecture or laboratory STEM courses to fulfill their academic load. Both lecture and laboratory courses may be designated as web-enhanced to signify the use of technology in the class. Each faculty member determines the extent and use of technology in their individual classes.

For this study, six faculty members of the School of Science participated in an interview that focused on their implementation of technology to facilitate active learning and the factors that influenced the integration of these technologies. Participants were selected using the same distribution of gender, years in at the institution, and discipline as those found in the School of Science, and given pseudonyms to protect their identity (Table 4-1).
Table 4-1. Participants in study

<table>
<thead>
<tr>
<th>Name</th>
<th>Gender</th>
<th>Seniority</th>
<th>Discipline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andrew</td>
<td>Male</td>
<td>24</td>
<td>Biology</td>
</tr>
<tr>
<td>Brittany</td>
<td>Female</td>
<td>4</td>
<td>Chemistry</td>
</tr>
<tr>
<td>Catherine</td>
<td>Female</td>
<td>15</td>
<td>Biology</td>
</tr>
<tr>
<td>Diana</td>
<td>Female</td>
<td>1</td>
<td>Biology</td>
</tr>
<tr>
<td>Eddy</td>
<td>Male</td>
<td>13</td>
<td>Chemistry</td>
</tr>
<tr>
<td>Frank</td>
<td>Male</td>
<td>8</td>
<td>Physics</td>
</tr>
</tbody>
</table>

During the interviews, notes were collected in the research journal, to describe each participant. These records assisted in understanding the personalities of the participants and perceived thoughts during the interviews. The following sections describe participants individually.

**Andrew.** The most senior participant, has worked at the institution for 24 years, has achieved continuing contract status, and teaches in the Biology discipline. He teaches both lectures and laboratory courses mostly the lower division Microbiology courses, these courses are focused on students that have a desire to continue in nursing and physician assistant transfer programs. During the interview, he addressed many of the questions addressing the student’s experience and the benefits that any strategy, resource, or technology would provide the students. Most of the teaching described was student-centered and he showed comfort with technology; he spoke freely about various tools like mobile devices, multimedia tools, and learning management systems.

During the interview, he focused on students’ life outside the classroom and made comments about the learning environment and how the use of technology should be about students. Many of his comments compared his experiences in the past, discussing how things were before technology was ubiquitous as a resource. He shows a bias towards the use of technology, as he looks positively at the introduction of technology into the learning
environment. He made comments related to the use of technology in everyday experiences for all. Finally, he placed emphasis on the importance of technology and that not embracing it would lead to being left behind.

**Brittany.** She began her career as an adjunct professor and earned full-time status four years prior to this study. At the time of the study she had not yet received continuing contract status, which she will apply to at the end of her 5th year as a full-time faculty, and she teaches for the Chemistry discipline focusing on lower division courses including introductory courses of STEM majors, Organic Chemistry, and Chemistry courses for students that have a desire to continue in nursing and physician assistant transfer programs.

During her interview, she described how technology facilitates the amount of work she must do, mostly because she teaches large enrollment courses with ~120 students per section. She is the only participant that teaches that volume of students in a single section. Most of the technology she spoke about she received from publishers. Even though she completed training for Blackboard (the learning management system in use at the college), she still feels deficiencies on how to use the platform. For her, time investment is important as it relates to grading, providing students with feedback, learning new technologies, and reviewing the material within the resources as she prepares for teaching her courses. She mentioned that using technology is easy and relates technology’s learning curve with the time she needs to invest to understand how it works; steeper learning curve, more time investment. She considers herself a technology user, compared to her peers.

**Catherine.** She has worked at the institution for 15 years, has achieved continuing contract status, and teaches in the Biology discipline. She teaches both lectures and laboratory courses, focusing in lower division Biology. Courses taught by Catherine include introductory
Biology courses for STEM majors, Anatomy & Physiology course for non-STEM majors, and Anatomy & Physiology courses for students that desire to continue in nursing and physician assistant transfer programs.

During her interview, she wanted to focus on developing student’s responsibility by determining hard deadlines for assignments. She considers the process of preparing and reviewing courses part of the learning curve associated with technologies. She provides various technologies as resources for students, each with their own independent learning curve, but described how using familiar systems facilitates the learning process for her. She mentioned that students use technology in questionable ways when completing assessments, and has various strategies to minimize these actions. She thinks technology can be used to simulate experiences in the laboratory, but has strong opinions about having laboratories taught fully online. She describes how technology can be used to increase student engagement. Her initial use of technology was not focused on active learning but by using technology she has been able to use it for that purpose.

Diana. She began her career as an adjunct professor and obtained full-time status one years prior to the study. She does not have continuing contract status. She teaches lower and upper division Biology lectures and laboratory courses; her focus is both animal and Molecular Biology courses. She began the interview by clarifying the definition of active learning and proceeded to provide examples of use in her class. She named various active learning strategies and focused on multiple opportunities for student participation. She uses instructional databases and centers her instruction on student control of the information.

She promotes the use of technology even when students voice resistance. She has a positive demeanor about technology and described multiple occasions where she uses technology
in preparation for class, during the class, and outside of the classroom as it related to her area of research in the field of Genomics. She is knowledgeable about computer software and has a basic understanding of coding that she used to analyze data during her doctoral studies. She can describe technology beyond that provided by publishers, and believes that exposure to technology facilitates student’s familiarity and understanding of how to use the tools.

**Eddy.** He has worked at the institution for 13 years and has received continuing contract status. He teaches for the Chemistry discipline focusing on lower division courses including introductory Chemistry courses of STEM majors and students that desire to continue in health-related transfer programs. He uses technology to facilitate communication and understanding because of what he describes as his “thick-accent”. He compares the use of his notes to students’ access to textbooks, where in both cases students may misuse the resource. He understands technology, but compared to other participants does not appear to have full knowledge of all potential uses. He considers himself to “not have known technology” prior to joining the full-time faculty and reports that his knowledge has been attained through professional development opportunities; through these learning possibilities he improves his teaching.

Eddy considers himself and faculty hired after him to be technology users, compared to faculty that were hired prior to him in the Chemistry department. Regarding faculty use of technology, he believes that some of his peers do not use technology correctly. Additionally, he described experiences where he observed students using technology in questionable ways, and claims that students rely too much on resources available through technology and do not prepare appropriately for class assessments.

**Frank.** He began his teaching career in middle and high school environments. He has been at the institution for eight years and has received continuing contract status. He teaches in
the Physics discipline focusing on lower division courses including introductory Physics courses for STEM majors, these include students interested in the natural sciences (Biology, Chemistry, Physics, and Mathematics) and students focusing on engineering careers. He uses technology as a method of engagement and described the use of various technologies in tandem.

Through his technology use, he focuses on maximizing class time, facilitating instruction, allowing improvisation during his class, and just-in time instruction. His use of technology centers on showing students what he is teaching. For him, technology is a tool. He identifies himself as different from the students in his views about technology, but he is versatile in the language and tools available. From those resources available, he understands that while there is institutional and departmental support, there needs to be constant updating of the systems. Throughout the interview, his focus was on student learning.

Use of Technology to Facilitate Active Learning in STEM Lecture Courses

This section focuses on the type of technology used by faculty members in STEM lecture courses and for what purpose this technology is being used.

Type of Technology Used by Full-Time STEM Faculty

To understand how technology was being used by full-time STEM faculty, the type of technology being used by faculty was determined. All instances mentioning technology were listed, coded, and categorized, resulting in three codes including communication, hardware, and resources (Table 4-2).

Communication. Codes cataloged under this category correspond to instances where participants mentioned technology as a form of communication, during class or outside of the classroom. The two codes grouped included social media and student response systems. Frank mentioned that “I don’t have Twitter and I know there are advantages of using social media in
Table 4-2. Codes and sub-codes from identified types of technology

<table>
<thead>
<tr>
<th>Code</th>
<th>Sub-codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>Social media</td>
</tr>
<tr>
<td></td>
<td>Student response</td>
</tr>
<tr>
<td>Hardware</td>
<td>Hardware</td>
</tr>
<tr>
<td></td>
<td>Technical equipment</td>
</tr>
<tr>
<td></td>
<td>Wireless</td>
</tr>
<tr>
<td>Resource</td>
<td>Database</td>
</tr>
<tr>
<td></td>
<td>Learning Management System</td>
</tr>
<tr>
<td></td>
<td>Multimedia</td>
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<tr>
<td></td>
<td>Online</td>
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<tr>
<td></td>
<td>Software</td>
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<td>Visual</td>
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class…” Here, he discussed how social media tools would help communication outside of the classroom, but he was apprehensive about using it because of concerns about his privacy. Likewise, Brittany mentioned clickers as student response systems that would allow her to collect information from students rather than collecting packets of papers.

**Hardware.** Examples within this category included physical tools that participants mentioned and wireless technologies including object and access to wireless fidelity (WiFi) tools. This category also included several examples of hardware, technical resources, and wireless tools. Phones as hardware were mentioned by all participants except for Catherine, and other examples during the interviews included computers, projectors, tablets, data storage devices (USB flash drives), and white-boards. Andrew discussed during his interview how he learned to use Macintosh computers during his doctoral studies and when he was hired he had to learn how to use personal computers (PC) with a different operating system. Furthermore, Eddy shared that “[m]y notes are at the back of me on the board and I will be just talking to them without even looking at the notes.” In another instance, he described how he used the board to discuss the progression in mathematical calculations during a Chemistry class.
“Technical equipment” included participants’ description of equipment associated with laboratory experiences and tools used for specific techniques in these settings. Some of these examples include microscopes, motion detection tools, and gas chromatograph coupled to a mass spectrometer (GC-MS). Moreover, the “WiFi tools” included the description of wireless equipment and devices in addition to the connection to the networks through WiFi. Andrew described how he has “a wireless mouse and a wireless keyboard in class and it moves around the room, so the students can input data on the screen…”

**Resources.** Technology that was associated with facilitating a process or access to information was categorized as a “resource”. From these tools, faculty obtained information that they would use to complement instruction in addition to obtain, store, and process information. Sample codes within the resource category include: databases, learning management systems (LMS), multimedia, online, software, and visual tools.

Diana, for example, used databases from the National Center for Bioinformatics Information to obtain peer-reviewed articles and information that she used in class for analysis. Likewise, she used educational databases to collect resources she would use in class to provide students with data about certain course topics or instructional strategies. All participants mentioned various LMS platforms like Blackboard, Desire2Learn (D2L), and those provided by publishers like Mastering from Pearson Education and Connect from McGraw-Hill Education. These platforms served to store information for classes, communicate with students, provide assessments, and as a repository of information from the publishers. Catherine discussed how she uses the technology from the publisher in her Biology class “they have videos which I use in class too, it gets their [the students] attention and it helps them to visualize what’s happening inside body.”
Many participants discussed multimedia resources provided by the publishers in addition to other sources such as animations, videos, YouTube, and massive video discs. Andrew recalled a time when he only had access to technology through a dedicated media laboratory; now, all classrooms are equipped with multimedia. Most of the multimedia resources were also linked to the platforms within the online space. Participants discussed online assignments, access to Adobe Cloud, websites, and emailing.

Resources classified as software were used by participants to process information including, Microsoft Word, PhET, R and SAS (both statistical programs), Mathematica, and a geographic information system (GIS). Diana shared how she used some of this software in her class:

There's games that you can do, statistical games and things like that where you have predator-prey interactions and things like that and I thought it would make it easier for me to say, ‘okay, now look at how what happens when you force this population to do this’ and it does…

Other examples included the lecture recording management software Panopto. Frank described how he used animations in Flash for his Physics courses, while others described how they used an adaptive learning platform called BioBeyond in Biology courses.

Finally, visual tools have been used by faculty to record information or enhance current technologies. Andrew uses this tool in his laboratories “[i]n all my life, people probably know this already, digital photography is a part of all my lab[oratories]s. Students take pictures of procedures, results, techniques, of every part of the experiment.” Likewise, he combines microscopes a technical resource described earlier, to collect information about microbes during his Microbiology laboratories. Other faculty discussed how they used transparencies, flash cards, graphics, and pictures in their class. While discussing the dialysis process in his Chemistry class
for nursing majors, Eddy shared “I cannot just picture how it will be, explaining to them what happens, how the blood is drawn, go in the body and coming back. I have live pictures or a lot of video type of that that I could use…” Once the information about the technology they used was collected, the following section focused on the integration of technology.

**Integration of Technology by Full-Time STEM Faculty**

Participants were asked about their use of technology following the UTAUT interview guide. Throughout the interview, participants shared their experiences with technology, provided examples of their current use and insight in future possibilities of integration. Instances that described (1) how faculty learned and became proficient about technology use through professional development, (2) how faculty integrated technology into their teaching practice, (3) how technology integration related to active learning, and (4) how they were using technology in their courses. The emerging codes were identified as professional development, integration of technology, active learning, and levels of use (Table 4-3).

<table>
<thead>
<tr>
<th>Codes</th>
<th>Sub-codes</th>
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<tr>
<td>Professional development</td>
<td>Technology in class</td>
</tr>
<tr>
<td>Integration of technology</td>
<td>Challenges in the process of integration</td>
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<td>Figures things out</td>
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<tr>
<td>Active learning</td>
<td>Examples of active learning facilitated by technology</td>
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<tr>
<td>Levels of use</td>
<td>Technology in the individual practice</td>
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<td>Technology in STEM classroom</td>
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Codes within categories are described below. The following sections will explore the codes deeper.

**Professional development.** The interviews revealed that faculty members were using the available professional development opportunities at the institution as they related to their
exposure, understanding, and implementation of technology. Within this category, faculty described their interest in continued training to impact their learning and teaching practice, in addition to complying with institutional requirements such as maintenance of rank and promotion. While most comments described a positive outlook regarding the current offerings, dissenting voices were also identified with comments for improvement.

At the institution, professional development is provided to employees through the re-named Center for Institutional & Organizational Learning (CIOL). This change occurred prior to the academic year when this study was conducted. Thus, many participants used the previous institutional name of College Training & Development (CT&D) to describe this department. Through these offices, the institution provides training and workshops to both full-time and part-time employees focusing on preparing employees to develop the skills needed for current jobs, assist them in effectively responding to job changes, and preparing them for future job requirements.

The mission of the CIOL was echoed through all the participants except Diana. Both Andrew and Eddy emphasized the importance of training during their interviews as a need for continuous improvement of their skills. The availability of professional development was utilized by Eddy as he described his first teaching experience where “I was kind of straight from university setting style so for me I didn’t know that I was going fast,” thus his experience at this institution was his first exposure to teaching in this setting. Later he mentioned that he used professional development opportunities and support from the staff to design a website that “even though I didn’t know much, I went in CT&D.” Likewise, Frank mentioned that he loved workshops because they give him the space to learn. Andrew described the culture associated to professional development; “the culture here is you’re not just trying to get credits to maintain
your rank, you’re trying to increase your professional skills and your technological skills.” It is these workshops and courses that led Brittany and Catherine to use Blackboard in their courses, and, as Andrew mentioned, it is where many faculty are exposed to technology.

Workshops provided by CIOL are available in various delivery formats including face-to-face, blended, and fully online. Some are informational, while others are used for continued education credits that faculty may use for maintenance of rank or promotion. Andrew comments about this:

[It] has actually made it easier for us to focus on what we need to transfer instructions to students without having to go the university where all you’re doing is [a] taking three-credit course just to meet your rank maintenance or to meet professional development requirement. It’s a part of the culture to take a class that you know will help you deliver technology to your class better.

As it relates to technology integration, Eddy and Andrew were the most vocal and explicit about their experiences. Eddy described how during his years at the institution, he has been present at anything CT&D did. He described how he learned to design a webpage he used to communicate with students and provide them with class notes. Likewise, he completed a training to use Panopto but he later discontinued its use. Moreover, Andrew described how he maximized professional development to improve his class:

What it does, is it gives you opportunity to pick out new technology by taking professional development courses and those have actually been helpful. Some years ago, I took one of those classes and what I’ve learned from that is how to integrate online links directly into your PowerPoint presentations so it is seamless… Some of those are linked through the professional development program, it’s almost a part of my normal PowerPoint design or preparation. Almost all of my PowerPoint slides are linked now. They’re generating 2 or 3 Gigabytes of information which cannot stay in one folder and cannot be presented at once but because it’s seamless students won’t notice you’re using two different files at once.
Even though most participants disclosed positive comments about professional development availability and Brittany describes it as part of the institutional support, criticisms were also voiced. While Andrew described that “[t]here’s almost unlimited potential for learning new skills, new technology skills to enhance your instructional science for this college.” He is critical of the use of professional development by fellow faculty members that only use professional development for maintenance of rank. Likewise, Catherine describes how her experience with online training for Blackboard was not enough. The handouts and practices that she completed during the training she did without a problem, but when she tried to implement what she had learned the actual work was not the same. She believes she would have benefitted more from face-to-face training.

Altogether the CIOL and the availability of professional development were identified by the participants as points of exposure to technology, and training on how to use and implement such tools. Andrew and Eddy were vocal and provided multiple examples of how they have used professional development throughout their careers. Brittany, Catherine, and Frank shared experiences with professional development. Though most experiences were identified as constructive, expressions also demonstrated that there is room for development and improvement.

**Integration of technology.** Examples of use of technology discussed in the conversation with participants were identified and coded as “integration of technology”. Comments included in this group describe how faculty use technology in the classroom and some of the challenges that accompany the integration. Furthermore, included in this code were various technologies described in Table 4-2 and technologies that were gathered through professional development opportunities. In addition to experiences integrating technology participants also mentioned how
colleagues are uncomfortable or do not allow students to have specific technologies, such as mobile phones, in class.

**Technology in class.** Participants described various forms in which they use technology. Andrew and Frank both described how technical resources such as microscopes and motion detectors are combined with other technologies such as digital cameras and mobile phones to collect data during laboratories. By using technologies such as these, students can record information about the experiments they are performing at the time of the experience, later this information can be used to analyze and further understand the concept. Andrew even described how he helped his students understand “[t]he idea that a phone can be used as a learning device, not just a social media tool.”

For all participants except for Brittany, the idea of showing the students what is happening in the phenomenon they were studying through visualizations of the process was very important. Catherine shared how she can use diagrams to make it easier for students to see what she is talking about. Diana discussed how she uses videos to present how water flows through marine organisms and said, “things like that it's when you see it doing it, it makes a difference.” Eddy talked about “live pictures” that he can show students as examples and how he showed them “the real thing.” And Frank joked that when he discusses projectile motion they do not allow him to use humans as projectiles, but that through animations he can demonstrate and help students connect the mathematical process with not only what is happening but also the effect.

In addition to visualization tools, many faculty discussed the use of technology as an engagement tool. Catherine and Frank mentioned how they use technology to grab student’s attention; similarly, Diana that mentioned after using a video “[a] lot of the class would be excited about it and it would be easier to explain [to] them and it explained it to them and easy
Andrew used more detail to explain how he used animations within PowerPoint to show items on the screen as he discussed them, and control how and what the students were listening to and saw. Frank supported Andrew’s use to manage the lecture and went further by talking about his class and how in the “[l]ecture is important to change the pace, it’s important to break it down into sections, it’s important to keep the students engaged,” and he used technology to help him in that process. Moreover Frank discussed how he used technology differently in each course for different purposes; “[i]n Physics 2 is for them to see what is actually happening, the actual phenomena not the effects of the phenomena. For Physics 1 is more result based to see if we make those changes what the result is.”

Outside the classroom, participants integrated technology for students to continue learning beyond the class time. Catherine described how she used publisher provided LMS to deliver class material such as PowerPoints and syllabi, and know the students would always have access to the information. Brittany also used publisher provided technology to deliver adaptive platforms to complete assignments that provided feedback as students completed Chemistry problems. From the information obtained through the LMS students got “a percent correct or incorrect so it also tells them whether [they are] understanding it or not and it tells me rather than [just scoring, if students are] understanding or not.” As faculty integrated these technologies, challenges arose as part of the process. The following section will focus on these challenges.

**Challenges in the process of integration.** Through professional development opportunities participants like Andrew described how integration is seamless and it worked for all his classes. For Diana, planning on using technology is more about the specific course and the level at which the students were:
I think it fits really well for certain courses. So, I think the higher level course…
the more technology you can put in. I actually believe that. The lower level
course, you have to gauge what your students are capable of…

Diana continued that description by giving examples of how she provided upper division
students with some key information or just mentioned where the students need to go and to
complete the task, while lower level students benefited more from other types of technology and
that she always encountered problems. To address the needs of these students, she described how
she reviewed all videos and technologies before she provided the information for students.

Diana was not the only one that mentioned the time associated with planning, Brittney
discussed the preparation of the LMS before providing students with online assignments because
“[M]astering [Chemistry had] more of a learning curve just because the shell they gave me I
have to modify the content before I open it. So that will probably take me an hour per assignment
which can be a lot.” Catherine confirmed Brittney’s comments as she talked about the Mastering
Biology platform, describing similar work behind the scenes during her time at home. Eddy, a
vocal proponent of professional development described that sometimes he
did not have time to
complete or follow-up his professional development for integration because he was working.
Therefore, time to complete the work and the learning curve associated with technology
integration are part of the integration process.

Moreover, Diana shared her experience interacting with students and their proficiency
with technology where she described that students that have been exposed to technology longer
in an educational setting were more used to the technology and therefore manipulate it with more
ease. On the other hand, students that were novices in the use of technology in the educational
setting showed more restraint and needed more assistance with the use. She shared this insight as
she described how in some of her courses without pre-requisites, the student population is mixed
with students with no college experience in the same class as those that are potential term graduates. This became a challenge for her as the level of understanding associated with the technology may not be the same for all students.

**Figures things out.** As faculty find a way to manage the challenges associated with the integration of technology, comments were identified that showed each participant’s interest to overcome them through their own initiative. Codes within this section refer to the action of working with the technology not the educational process of integration.

Brittany and Frank both described their interaction with the technology as being a hassle. When Brittany tried to integrate a publisher technology because they offered hints to students while completing assignments, it created more problems to her because the hints were not good and generated more questions from the students. Similarly, Frank described how the computers in his workstation lock themselves for security reasons after a given time, thus if he stopped an animation to have a class discussion the computer may lock itself and the process of returning to the animation or video is a long process. For Diana, she wanted to use the adaptive learning platform BioBeyond in her class. As she prepared the course and navigated the program before assigning it to students, she found issues with the platform and became frustrated. This had an impact on her implementation of technology because as she thought of her students, “if I'm getting frustrated I expect they will too.” Thus, she had to find the answer to the technical problems the students found before they found them.

Regardless of their troubles these faculty members did share their success and in general, both Andrew and Diana consider that they do not have problems with technology. For Eddy, these are challenges that he overcame in the past where he “did whatever I could to learn whatever it takes to just use that.” He continued to mention that when he had problems with a
piece of technology that he looked for a workshop from CT&D. For Catherine, it meant that she had to prepare all the material in advance of the semester and deploying the class. In other instances, Brittany described how the gradebook in the LMS was intuitive and it was “already figure[d] out, like already tells you a category and then within a category, you can put a column and then you can tell the category drop one, drop two, drop whatever and then subcategory, so it’s beautiful.”

**Active learning.** Faculty members have made students participants in their learning process as engagement practices. This code contained all instances where participants described their definitions of active learning. For Andrew, “[t]he information is open to challenges for the whole class – open to debate, open to correction, open for questions, editing… not just what the textbook is saying.” In his classroom, he worked with students to break down the information until reaching the understanding of concepts. For Diana, she talked about in-class projects where students work together. Moreover, she discussed how by using technology:

[I]t's more the way I use it has changed… I used to just offer it to them on a handout here are some interesting websites and that now I'll actually use the websites in my lectures and things like that… so they can see things.

By introducing technology, she discussed how it facilitated active learning in her class starting various interactions with and between students, and allowing her to expand the course content. The following section will focus on explicit examples discussed by the participants.

**Examples of active learning facilitated by technology.** Like the example discussed by Diana, Andrew used multimedia to start conversations in his class. He discussed how using animation tools in PowerPoint, he can show certain parts of a pre-designed slide each time adding more information for students to discuss. Likewise, he encouraged his students to look for information using their mobile phones accessing the Internet and going beyond the information
in their textbooks. He provided information and guidelines within his syllabus on how and what is expected of the students. Regarding the information, the students brought to the class he said “[b]ring it in. Let’s debate it. If it’s acceptable fine. If it’s not then you’ve learned that everything you see online is not necessarily scientific true.” Through this process, he also focused on teaching the students to discriminate appropriate information found in the online environment. For him, it was about guiding the students through the acquisition of information.

For Eddy, technology allowed him to use flipped classroom instruction where he provided his notes on a given topic online and when students came to class they work on problems associated with those topics. “Although my notes will come with some of them [the examples], I don’t give the answer. On the class, I bring the example and we work it out… you have to come in class because I make some examples right there.” Frank also used technology to facilitate active learning strategies by breaking the lecture portion of the class.

If your lecture is straight three hours and 30 minutes, after 50 minutes, they are not there, so I try to change the pace… So, breaking it making small blocks where you focus on a very important concept and then start demonstration using technology and you collect some data, and you try to interpret that data and then you make the physics evident behind results.

Diana mentioned similar strategies when discussing her Biology course. For her, she used statistical programs to simulate predator-prey interactions and used gamification strategies to have the students analyze various scenarios.

**Levels of use.** Comments quantifying how participants used and would use technology, and how technology was being used in courses were all coded as levels of use. Within this group participants looked at their own experiences and discussed the role of technology as part of their practice and the School of Science.
Technology in the individual practice. When considering the role of technology in their practice, participants initially discussed the process of integration for their current practice. Andrew considered himself an early adopter of technology describing how he used technology since he began working at the institution. Likewise, Eddy described how he has tested everything the college has offered relating to technology and that he understands that he was one of the initial faculty members that started integrating technology in the Chemistry department. Likewise, Frank describes himself as a hands-on person that is good with integrating technology into experiments and other classroom activities.

In contrast, Brittany describes herself as hesitant to start using technology in her class, even though she has spoken to various peers about the benefits. Eddy also described how at the beginning technology had a steep learning curve for him, it was tough and he struggled. Although Catherine also describes a steep learning curve, she summarized all other participant’s comments when she said:

[T]he thing though [about technology] is getting it up and running and getting proficient with it. There is a learning curve there. So, the first semester, there is something new [and] is always a little bit trying but after that it’s good.

When asked about their future work with technology, all participants answered that they would continue to use technology. Catherine said that at a minimum she would remain where she was, that she would consider adding more technology but that it would be in the future. Brittany said she would use more technology and shared her intent of including more student response systems into her class. When asked about how much more she responded by saying “I think I would just go more from now, because I kind of went through that threshold of just trying it and now that I tried it, I like it.” All other participants agree with her in that they will use more technology. And Catherine, Eddy, and Frank make it a point to mention that they were open to
trying new technologies. Lastly, Andrew stated that “[t]here’s almost no scenario that will separate technology from the active learning process for me, right now.”

**Technology in the STEM classroom.** As the conversations turned to the future, the two senior faculty members were those that provided the most insight and examples as to where they saw the potential of technology in the STEM classrooms. Catherine discussed how she did not require a textbook in class because she provided all resources through the publisher’s LMS, and that she is looking forward to determining what Blackboard will allow her to do. Likewise, she advises that technology could be used in the laboratories more often to offer students simulations of experiments we may not be able to perform in our existing facilities.

On the other hand, Andrew acknowledges that some of his peers are at different levels of understanding regarding technology but he shares that we should “remember we all have an opportunity to pick up professional development opportunities to improve our skills.” He also advises that students are aware of how technology is being used at other institutions around us and for this institution to remain competitive, technology use should become routine.

**Factors Influencing Integration of Technology by STEM Faculty in Lecture Courses**

STEM faculty may choose to designate their courses as web-enhanced to signify the use of technology in the class, and each faculty member determines the extent and use of technology in the individual courses. The process of choosing a type of technology and the level of integration can be influenced by various factors. Through the exploration of emerging factors in the data (Table 4-4) the aim of this section is to determine factors that influence the adoption and implementation of technology by faculty members, the source of the factors, and the influence these factors have on the implementation of technology.
Table 4-4. Factors and codes within identified factors influencing integration of technology

<table>
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<tr>
<th>Factors</th>
<th>Codes</th>
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<tr>
<td>Attitude towards integration of technology</td>
<td>Beliefs about themselves</td>
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<td>Beliefs about peers</td>
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<td></td>
<td>Beliefs about students</td>
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<td></td>
<td>Digital divide</td>
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<td></td>
<td>Beliefs about technology</td>
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<td>Technology adoption</td>
<td>Publisher role</td>
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<td>Expectations of technology</td>
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<td>Impact on work</td>
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<td>Impact on teaching practice</td>
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<td>Resource decision</td>
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<td>Challenges related to student use</td>
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<td>Pedagogical</td>
<td>Real-world experiences</td>
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<td>Improved instructional delivery</td>
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<td>Assessment</td>
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<td>Self-evaluation</td>
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<td>Observable outcomes</td>
<td>Related to faculty</td>
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<td></td>
<td>Facilitating instructional process</td>
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<td></td>
<td>Facilitating tasks beyond classroom</td>
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<td></td>
<td>Related to students</td>
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<td>External sources</td>
<td>Institutional role</td>
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<td></td>
<td>Access</td>
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<td></td>
<td>Faculty collaboration</td>
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**Attitude Towards Integration of Technology**

The decision to use and how to use technology is determined by the individual faculty member. These choices are influenced by the individual’s attitude towards technology. This section describes the attitudes of the participants as it relates to themselves, their peers, students, technology itself, and the participant’s beliefs associated with its use.

**Beliefs about themselves.** As faculty members consider the adoption and integration technology, their perception about themselves and technology play a role as they consider their time investment and usefulness of the technology in their practice. Throughout the interviews,
most participants described themselves as open to the use of technology and in some cases enjoying it. For Diana, she describes herself as liking working with technology and being able to “figure things out” on her own. Similarly, Brittany discussed how she was receptive to using technology for instructional purposes, and once she tried it she liked it.

Other participants, like Frank, shared that familiarity with technology facilitated its use; when describing social media tools in his class he said he did not use them because he was not familiar with them. Moreover, Catherine discussed how she approached the use of the LMS Blackboard, “I thought that I kind of knew a little something about computer but when you get a new program [like Blackboard], I thought it would have been easier but it’s not so easy.” Likewise, Eddy shared that he did not consider himself knowledgeable relating to technology when he joined the faculty, but he was open to learning more about it and utilizing professional development opportunities to better himself. From a general perspective, all participants had an openness to explore technology for different instructional purposes, but some exhibited a level of apprehension impacting their practice.

**Beliefs about peers.** While participants described themselves as being open to the use of technology because they liked using technology or because they wanted to improve their practice, opinions about their peers showed mixed feelings. Andrew shared how in his experience in the college, the faculty has shown a general willingness towards the integration of technology in courses. He shared an optimistic view about technology and how others should view it. For him, “[a] faculty member, who is not comfortable with technology, probably cannot work here because our students take all of the classes and they’ve already experienced the positive side of technology.”
Brittany shared that she believed most faculty have tried technology at least once. Interestingly, during her interview she referred to another participant of the study and to her: “I know Eddy had used Mastering [Chemistry] before but I think he didn't continue.” Moreover, Diana and Eddy discussed how they understand that certain faculty are resistant or completely avoid the use of technology.

While age was not identified for this study, many participants agreed that their senior colleagues were more averse to the use of technology than they were. Eddy includes himself with what he calls the newcomers to the Chemistry department when describing who are the higher technology users. Although Brittany believes most faculty in the Chemistry department have tried some form of technology, she described how the more senior faculty discontinued its use. Frank was the most explicit regarding this topic when he stated: “I think somebody older would have more difficult time. Faculty member that has been doing the same thing for a very long time, they are not likely to change.”

**Beliefs about students.** For all participants, students are more partial to using technology, but they shared experiences where students did not maximize technologies’ potential as instructional tools. For Andrew students relate better to technology and because of this, instruction should mirror their world.

The students are able to put in as close to a normal environment as possible. Delivering information in a convenient form that they live with every day. They use the TV, they use the Internet, they use wireless devices such as Tablets, phones… That’s the whatever have you, that is their world.

Later in his interview he specifically stated: “I’ll be very surprised if any student feels technology has been adverse.” Yet, Diana shared that some of her students hate technology. She expanded saying: “some students that just got so frustrated with the actual act of doing it that
they either went right to the book or went to a book to learn it, and didn't necessarily get it.” Subsequently she described that some students use the technology as cursory and do not maximize the tools provided.

For others like Eddy, he understood that students like technology but focused more on how they use it:

[S]tudents have a tendency in using that [technology] in their own disadvantage. Meaning that they will bring the notes, now they have all cellphone and so forth, they will just save it or take a picture and so forth, store in a phone and they come on the test and that’s it. They don’t study anymore.

Meanwhile, Brittany shared that her students gave her feedback that technology provided vague or inappropriate feedback. This feedback referred to the adaptive nature of the program that responded to student’s answers by providing guiding feedback directing students to the book or hints as to how to answer the questions. Frank helped to summarize the general feel of the participants when he stated, “not everything works the same way for all the students. So, trying to keep them engaged and using the same method you for all of them, it’s a problem.”

**Digital divide.** As participants described students and the role of technology for them, a topic that emerged from the way some participants spoke was a difference between “them” (students) and “us” (faculty). Throughout Andrew’s interview, for example, he made multiple comments about the student’s technological world and how faculty needed to catch-up or be left behind; “[i]f there’s any fear for me is that technology might go so rapidly, the students are way ahead of us, we could get left behind.” The concept of being “left behind” was a recurring aspect during his interview. He even compared how instruction with technology would be different for him: “All my expectations are from the students’ perspective. There are things I would do differently if it was for me, but this is about them.”
Catherine echoed many of the comments made by Andrew describing herself as “old school,” and saying that faculty needed to “keep up.” Frank describes himself as not being a computer generation person, while:

“We live in this generation and anything that have to look computer, or phones… at least at first, you will catch the[ir] attention. If it’s a YouTube video they will start paying attention to it, may be later they will dissociate but the fact that it is a visual they will try to.”

When describing current students and the use of technology, Diana mentions: “I thought, its especially with the younger generation of students, I thought they'd eat it up.”

**Beliefs about technology.** Throughout the interviews, faculty not only expressed their beliefs about individuals and technology, but also about technology itself. Eddy was explicit saying that he believed that technology was useful in his course. Others like Diana shared the belief that there are advantages to using technology and that by using it she “would get the students interest more and get them more involved in the course.” Like Diana’s approach, Andrew uses technology as an engagement tool and specifically describes that: “[t]here’s almost no scenario that will separate technology from the active learning process for me, right now.” Moreover, Catherine labeled the use of technology in her class as refreshing and that she thought that integrating technology was good.

From the participant’s perspective, technology is a tool that helps them in various aspects of their practice. Andrew described multiple ways he used technology and how he understood that it facilitated the learning process. He shared, “[i]n terms of the experience it is a standard method of instructional delivery for my courses.” He described in his interview how he uses technology in the lecture but also the laboratory to enhance student learning and collaboration.
Moreover, he believed that technology has been useful in increasing other aspects beyond instruction, such as enrollment;

The college has been at the forefront of advancing technology as a learning or instructional tool. We may never know, that may be one of the reasons why our enrollment is so high and why we have one of the largest student enrollments in the entire country.

Like Andrew, Catherine proposes that technology could be used to enhance laboratory experiences by providing students simulations for experiments that cannot be performed with current equipment or within the instructional time. Diana and Frank described the usefulness of technology. For her, technology is helpful for students in different aspects of their learning experience. Frank described how technology is a benefit because it provided information as the experiences are happening rather than at the end; “technology in the labs is just huge plus. It’s not the same collecting data blind.”

But there are other perspectives regarding the use of technology. Besides the positive aspect he described, Frank mentions that “with the technology would have that means you need to stand right next to the computer and that’s not my style I cannot do that.” Thus, there are limitations associated with the use of technology for some participants.

Eddy provided the most in-depth descriptions regarding the use of technology. He described how technology could be an impediment for students as they may use it as a crutch in their learning. Other examples included how he resolved mathematical problems in his Chemistry class and that to explain these concepts he does not need technology. He was critical about the misuse of technology and how students become sluggish when completing work. His evaluation of the use of technology was not limited to students, he also shared that:
In usage of technology, the critique [I have] from some other people that I saw using technology, [is] all right. Some of our colleagues, could be adjunct, full-time and so forth, what they mean by technology is just to get a PowerPoint from a publisher and that’s what they go, they flip over one [slide] by one and that’s it.

Therefore, the use and efficacy of technology for instruction may be variable. Overall, one of his last statements during his interview summarized this idea, “how they [the faculty] use that [technology] sometimes it’s not as effective as it should [be].” Therefore, factors that influence how technology is adopted and later integrated are significant to the effectiveness of technology use. The following sections focus on specific factors described by the participants.

**Factors That Influence Technology Adoption**

Before full-time faculty members choose to adopt a specific technology, various factors influence their decision. The source of the technology can determine their choice between similar tools. Moreover, the expectations associated with technology will relate to the individual’s perception of usefulness and the impact on additional effort associated with the adoption. Finally, factors related to technology and the impact on the students also play a role in how technology is ultimately adopted. The following sections explore the factors linked with the adoption of technology in STEM lecture courses.

**Publisher role.** For many participants, their first exposure to educational technology as an educator was through publisher provided materials. These tools include resources like videos, PowerPoint presentations for lectures, and learning management systems that include assessments and store other resources. Catherine described how she “used [the] blackboard and text book basically… and then I realized the textbook came with the PowerPoints, so I modified them and started using them and that was so refreshing.” For Brittany, she was first introduced to these resources during a publisher sponsored lunch to the Chemistry faculty and there, she saw the various platforms and their ease of use. Catherine later described how she used the
publisher’s LMS, “now that is actually a part of the [LMS] like Connect or source, like you can just look into that chapter, you will search through and you will find what you want, so that’s easy.” Thus, the resources provided by the publishers’ impact how faculty view technology.

Likewise, the role of publishers and the available technology extends past the availability of technical resources. As a senior member of the School of Science, Andrew described how in the past book adoption was linked to the technology available to the faculty and how this served as standardization of use for the department. Moreover, Catherine and Eddy describe how some of the technology they use is what came with the textbook. Furthermore, Diana talked about the use of the resources that come with the publisher’s material and the advantage of having access to BioFlix. Thus, there is a connection between the publisher resources relating textbooks and technical resources, plus how faculty will choose materials for their courses; sometimes impacting multiple sections in a discipline, not just linked to a single faculty member.

Once the technology is adopted, faculty explained how the support provided by the publisher’s team allow them to integrate into their classes. Brittany shared that when she prepared her online content, a publisher has “a content expert who makes [and] sets-up the course, [and] that was great.” In other cases, “[for] Mastering [Chemistry] the Pearson rep[resentative] is the one who kind of chooses the content and then I have to go back and just make sure that when she takes matches [or] it's not covered.” She then talks about how with the shells provided by the publisher there is no added time investment. Similarly, Eddy supplements Brittany’s explanation by describing that when he has questions he contacts the publisher and asks for assistance.

While these technologies are not the only sources of information, many faculty use them as a default and comparison for future adoption of technology. During her interview and while
discussing the institution’s LMS, Catherine described how Blackboard is not as user-friendly as those provided by publishers and that to do many of her normal functions it is a new experience and learning curve. Thus, the technology provided by the publishers sets a standard for use for faculty, and serves as a measure for future technology adoptions.

**Expectations of technology.** As faculty adopt technologies for their courses there are expectations associated with how the technology will affect their routines. These expectations relate to the learning curve linked with understanding and integrating the technology into their courses; the impact the technology will have relating to their work, and the impact the technology will have related to their class and teaching practice. While all participants expressed positive comments involving their expectations from technologies and how these expectations were met through the discussions, comments about how these factors drive the use of technology or sometimes delayed the process of adoption and integration were shared by participants.

**Learning curve.** From the participant’s self-evaluation about their use of technology, there is a gradient from those that consider themselves “technology savvy” to those that do not. For Diana, her learning curve is “usually fairly quick.” On the other hand, Frank expressed that while he catches-up to hands-on technologies very fast, “depending on software. Yes, it could be time consuming, it could be tedious.” Similarly, Eddy shared his experience with the lack of knowledge and how he maximized professional development opportunities.

Brittany’s experience helps summarize the link between expectations associated with learning curves and technology adoption when she described her initial thoughts about integrating the textbook publisher’s LMS:

I was always hesitant to start… Mastering [Chemistry] because I thought there'd be a very big learning curve and at the beginning since we were just hired I thought there was going to be a pain, [but] I found that the Mastering [Chemistry]
is actually very straightforward because they already have an integrated grade book.

Even though she made this comment describing her hesitation, throughout her interview she spoke about learning about technologies as something easy and straightforward. Therefore, her adoption and use of technology was initially linked to what she expected would be time expenditure associated with learning to use the technology.

Impact on work. While some faculty expressed uncertainty about adoption or use of technology, a factor that influenced adoption was how the technology would facilitate their work. Andrew, for example, described how he used video discs to build his course around them. Brittany described how she is considering adopting student response systems to facilitate offering students extra credit because all responses would be collected by the system and she would have less paperwork.

When asked about his use of technology, Eddy shared one of his first experiences. He wanted to improve how he communicated with his students during class. Eddy described how students complained that his accent was not allowing them to understand him. To address this, he used technology available at that time to share his notes with students during and after class. Thus, students could follow as he explained Chemistry concepts during class. “I was trying to kind of make myself better for my listener… I would say that they [the projected notes] greatly facilitated the work and now I don’t have those complaints anymore.”

Impact on teaching practice. Whether by design or because of technology’s impact on work, faculty described how they have adopted and integrated technology to improve their practice. Andrew describes how technology makes it easier to deliver information and then relates to active learning by describing the increased interaction. Brittney describes how by using
adaptive lessons within the publisher’s LMS “[m]y main, ‘hope’ is that they would have gotten live feedback when they were doing something wrong.” She makes a point of this because she feels that sometimes students do not understand Chemistry problems while working at home and the time between their work and class leads to students not looking for help. Using technology students have access to feedback that would later facilitate the teaching process, leading to more questions during class time or office hours.

For Catherine technology was a tool to improve student involvement in the course. While she described that not all students met that expectation, “maybe 50% of the students will do that and they will come and they will show, they will say, there was this question that I didn’t quite understand.” Moreover, she expected that technology would give her another point of contact for the students with the concepts discussed in class; “like I keep telling them that, the more you use the information, the more you put into your long-term memory, the more you understand the concept.”

**Resource decision.** As faculty move forward with the adoption of technology, students play an important part in what technology is ultimately adopted. All faculty discussed how the choice resided in the faculty but they take into consideration students’ feedback, which includes costs associated with the technology and ease of use of the technology for students.

Many faculty made a clear assertion that the choice to use a type of technology is up to them. While the Chemistry and Physics faculty were very specific about their individual choice, the Biology faculty mentioned in some instances that the choice is made by a committee. Andrew describes how “faculty has some independence on how they run their lectures, but again all we’re trying to do is agree on setting formats.” Thus, for these courses technology is used as a standardization between courses for students to be exposed to a similar experience. Likewise,
Catherine described how for the course she teaches one section of a course she used the technology that the committee had chosen, but for a course she is the only faculty that teaches it she made the choice herself.

Brittany exemplified the influence of students on her choice for technology when she mentioned that she should use traditional end-of-chapter questions, but for her it seemed students were already using technology to study. She followed by saying that student feedback is important because they say if they like the technology or not. Andrew echoed these comments when he discussed how vocal his students were and that they would share their like or dislike for technology. For Frank, his students have a clear influence on his decision about his adoption, “I have disregarded those that weren’t [working] very well for me or for my students.”

For others like Brittany, Catherine, and Diana, the monetary cost associated with the technology and how students can use the technology influenced their adoptions. Catherine described how sometimes the technology was an added cost for students, and that is why she focused on those packaged with the textbook. Brittany also shared how cost is important to her and she considered alternative methods of content delivery. Moreover, Diana mentioned how she considered technology and focuses on both hardware factors associated with the technology and how challenging the use of the technology may be for her students. When describing an option of technology, she talked about the hardware requirements for the students saying that students would need a “gaming computer” to be able to use some programs. Later, she talked about “if it's hard for the students to use or it's hard there's not a good protocol…” then she would consider other options for technology like what Brittany described.

Altogether, these factors impact the choice faculty members make regarding technology. Based on these, a faculty member may consider adopting technologies associated with publisher
material that accompanies the textbook or look beyond the provided material. Overall, faculty reflect on technology that is available to them through publisher material, the expectations associated with the technology and impact on students when determining the technology that will be adopted for a course. Once the technology is adopted, factors associated with how it is incorporated into the teaching practice and the role that it plays in their pedagogy are explored in the next section.

**Challenges related to student use.** Catherine and Eddy shared how they have experienced students’ misuse of technology to increase their exams scores or to get a step ahead in online assignments. Eddy specifically mentions he has identified instances where students are using technology to get an advantage during exams. As a response to this, he has limited the use of mobile devices to limit access to notes during summative assessments.

When discussing online assignments, Catherine shares “students will sit together and do it, you cannot, you are not really assessing how much each student have learned and whether they have a problem area.” As a result, she does most of her exams in class and when she does offer online testing she does with the premise that it is an “opportunity them to get good [a] grade to help to boost their [final] grade,” and not necessarily assess student learning.

While these concerns were described during the interviews, all participants were optimistic about the use of technology. Although they understand that some students will not maximize the opportunities afforded by technology, they have implemented strategies to deter these practices. Catherine, for example, shared how she uses multiple questions and randomizes the assessments students complete online. “I can put a pool of how many questions so that when they are doing a test, it’s random what each student gets, what questions each student gets, so that again helps.”
Pedagogical Factors Influencing Integration of Technology

As technology is adopted in the various courses by faculty members, a recurring topic of interest was the role of technology and its impact on their practice. As participants described how they integrated technology they described their reasoning for using technology in the classroom, how the technology has impacted their teaching, its utilization to assess students, and finally their evaluation of the efficacy of technology in their practice.

Real-world experiences. For many of the participants, the rationale behind their technology integration was to link the learning experience to student’s real-world familiarity. Andrew specifically spoke about this when he mentioned:

The closer your class is to their normal life the more comfortable they’ll be through the learning process. The whole idea was to make this as close to what they would do with their electronic devices and make it part of their normal life, normal experience.

Therefore, there is an understanding by participants that technology is part of the student’s daily routine and that by integrating this approach it will facilitate the learning process. Likewise, Eddy echoed the comments by Andrew when he stated that for him, the integration of technology had an everyday application. Moreover, participants like Andrew and Catherine were explicit when they discussed the role of technology in society describing that society was headed towards the use of more technology. To this effect, they described things like mobile banking and the ubiquity of devices.

Beyond the use of technology for day-to-day activities, Brittany discussed how technology is already present in each student’s learning process. Specifically, she mentioned as she discussed strategies to implement practice problems in her Chemistry class that, “it seems that students already [are] doing most of their homework online.” Because of student’s use of
technology for studying purposes she has decided that rather than assigning end-of-chapter questions, she was going to use publisher technology that also included other resources.

Overall, the use of technology seemed to permeate into the learning space as a reflection of customary student practice and because of its use as a studying tool. As faculty members choose to integrate the technology, the next section explores the role of the technology in their practice through the change in their approach to teaching.

**Improved instructional delivery.** Integration of technology was described by participants for multiple purposes, mostly for the improvement of the instructional delivery. Catherine describes how she relied more on technology as it allowed her to keep a sequence in her teaching and that when technology is absent, she must keep in mind she has not missed something. Moreover, she also described how she has been able to move content to the online space to free time in her classroom.

Brittany described how sometimes she would like to do just-in-time assessments as extra credit for students and this process takes time during class and later for grading. By integrating student response systems, she provided extra credit possibilities and that would serve as an engagement tool. Likewise, she discussed how integrating online practice problems impacted her students, “I see that it's helping them as compared to when I didn't have it.”

For Andrew, integration of technology has helped in the process of pacing his lecture. “What I’ve noticed when you open it in one step, students are distracted by everything you have on the screen and they’re not listening to you anymore.” To aid in this, he uses animations in PowerPoint to reveal topics at the same time he discusses material, ‘[e]ach of them is coming out one at the time so you’re able to pace the lecture more efficiently.” Similarly, Catherine argued
that she liked combining online support material with her class and she asked students to complete work in a timely manner as the topics are studied in class.

This type of integration and revision of instruction is not limited to the lecture. Andrew discussed that in his Microbiology laboratory most of the material is observed through microscopes and that guiding students is difficult through a single lens. By integrating technology, he can connect a microscope to an overhead projector and have discussions with students about what is seen. This information, he explained at various times, can be used as a teaching moment in the laboratory and be exported to the lecture as well.

**Assessments.** In addition to delivery of instruction, all participants made references to the use of technology not only as summative assessments but also as formative assessments. Catherine described how in her Anatomy course, most of the course is based on memorization and recognition of structures. To this end, she does many assignments in class and provides multiple practice sheets. When discussing these assignments, she described how she made them available through an LMS and all were accessible since the first day in class. Likewise, Eddy provides various homework assignments though the LMS. Other integrations of technology include the collection and storage of information throughout the semester, as Andrew described:

Students take pictures of procedures, results, techniques, of every part of the experiment. In essence, every student has an own version of his photographic atlas at the end of the course. It’s their own generated database. But it becomes part of the final report when they submit at the end of the term.

Another application of the technology, as described by Diana, is questions during class. “I'll do like think-pair-share and so I'll do a little definition for something or ask a question in the middle of my lecture.” Through technology she facilitates student participation by providing visuals and promoting conversation between the students. Frank described similar activities in
his Physics class and expands on the use of technology by saying “you notice a student to have a
deficiency and if you know where to go to address that deficiency, you could do it right there and
then. So, in a short period of time, you took care of somebody’s needs.”

**Evaluation of technology use.** Through the process of technology integration,
participants showed instructional design strategies in the process of adoption, integration, and
later evaluation. Participants described how during and after integration of technologies into their
courses, they collected feedback from students and their own evaluation of the efficacy of
technology in their courses. Andrew described how his students were vocal about the usefulness
of the tools he implemented in class and in addition to student feedback he collected his own by
“constantly monitoring to see the feedback of how they’re responding to this.”

As it related to the effectiveness of the integration, Brittany shared how she compared a
course where she integrated tools through an LMS with a course in which she used a traditional
approach. By comparing the courses, she noticed that while the average scores in her exams
remain similar, student participation and volume of work had changed. Through the interview
this led her to discuss how there need to be modifications and that she will consider utilizing
these technologies in different forms in the future. Like the evaluation of the integration, Eddy
used his experiences in the classroom to review his material and “[if] I noticed there’s something
there or there was a little mistake there somehow, I correct it.”

Frank summarized this approach to technology and the general outlook regarding
technology when he stated,

[I]n the profession we are, we need to understand that at every day, something
new comes up, a new style comes up and it’s our responsibility to know, and at
least give it a try, I know there is no absolute method that works for everybody,
but give it a try.
Thus, the use of technology and its impact on participants’ pedagogical approach includes a cycle that incorporates the constant evaluation of the material that is being used in the class, in addition to the efficacy of this material in their practice. Collectively these evaluations produce observable outcomes with impact for both students and faculty. The following section will focus in the outcomes expressed by the participants of the study and their ultimate role in the integration of technology.

**Observable Outcomes Influencing the Integration of Technology**

In addition to sharing the impact of technology in their practice, faculty also shared the outcomes after integration. Through participants’ view of the conclusions associated with technology, decision to continue or discontinue the use of technology has an impact in further integrations. Thus, this section focuses on the outcomes participants related to themselves and those that relate to students.

**Outcomes for faculty.** For participants, the technology had two major roles: facilitating the instructional process and, simplifying grading and the amount of work. As they discussed the impact of technology, many discussed how the use of technology opens availability of information for them and their students and how it has helped in their teaching practice. Likewise, the use of technology provides an easier way to assess students and relieve them (the faculty) of the time consumed by these tasks to focus more on the results associated with these assessments.

**Facilitating the instructional process.** Many participants used technology as a teaching tool. As Andrew describes, “[w]hat that does is it takes information out of the classroom setting. Once you have that potential it’s almost impossible not to use technology because now it’s not just about reading books, it’s about electronic information that is almost unlimited.” After
making that statement, he described how he can use technology to build lessons around the new material and use updated information beyond what is provided by the textbook.

Catherine shared her experience with the publisher material and compared it to what she would use.

[Now] I am using a PowerPoint and I am talking, there may be a diagram there, but what I have found is that although that diagram may be a better of diagram, than what I would draw on the board and so on but I find that using that.

She continued to express how she showed diagrams to help the students navigate procedures associated with biological pathways and that it helps the students understand better. Similarly, Diana mentioned how the use of these diagrams makes her job easier and students understand better by looking at these visuals. From these uses, she then described how simulations allow her to engage students in critical thinking by providing various scenarios for them to analyze:

Sometimes I would say okay in this video we did this, what do you think the outcome would be if we altered things. So, it gave me the possibility of offering different scenarios using a similar model basically and that so the students could think of different aspects of it and without going through each example kind of things like, okay if we change [this or that]… it allowed the students to explore other options that they might not have considered.

Frank also described the use of simulations in class where: “[t]he fact that you could do a lot that took before 30 minutes in 10 minutes, and if something go wrong you could just repeat it and then just focus on analyzing the results.”

Altogether, participants expressed a combination of expanding their instructional possibilities by either providing new material or by facilitating the time associated with non-technology methods of instruction. The value associated with time goes beyond the classroom, where faculty described an ease associated with tasks outside the instructional process. The
impact of technology associated with grading and volume of work are discussed in the following section.

**Facilitating tasks beyond the classroom.** While many of the examples used associated with instruction described how they interacted with the students, many faculty also expressed the role of technology in tasks outside the learning space. These comments centered on the preparation prior to the time in the classroom and the time required for tasks after class meetings such as grading. Brittany discussed how “I was tired of creating manually all those assignments and I was like well let me give it a try and I saw the feedback was pretty good and it just simplified my life.” Moreover, she shared how in her large classroom she could not assess student deep understanding because of the volume of assignments collected:

I would have to go one by one and it was mostly based on completion because in a class of 40 if they turned in a packet of paper each for end of chapter questions I couldn't really assess whether they were doing it right or wrong. So, I was more okay, completion, check they got the point.

After integrating assessments in the LMS she said: “then it just makes my life easier, I already see the grade, boom!”

Catherine also used assignments provided by an LMS and she shared how she combined in-class worksheets with online assignments that helped her minimize paperwork. Moreover, she expressed how now she has less paperwork to take to classrooms because all her course material is stored on USB drives. Eddy also discussed how when he shared his notes with his students through a website, this facilitated student comprehension and the access to information; “I use technology as a tool to help me pass the message.”

**Outcomes for students.** As described by all participants, the outcome of the use of technology for students is that it increased student engagement and ownership of the material in
the course. Diana discussed how by using technologies outside the classrooms, students control and pace themselves through the material. Andrew described how his class mirrors the scientific process, by aiding students in the construction of the material and opening that material for discussion.

For the interactive aspect, I have a part of the course where we and the students interact generating data online and making it part of the course... the students can input data on the screen and they can challenge. I usually call it a classroom version of Wikipedia, generating information from the student’s perspectives.

For Andrew, the use of technology is an asset to students: “I’ll be very surprised if any student feels technology has been adverse. If anything, it has enhanced the learning process for them.”

Other participants like Brittany share Andrew’s perspective regarding the impact on learning. She also related the use of technology to enhanced student learning. Catherine was explicit in her use of technology to increase student contact with content, sharing that it increased points of contact and allowed for better understanding of the material. Reflecting on students, Diana stated “I think it increased their understanding of the processes that we’re talking about.” Eddy focused on the availability of the material and the access that it allowed to all.

Overall, participants focused on how students used the technology in-class and outside of class to engage with the material. They shared experiences and their expectations that the technology facilitated how they went beyond the material in the textbooks or what was provided to them in the class. Catherine shared how students that used technology at times would share what they had seen related to someone in their families or among friends. By promoting these conversations, she explained that it provided depth to her courses and students became more linked to the material. While using it as a tool to provide extra credit, Britany says: “I just want to make sure that they like focus, paying attention, it keeps them engaged.” Diana shared that
during her Oceanography class, a non-majors STEM course, she used real-time data and this helped expand students’ interest, “so I think it drives them to learn about other processes that are related.” Altogether participants provided insight into their outcomes as professionals and what they perceived as outcomes for students, based on the results associated with the implementation in their courses.

**Role of External Sources in the Integration of Technology**

Throughout the interviews, participants made it clear that the decision to adopt and integrate technology was up to the individual faculty members or it was an agreement within a group of faculty members forming a discipline or subject area committee. Nevertheless, aspects relating to external sources influencing these decisions emerged from the various conversations. This section focuses on the exploration of external factors that influenced faculty members in the integration of technology in STEM lecture courses.

**Institutional role.** When asked what they understood was the institutional approach towards the use of technology, all participants agreed that the institution was encouraged the use of technology. Brittany shared that she believed that the institution promoted the use of technology and that is why they allowed the access of publishers to present their new technologies to faculty. Frank shared:

> When we have all those retreats it gives us a little taste of what’s going on, so do a better job than others, so yeah, this is not bad as far as information goes and it does expose you to a few things.

Yet, while they expressed that the institution supported the integration of technology, they did not feel that it was being pushed on them. Brittany shared:

> [F]or our particular department it’s open to whether or not you want to adopt any technology there’s no requirement, if we feel that it’ll be an asset to the class or it’ll help us then we’re able to add it but if we feel that we are not interested or it’s not going to help us then we don’t have to.
All other participants expressed similar experiences within their departments and with the institution. Only Diana commented that she believed that some colleagues had been told to integrate a technology, but she understood that for the most part, it was up to the faculty.

While Frank supported the view that the institution provided encouragement for the integration of technology, he mentioned concerns focusing on resources relating to updating hardware and funding allocated to technology. He described that the technology presented was not specific to his subject area and that there was no institutional support to participate in content specific conferences. Moreover, he shared that some of the technology present was not updated to the current standards and requirements to use certain software; “the computers need to be updated the same way. We are running Windows 10 in computers that are 7 or 8 years old. They don’t have the memory to run Windows 10.” Nevertheless, he did mention that there was support to purchase new technologies from various institutional secured grants, “as far as I look at support, I just spent five, six, seven thousand dollars on new technology. So, the support is there, the encouragement is there.”

Altogether, the participants shared a positive view regarding the role of the institution regarding technology. All participants emphasized the opportunities provided through professional development and the support provided by the institution’s network services. When describing the development laboratories, Eddy mentioned “[in] those labs they’re always there open and you have somebody there helping which means that the college supports.” Others agreed with this statement and spoke about the access provided by the institution to these resources for their development and support in their practice.
Access. “[T]he first positive decisions in college took was to put the desktop computer on every faculty member’s desk,” was stated by Andrew as he described how the institution provides resources to the faculty. His perspective as the most senior participant spans over two and a half decades. During his interview, he provided multiple comments about how during his tenure at the institution, he has noticed how the support to provide access to technology has made a difference in faculty’s instructional approach. “Now everybody has a computer in it’s all routine. While we may not realize how that has changed the way we think of an instruction because we transferred it to classroom.”

Catherine supported Andrew’s perspective when she discussed how she could assign technology-oriented instruction,

[O]ne disadvantage is that, not everybody have access to good computers and so you will find students will always be calling that this happened then this happened then this happened. So, my solution now is [to] tell them if you know your computer is not up to date, do it at the school especially when I am giving a test… [I]f you know your computer is not up to date, do it at school.

She continued to describe how students have access to computers in some classrooms and in the laboratories. This, she described, helped promote the use of simulations that may be incorporated into the instructional process.

For faculty, access is not limited to contact with hardware or software it is also extends to the access to assistance when needed. Support provided by the institution through departments like Network Services helps the faculty resolve technical situations that may hinder their integration process. Moreover, support for faculty is not limited to structures within the institution. The next section focuses on support provided by other faculty members and the collaborative process associated with the integration of technology.
**Faculty collaboration.** Participants were asked during the interview if they considered if they had the necessary support to integrate technology. While many discussed the role of the institution, an emerging concept was the support provided by colleagues. Many participants felt that they could ask another faculty member for assistance if needed and provided examples. “I thought, ok if I you need to figure out how to drop one of these nine labs… the students told me that [a Biology Faculty] knows how to do that apparently because he drops two labs or something,” shared Brittany when discussing how she used the LMS to manage grades in her class.

Catherine provided a clear example of how the collaboration between faculty members influences the integration of technology as she talked about her Anatomy & Physiology course:

> [W]hat I liked about this department is that we help each other, yeah, that’s what I like and so, if [another A&P Faculty] will come over and help me and when he has something, not necessary computer but something else, I will help him, so I like that, that assisting each other and so, I didn’t feel anyway about the fact that it was a steep learning curve.

Because of this collaboration, Catherine could overcome certain doubts about the use of technology in her course and it facilitated the learning process. Diana furthers the explanation by mentioning assistance from faculty and sometimes asking students for feedback and support on how they did a certain task. Similarly, Eddy helped summarize the collegiate nature of collaboration and peer support:

> If I cannot [do something] and I ask them [at Network Services], [if] they don’t know. I ask a colleague… I help when I know it. I tell somebody that’s actually the best thing to do. When I know it, I share. If I don’t know, I ask.

Overall participants shared their understanding that support to integrate technology was available and they would recommend the use to others. But while the support to overcome barriers at the technical or instructional level may exist, additional factors like the student role in
the integration were also identified in the various interviews. The following section describes how student motivation served as a factor that influences integration of technology.

**Student motivation.** All participants described technology in a positive view related to their practice. They discussed how it helped and how it was used as an engagement tool for students. But while the general outlook on technology was optimistic, instances that described the students’ role in the integration of technology made some participants apprehensive about its use. For Catherine, she describes how not all students use technology in her class regardless of availability or access;

> The students who would get an A whether you use white board or that [technology]… they are ones that I use it. The B students will use it sometimes, the C students, if they feel like it and the others don’t even look at it. And that’s why they are getting that Ds and Fs because they are not utilizing all that’s there for them.

Earlier she discussed how she integrated technology to increase student participation in her course, but only half of the students would truly use the resources.

Diana also shared her perspective about students’ motivation to use the technology when she mentioned that some of her students do not complete the required assignments, or they just give up. She discussed how she believes that students that have been exposed to technology in an instructional setting for a longer period would be more inclined to use it; but she mentions, some of her courses are introductory courses and students’ first exposure to this type of resource.

Moreover, other students’ practices relating to technology also hinder the full use of technology in aspects of the instructional process. The next chapter focuses on participant’s experience with students’ questionable use of technology in their courses.
Summary of Results

During this chapter, participant’s responses to the interview questions relating to the use of technology and the factors that influence this integration to facilitate active learning have been reviewed. Emerging themes and categories provide an understanding of faculty’s viewpoints about the research questions. While all participants described an understanding regarding the role of technology in student learning and engagement, factors discussed play an important role in how faculty members will adopt and integrate technology into their classes. Throughout this chapter, insight into the decision-making process related to how technology is used and the role of influencing factors had been explored.
CHAPTER 5
FINDINGS AND IMPLICATIONS

This chapter focuses on the discussion of findings about the use of technology and factors that influence the use of technology to facilitate active learning by full-time STEM faculty at a community college. The findings of this study are examined as they relate to the research question and implications are framed as both recommendations to the institution and their impact on the field of study. Finally, limitations and future research approaches are discussed within the context of this study and the literature.

Summary of Study

In an effort to engage students in science courses, calls have been made to revise how science curricula are presented to students (Bergstrom, 2011; DiCarlo, 2006; Gardner & Belland, 2012; Michael, 2006; Woodin et al., 2010). Various reports focusing on the importance of improving STEM education have been published since the 1990s by various agencies (Labov et al., 2009). As the science community considers engagement strategies to facilitate student learning, teaching practices have emerged as an area of focus and analysis. As a means for student engagement, active learning strategies that focus on student-centered learning have been proposed. To address challenges associated with active learning implementation, practitioners have introduced various technology based approaches to facilitate content delivery. This study focused on identifying how faculty members use technology to facilitate active learning strategies and what factors influence their implementation within a community college environment.

The School of Science at the institution that served as context for this study has a vested interest by its leadership to promote the use of active learning strategies and the development and scaling of current practices throughout the science faculty college-wide. To facilitate active
learning in STEM lecture courses, some faculty at this institution have adopted the use of technology and technology-related practices described in the literature; therefore, it was important to understand how technology is being integrated into the curriculum within this specific context.

To incorporate active learning practices into traditional lecture courses, instructors have used technology to facilitate the learning process and at times, moved content outside of the physical classroom. To understand how technology was being used by full-time STEM faculty, the type of technology they used was identified through a series of interviews. This study used an exploratory qualitative approach to understand how faculty members use technology. Using parameters established in the UTAUT model (Venkatesh et al., 2003), participants from the School of Science were invited to contribute to this study after identifying themselves as technology users. Participants shared their experiences with technology describing (1) how faculty learned and became proficient with technology use, (2) how faculty integrated technology into their teaching practices, (3) how it related to active learning, and (4) their vision of how technology should be used in the future.

Members of the faculty choose the types and extent of technology integration that will be used in their classrooms. These choices may be made individually, or collaboratively by a committee of instructors teaching a course to ensure a level of consistency in the course independent of individual instructor. Thus, to understand the process of choosing technology and the level of integration, various factors that influenced this choice were identified. Through the exploration of emerging factors, this study aimed to determine influences on use and implementation of technology, the source of the factors, and the influence these factors have on the implementation of technology. When these factors and their relative impacts were examined
together, this study revealed insights into the use of technology and the factors that influenced the decision-making process related to how technology is used to facilitate active learning strategies in STEM lecture courses.

**Discussion of Findings**

The results of this study provided insight into participants’ interpretation of active learning, STEM faculty members’ use of technology, and factors that influence the implementation of technology to facilitate active learning. The following section discusses these findings using the UTAUT model of technology integration (Venkatesh et al., 2003) as a framework gathering insight into actual user behavior and faculty’s behavioral intentions.

**Participant Interpretation of Active Learning**

Student-centered approaches to instruction as defined by the *Vision and Change in Undergraduate Biology Education: A Call to Action* document are courses and curricula “that take into account student knowledge and experiences at the start of a course and articulate clear learning outcomes in shaping instructional design” (Bauerle et al., 2009, p. 22). Some of the approaches discussed and reviewed in the literature (David H Jonassen, 2014; King, 1993; Musante, 2011) focus on student-centered learning, demonstrate the collaborative and social nature of the approach, the individuality of the learning process, and the role of the instructor as a guide. Specifically, active learning is a student-centered strategy that not only addresses new approaches in pedagogy, but also responds to calls for the development of inquiry in the students and relevance of the material with real-world problems (DiCarlo, 2006).

During this study, faculty members were asked to describe how technology has facilitated active learning practices in STEM lecture courses and what factors influenced their integration. As participants described their experiences, the description of various strategies highlighted in
the literature (Gardner & Belland, 2012; King, 1993; Woodin et al., 2010) as collaboration and student discussion were identified. Faculty members described the use of these strategies to enhance courses by departing from a traditional lecture format and allowing for increased student participation. Likewise, technology was identified as a facilitating tool for some as some faculty used flipped classroom strategies, videos to facilitate discussion, and adaptive technology platforms. Moreover, some faculty members were specific in describing the roles of student-response systems, LMS platforms, and other tools that provided a platform for students to be at the center of instruction in increasing student participation and engagement.

While their teaching strategies were identified as those that focus on student-centered practices, it was evident that not all participants shared the same definition of active learning as that described in the literature (David H Jonassen, 2014; King, 1993; Musante, 2011). Three of six participants were purposeful when describing their experiences promoting student interaction, collaboration, participation, and ownership in the course. Other participants did not focus specifically on these practices. For them it seemed as though “active learning” was defined as the” act of learning”. Thus, when describing their experiences, they shared practices where students demonstrated learning in-class, were assessed about their learning, or how technology addressed criticisms regarding understanding of the material or the faculty member. Regardless of their definition, through their discussion it was clear that technology had a role in active learning strategies and their general practice.

It is important to note that STEM faculty at this institution are not required to have formal pedagogical backgrounds, except for a graduate level course titled Analysis of Teaching in Higher Education required for faculty as part of their application for continuing contract. Faculty members can complete this requirement at any time within their first years at the institution.
Other pedagogy related opportunities are available to faculty through professional development, but are not required. Therefore, many participants may not be familiar with terminology or specific characteristics associated with new teaching practices, like active learning, although they may be using them.

**Faculty Use of Technology to Facilitate Active Learning**

To address the research question focusing on how full-time faculty use technology to facilitate active learning, faculty described how they use technology to open the discussion with students and allow them to participate in the learning process. Frank was specific about this practice when he described the use of technology to “break the lecture.” In doing so, participants allow students to communicate during their lecture courses in various modalities. Specifically, some participants used student response systems to gather information. Others shared experiences where they used technology to pace their lectures and promote discussions in the class relating to the course topics. Andrew and Diana shared how they used technology in their courses to provide insight about the topics and allow students to discuss the material, or even bring new information to the class outside of that provided by the instructor or the textbook. In doing so, students take ownership of the course and explore new avenues that will allow them to understand not only the material in the syllabus, but as Andrew stated, “the process of science.”

Other instances beyond participants’ use of active learning focused specifically on use of technology in facilitating their work. These practices echoed the work described in the literature of flipping the classroom or facilitating the participation of students in large classroom settings (Eichler & Peeples, 2016; Mayberry et al., 2012). Many participants described concerns about the amount of material needed to be covered, but used technology to provide instruction outside of the classroom time as described by Catherine. Moreover, this practice is not limited to
instruction but also assessment delivery, although not all participants were confident with how students approached assessments online. Nevertheless, while they were not reliant on this type of assessment they considered it as an alternative to traditional in-class assessments. By transferring this task to the online space, faculty shared how that opened time in their courses for other activities and discussions.

Using technology to facilitate both active learning and their instructional tasks, many participants shared how they could collect information about student learning. These methods included providing students with feedback outside of the classroom that could be used to promote discussions in class, and maximizing technology to flip their classrooms and exploit the time in-class to focus on specific needs of students. Frank shared his example of how technology facilitated his practice by minimizing the time associated with the set-up of demonstrations and allowed him to focus on the analysis of data.

Factors Influencing Integration of Technology

To address the research question focusing on the factors that influence faculty’s implementation of technology, participants’ responses are discussed within the factors in the UTAUT model (Venkatesh et al., 2003). Faculty members at this institution have the control to choose (1) if they will use technology in their courses; (2) what type of technology will be used or (3) to discontinue use, and (4) to what extent the technology will be integrated in their course. Therefore, through the interview process it was important to determine the factors that influenced faculty members when making these choices. Throughout the interviews, all participants made it clear that the choice of technology adoption, use, and integration was up to them. While some described a consensus through faculty discipline committees charged with determining curriculum standards, these groups are composed of individual faculty and there was no
participation from administration. However, some participants shared moments where technology implementation was promoted by the administration. Likewise, the overall feeling of participants was that the institution encouraged the use of technology, not necessarily as a mandate but through their support and availability of resources.

Outlined within the UTAUT model (Venkatesh et al., 2003), the interaction of factors that modify faculty’s intentions and use are framed focusing on (1) performance expectancies, (2) effort expectations, (3) social influence, and (4) implementation of technology. During this study, factors within these categories were identified that guide faculty’s choices regarding technology in their practice. The following sections focus on the exploration of these factors and the impact on technology implementation to facilitate active learning.

**Performance expectancies.** A significant factor before the adoption and integration of technology focuses on the technology’s predicted usefulness and the participants’ perception of if and how the technology would fit into their course or teaching-style. Eddy shared that there are some aspects in his class that he cannot do with technology, such as explaining mathematical operations, and Catherine spoke about her apprehension regarding online laboratories. Thus, when choosing a technology to be integrated, the value added is an important factor. Nevertheless, the overall attitude of the participants was that technology did provide multiple added values to their practice.

Various uses of technology and how they impacted their course were described by participants during the interviews. Most of them saw technology as an engagement tool that facilitated student interaction in the course. Technology assisted during the instructional process by facilitating the access to information. Andrew and Frank shared various experiences of how collecting data from technology sources provided information for students in real-time that
allowed for teachable-moments during their classes. Furthermore, others shared how technology opened their possibilities to demonstrate and discuss material that may not be easy to visualize or explore within the limitations of a classroom. Likewise, other uses of technology focused on how it facilitated their instructional tasks like grading and providing information for students beyond the textbook.

Altogether, participants described the value they found in the use of technology. Participants like Brittany shared that using technology opened the possibility of integrating additional types of technology, even though she had initial reservations. Thus, while critical about the potential of technology, faculty members do find a use for them in their practice. As explored in the next section, after determining the value of the technology, the focus then shifts to the impact the integration of technology will have on the individual.

**Effort expectancies.** The effort associated with the integration of technology in this study was linked to the time investment regarding learning the technology and later integrating it into their classes. Thus, a faculty members’s assessment of their time investment becomes a factor that influences the decision-making process. While they may determine technology to be useful for their practice, the time investment may be too large of a commitment. Overall, for participants, their time investment was described within the context of self-efficacy and the support they received to integrate the technology.

As described in the literature, the knowledge faculty members have of and their proficiency with technology play a role in their use of the technologies. Participants in the study described how, if they were more familiar with something they would be more inclined to integrate it. Most participants described themselves as being open to technology and to the possibility of learning something new. However, many participants described themselves as “not
technology savvy” or as realizing they were not as proficient as they thought when using a new technology. In other instances, faculty described a steep learning-curve associated with the use and integration of technology. For this study, this factor was not a deterrent when using technology as most of the participants that expressed limited knowledge shared the availability of support systems in the institution that allowed them to overcome this limitation. Also, while initially hesitant or apprehensive about integration, the usefulness of the technology in their practice served as personal motivation.

Overall, most participants acknowledged that integration of technology included a time investment and that its integration would result in more work for them, at least during early implementation. Regardless, as described by the interaction of factors in the UTAUT model (Venkatesh et al., 2003), other aspects modulate its impact. For participants, the motivation associated with the usefulness of the technology overcame uncertainty associated with integration. Likewise, institution and peer support provided the assistance many participants needed, as discussed later in this chapter.

**Social influence.** Motivation to use technology, while for some participants in the study is intrinsic, it is also influenced by social components. For some participants, their desire to use technology because of the usefulness value served as sufficient incentive to move forward with the implementation process. These individuals would be characterized as “early adopters” by other implementation models such as that described by Rogers (1995). As such, these faculty members overcome apprehensions related to being the first to use the technology. In this study, three participants demonstrated these qualities. Many were innovators and brought technologies and practices to their departments regardless of what their peers were doing. These participants later served as models by sharing their experiences with other faculty members and assisted in
their integration processes. As shared by some of these participants, the support provided by the institution as described later in this chapter or their own motivation to “figure things out,” as described by Diana, facilitated their integration process.

For faculty that were not early adopters, potential usefulness of the technology served as the major impetus that encouraged them to integrate technology and related resources into their own courses. In addition, questions of the effectiveness for other faculty and transferability to their courses also becomes an influencing factor. In this study, participants within this category shared initial apprehension at the integration of technologies such as Blackboard or student-response systems. Yet, through the interaction of other influencing factors, these individuals found support through professional development, peer-support, and support from publishers. Moreover, as stated by some participants, the use and integration of a technology at times facilitated the possibility of using other technologies.

Facilitating conditions, as described in the UTAUT model (Venkatesh et al., 2003), provide faculty with the support for their technology use and integration activities in order to facilitate active learning in their courses. The following section describes these facilitating conditions as the process of technology implementation. Likewise, the interaction of all the previously described factors influences faculty’s behavioral intent, which together with facilitating conditions, impacts faculty’s actual use.

**Implementation of the technology.** As faculty members commit to the use and integration of technology, factors described previously serve as constraints as individuals question the usefulness of the technology or their self-efficacy for use and integration. Thus, support associated with the implementation of the technology influences the decision-making process. This support can come in several ways. For instance, the institution might provide
professional development and training opportunities to faculty to allow exposure to and increased understanding of more technologies. Alternatively, the availability of peer support may also play an important role. Participants in this study shared that the institution has an effective professional development program that facilitated training and supported the integration of technology. Moreover, multiple instances of faculty of interaction were also shared, demonstrating the peer-support sometimes necessary during the integration process.

The support associated with the integration of technology was evident as an important factor for participants. This support was described from various sources and they addressed the needs of the individuals. For those that described themselves as ‘not technology users’, professional development opportunities provided by the institution supported them when they had questions or helped overcoming obstacles. Likewise, others maximized peer-support as guidance when having specific questions or as models they could adapt to the needs of their own courses and students (as supported by the social factors discussed previously). Moreover, support beyond the institution or peers, as that provided by publishers, facilitated the integration for participants like Brittany. The shell provided by the publisher to integrate learning modules and assessments into her LMS, lessened the time invested by her when preparing her courses. During her interview, she described how the publisher provided a content-area specialist that prepared the shell and all she had to do was make sure the material was appropriate for her course. Thus, the time investment in preparation of the course was reduced and overcame limitations of her time.

When taken together, all factors described by the UTAUT model (Venkatesh et al., 2003) were present in this study. While the model informed the interview protocol, the questions used in the interview were general and open-ended. Nevertheless, factors described within the model
were identified as having an influence in faculty member’s technology implementation. What is most important as a finding is that beyond the identification of these factors, the interactions described by the model were also evident. Concerns about the usefulness of a technology are addressed by social factors by the individual’s early adoption and later modeling at the institution, or the support by institutional components such as professional development and the availability of peer interactions.

**Research Implications**

The results from this study provide insight into the use and factors that influence STEM faculty integrating technology in lecture courses. The data highlighted participants’ technology use at this institution, the resources that assisted them in their integration process, and factors that influenced their decision-making process and integration. The following sections describe this study’s findings, impacts, and suggestions relating to the institution and concludes with its contribution to the current body of literature.

**Recommendations for the Institution**

Factors described by the UTAUT model (Venkatesh et al., 2003) help understand their influence on an individual’s choice relating to technology. This plays an important role at this institution where many participants made it clear that the selection of technology and how it was implemented in the classroom was up to the faculty. Thus, insight into these factors provides information that can be used to facilitate the use of technology to support active learning.

As part of the social influence, the role of faculty collaboration at this institution emerged as an important factor. Many participants described how this support helped them to be exposed to new information and later integrate these new strategies into their classrooms. Thus, leveraging these relationships through discipline or campus professional networks will increase
the interactions between colleagues and may increase the spread of technology and active learning pedagogies to more members of the faculty. Likewise, the institution should consider the exposition of best practices in public forums where faculty members could present and discuss best practices and classroom innovations. By highlighting successful strategies, the institution will be able to diffuse these practices throughout the college.

Likewise, leaders can be identified to serve as centers of support and resources for faculty. Networks of scholarship promoted amongst the faculty to share resources and experiences may play an important role in future adoption and integration practices. Professional development must go beyond implementation in the use of the strategies as part of their course development (Michael, 2006). Moreover, professional development opportunities could be developed based on faculty interest on specific topics and approaches.

Opportunities, such as short courses that model active learning strategies as part of the course and model the integration of technology to bridge content and strategies, need to be developed. Many participants described their professional development opportunities as satisfactory and positive. It was evident that this is an institutional asset that faculty members exploit to increase their understanding of new technologies and expand their teaching practice. Therefore, the institution must exploit this strength and use their professional development opportunities to provide faculty with additional support. As discussed in the following sections, professional development can address the needs relating to technology, active learning, and pedagogy.

**Technology and Active Learning**

Active learning practices focus on student engagement and their involvement in the learning process. While traditional laboratory courses foster student engagement through inquiry
and problem-based learning, lectures conventionally remain passive learning environments where students consume information. Therefore, active learning strategies must be incorporated into lecture courses to not only engage students, complement their learning and understanding of the STEM disciplines, and promote student ownership of their learning.

Strategies associated with these practices have been criticized because of the time investment and the strain on content coverage (DiCarlo, 2006; Fata-Hartley, 2011; Gardner & Belland, 2012; H. W. Lee et al., 2008). As described in the literature (Cotner et al., 2013; Eichler & Peeples, 2016; Gardner & Belland, 2012; Mayberry et al., 2012; Nogaj, 2013), faculty at this institution have met these obstacles with technology. Participants described multiple ways in which they use technology to facilitate active learning. Some participants used technology to promote student engagement in the course through in-class discussions, as described in the literature (Eichler & Peeples, 2016; Mayberry et al., 2012; Nogaj, 2013). Likewise, they opened their classes to additional material provided by the students and allowed them to construct their understanding of the material serving as a guide through the course. Moreover, some of the strategies also maximized communication between students and provided students with a space to take ownership of the course. Therefore, there is a group of faculty members that show an understanding of how technology can be used to facilitate these practices in the future. Overall, their practices echo strategies previously described where technology serves as a facilitator for the strategy (Cotner et al., 2013; Eichler & Peeples, 2016; Gardner & Belland, 2012; Mayberry et al., 2012; Nogaj, 2013).

Other participants in the study integrated technology into their courses with the goal of increasing student engagement, but not necessarily focusing on active learning. For these participants, the focus was on their perception of students’ preference to the use of technology or
the impact technology would have facilitating tasks within their practice. Interestingly, while focusing on other aspects of their practice, they unintentionally promoted active learning strategies by stimulating new discussions in class, moved content online and provided in-class time to work together with students, and fostered communication between faculty and students providing formative assessments that allowed for just-in-time instruction. Thus, these participants also served as examples of how technology helps to facilitate active learning.

Therefore, while all participants valued the usefulness of technology in their practice, there is a heterogeneous population aware of the connection between active learning as defined in the literature and the integration of technology. Thus, pedagogical context and teaching strategies associated with active learning will benefit faculty that share characteristics with participants when presented with new technology. As mentioned previously, STEM faculty are not required to have a pedagogical background and do not need to be updated with current teaching strategies and terminology associated with their field. Consequently, the next section focuses on how professional development can promote the use of technology and assist in connecting it with pedagogy and instructional practices.

**Professional Development and Pedagogy**

All participants shared positive attitudes towards the professional development opportunities at the institution. For them, these offerings provided exposure to new technologies and the support to integrate them in their courses. Nevertheless, the pedagogy aspect related to technology use was not evident. In fact, Catherine mentioned how her training in Blackboard was not enough when integrating the LMS and she needed modeling from peers to properly use the technology. Thus, there is a need to support pedagogy strategies when presenting technologies to faculty members integrating such tools.
Workshops and training sessions focused on not only what can be done with technology but specifically how to integrate it are imperative. Here lies the difference between technology use and technology integration. Currently, the available experiences for faculty members center on the availability of technology rather than the pedagogy associated with its integration. Thus, professional development offerings need to be developed for the integration of specific technologies into faculty members’ courses. Moreover, these offerings must be designed to model practices that intentionally demonstrate how technology is being used within teaching strategies. Consequently, faculty would use these strategies to later modify what they experienced in the training sessions to their course’s needs.

Furthermore, additional opportunities to the initial pedagogy course required for faculty within their first years at the institution also address this need. The exposure to new faculty that may not have experience within the field of pedagogy is important. But as evidenced by the distribution of faculty where only 16% of faculty have not yet received continuing contract status, most the faculty at the institution completed the course early in their careers and may not be aware of new developments, teaching strategies, or pedagogical approaches. Moreover, faculty in the STEM disciplines are not required to have an education background. This may limit their knowledge of potential teaching strategies they can use in the classroom. While some faculty, as described by some participants, will look for the information to enhance their practice, others may only be mirroring strategies that were used during their education. By providing faculty with the opportunity to develop their instructional practices, this platform allows for faculty development both in the use and integration of technology to facilitate active learning.

It is important to note that active learning alone does not lead to learning and that learning may occur without the use of active learning strategies. This study explores how STEM
faculty members use technology to facilitate active learning and what factors influence their implementation of technology. Thus, it assumes that faculty members are familiar with these strategies and their benefits as described in the literature and that the strategies are being used positively.

**Impact Beyond the Institution**

The focus of this study was to explore full-time STEM faculty members’ use of technology and factors that influence their integration to facilitate active learning in lecture courses at a community college. While this findings describe participants of this study, outcomes described provide insight into the community college STEM faculty and the efficacy of the UTAUT model (Venkatesh et al., 2003) to provide guidance in obtaining participants’ intentions and use.

**STEM faculty at community college and active learning.** As described in the work by Twombly and Townsend (2008), the population of this institution mirrors the described demographics except for their ethnic distribution. While not used as a sampling parameter for this study, most participants were not predominantly white as those described by Twombly and Townsend (2008). The focus at this institution is also on teaching rather than research, focusing on lower division courses and unlike those described in the literature, participants at this institution do have support for research although not research is not central as a required task for faculty. Like results reported by Twombly and Townsend (2008), participants of this study employed active learning strategies as engagement tools and these strategies are sometimes met with apprehension from some students that later came to see their usefulness.

Thus, the findings reported in this study add and update the current body of literature by supporting previous findings. The use of active learning strategies is also a tool for student
engagement and as described in this study’s findings, it supports other results in the literature that describe how technology facilitates the integration of active learning strategies (Cotner et al., 2013; Eichler & Peeples, 2016; Mayberry et al., 2012; Nogaj, 2013). Moreover, this study also describes how participants used technology to facilitate the tasks associated with their practice such as grading, providing students with feedback outside the classrooms, and moving content and assessments online to alleviate in-class time (not associated with flipped classroom strategies).

**Effectiveness of UTAUT model.** As described by the interactions shown in Figure 3-1, the UTAUT model focuses on the perceptions and beliefs of the user as it relates to innovations, where 4 major constructs from different models guide the understanding of the behavior: performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh et al., 2003). As part of this study, the modified interview protocol by Evers (2014) served to explore the intentions and use of technology to facilitate active learning. Through the findings in this study, the relationships described by the model are evident. Concerns associated with participants’ performance or effort expectancies influenced a faculty member’s intent on use and integration of technology, but the interaction of other factors such as social interactions and facilitating conditions, also influenced faculty members’ final use and integration. Thus, faculty’s final behavior related to technology can be understood as an interaction of all these factors.

The model’s modulating factors such as age and gender were not shown to have an impact in this study. Interestingly, while experience was defined in this study as years teaching at the institution Frank was explicit when mentioning that familiarity to one technology facilitates its use, and Brittany shared that because she used one technology for active learning she was
now open to using more. Experiences such as those shared describe a connection between the use of technology and the faculty’s exposure and practice with it. Within the UTAUT model (Venkatesh et al., 2003), experience serves to influence faculty’s use making the direct relationship that given more exposure (time) users would be more willing to use the technology. Thus, experience emerged as the time exposed to technology. Moreover, the factor associated with voluntariness of use was implicit as all participants were self-identified technology users. Therefore, this study serves as further support for the UTAUT model’s use when considering factors that influence technology use.

Limitations

This study aimed to explore the use and factors that influence the integration of technology to facilitate active learning strategies in STEM lecture courses, through a qualitative analysis of full-time faculty at this institution. Through the examination of this study, various limitations were identified. In this section, the impact of sample size compared to the population of full-time STEM faculty at the institution, the identification as technology users before participation in the study, the diversity in technology use and integration of the participants, and the limitations associated with the instrument are discussed.

Sample Size

The sample for this study is not representative of the number of full-time STEM faculty at this or an alternative institution. The number of participants in this study represented 6% of the total School of Science faculty. Moreover, participants that agreed to contribute to this study were all from the same campus. While most resources and opportunities are available to faculty in all campuses throughout the institution, individualities associated with faculty distribution or how the administrators at those campuses support the integration of technology may result in
other answers by faculty at those sites. Moreover, the representation of participants at this institution is not necessarily comparable that in other community colleges. Therefore, findings in this study may not represent the beliefs of other faculty members in another campus or another institution.

**Faculty Identification as Technology Users**

Faculty were invited to participate in this study with the constraint that they used technology to facilitate active learning. Most of the faculty contacted agreed to participate, but there were individuals that were approached that declined to participate because they assessed their practice as “not including technology”. Thus, participation in this study was limited to those participants that identified themselves as technology users. This is important because one of the modifying elements within UTAUT is voluntariness to use related to technology (Venkatesh et al., 2003). Therefore, all participants in this study already had intent or were using technology. Thus, their responses may be different than those that may have a lesser level of voluntariness.

Furthermore, participant’s identification is based on the evaluation of their practice. While they may consider themselves as not technology users, they may be using technology that would have provided additional insight for this study. Likewise, participants in this study assessed themselves as technology users but that does not set any standard to their level of use or integration. The following section further explores the limitation associated with the diversity of participants.

**Participants’ Diversity**

Participants’ identification as technology users for this study allowed me to obtain information about participants that were using technology to facilitate active learning strategies. This open invitation and lack of definition of what is a technology user included a diverse group
of participants. Thus, rather than a comparison of a specific group within the STEM faculty population a larger group was investigated. From the results of this study, the participants can be arranged as a graduated continuum of technology use. Although some participants may use and integrate technology in their courses, not all participants shared the same level of technology use, integration, or link to active learning. For example, Eddy said he could not pace information in a PowerPoint, while Andrew shared how he controls how he presents information to students to promote discussion.

Although the diversity of participants offered richer descriptions covering a wider group, some interviews focused more on how technology facilitated their work rather than active learning strategies. Therefore, the information gathered is limited by how participants evaluated their practice and others. While the youngest participant believed that she used more technology than senior faculty, the most senior faculty in the study shared various experiences about technology integration that were not described by other faculty members.

**Interview Protocol and Self-Reporting**

As information was gathered throughout the study, the answers by participants were limited to their perception of their own experiences. Many participants shared explicit examples of active learning and how technology facilitated this process, while others described their practice as being active learning. This becomes a limitation for the study because as mentioned in the literature, some faculty members may choose to use technology only as a replacement of previous teaching strategies and not necessarily focusing on student-centered practices.

The interview protocol used in this study focused on participants’ intentions and behavior of technology use, not specifically their practice. This becomes a limitation as identified in the results section, because not all participants shared definitions of active learning aligned to that
described in the literature. Questions as “what expectations did you have of the added value of using technology for active learning in the classroom?” and “where your expectations met?” while probing for productivity and expedition of tasks, sometimes were answered focusing on grading and paperwork associated with their practice rather than in-class activities. However, while a limiting factor, these questions led to the identification of unintentional added value associated with active learning, as assessed by this study.

**Future Research Direction**

The current study focused on exploring the use and factors that influence the integration of technology by full-time STEM faculty to facilitate active learning. Based on the findings and limitations associated with this study, other areas of potential research can be identified. This section addresses questions identified from concerns of participants relating to the efficacy of the use of technology and the impact on student achievement, and limitations described associated with the instrument used to collect results and determine the study’s findings.

**Impact of Technology Use to Facilitate Active Learning**

Participants in this study described how technology facilitated the tasks associated with their practice and more importantly for this study, how it facilitated active learning strategies in STEM courses. While most participants shared positive experiences, concerns about student engagement were identified. Some participants in the study expressed that regardless of the learning strategies, some students will maximize opportunities while others will not. Therefore, future studies focusing on the impact technology has on this population are imperative.

Studies have discussed the impact of active learning strategies facilitated by technology in community colleges (Edward et al., 1997), but they focused on student perception of these strategies. The work by D’Avanzo, Anderson, Hartley, & Pelaez (2012) reviewed a comparison
of the outcomes between various institutions including community colleges and did not find significant differences between the institutions. Thus, while this study has identified how faculty integrate technology into their courses, the impact of the instructional delivery has not been discussed. Focus on comparing the outcomes in classes similar to those described by Edward et al. (1997), where part of the course is taught with technology and part without, the use of technology could be used to determine difference in treatment.

**STEM Faculty Technology Level of Use**

As identified in the limitations section of this study, there is a variety in the level of use and integration of technology in STEM courses. By focusing on defining faculty members as part of categories associated with the use of technology, focused professional development opportunities could be proposed that address the needs of each group. Adoption frameworks such as CBAM (Favero & Hinson, 2007; Straub, 2009), can help determine levels of use. As faculty members are assessed within the CBAM framework, the use will be categorized and evaluated. Use of this model would focus in understanding the individual and their role in the adoption and implementation process, with the potential of supporting further growth.

**Summary of Findings and Implications**

The current study used the UTAUT model (Venkatesh et al., 2003) as a theoretical framework to explore: how are active learning strategies facilitated with the use of technology in STEM lecture courses taught by full-time faculty? Faculty members self-identified as technology users were interviewed using a modified UTAUT protocol from Evers (2014). Findings in the study identified that participants are using technology to facilitate active learning strategies and that interaction of factors identified by the UTAUT model play an important role in the implementation of technology to facilitate active learning.
Implications of the study’s findings described how there may be a disconnect between the definition of active learning in the literature and that used by faculty. The discrepancy identified by the current study can be addressed through maximizing professional development opportunities, as they were identified by participants in a positive manner. Moreover, this study provides insight into the STEM community college faculty and their active learning practices. Likewise, the effectiveness of the UTAUT model (Venkatesh et al., 2003) as a framework to provide understanding of participant’s behavior of use and interaction of factors within the model and modulating factors, was also discussed.

Several limitations were identified that were part of the research design and others that were beyond the control of the study. Sample size was a limiting factor associated with the design. Only a small portion of the faculty from the School of Science and members of a single campus at the institution participated in the study. Thus, findings of this study are not generalizable or comparable to other institutions. Moreover, faculty identification as technology users, diversity of participant’s technology use, and limitations of the instrument, were all restrictions beyond the control of this study.

Finally, potential future research directions focused on addressing concerns from participants and limitations described in the study. Questions about the impact of technology use in student achievement associated to active learning call attention to gaps in the literature. Moreover, uncertainty regarding the level of technology use in this study served as a limiting factor. This study helped to expose both potential research opportunities that would add to the body of knowledge in the literature and support the information gathered in this study.

As noted in the literature, there is a need to address student engagement in STEM courses and student-centered practices aid in this process. While these practices have been characterized
as time consuming in already ambitious curricula, the use of technology has been used to facilitate this process. Throughout this study, participants at a community college have shared that their experiences are like their counterparts in other institutions. Through the exploration of the findings in this study, efficient practices as professional development opportunities and peer-support show how some of concerns associated with implementation can be addressed. While there is room for improvement, something that was clear in this work is that faculty members have both a strong commitment and a willingness to support student success.
Dear STEM Faculty member,

I am interested in conducting research that will allow me to understand the use of active learning strategies and how technology facilitates these practices in STEM lecture courses at MDC. I would like to invite you to participate of and interview for this study, as your experiences and insight will help me understand better how you have implemented technology in your course. I aim to compile information from the Biology, Chemistry, and Physics faculty members part of the School of Science, and your participation will be greatly appreciated.

The interview will last no longer than 45 minutes. You will not have to answer any question you do not wish to answer. Any specific information will be removed from the final transcript and kept confidential. There are no anticipated risks, compensation or other direct benefits to you as a participant in this interview. You will be free to withdraw your consent to participate and may discontinue your participation in the interview at any time without consequence. Your interview will be conducted after you sign a copy of a consent form. At the end of the interview, I will ask you share with me access to instructional material displaying your use of technology and active learning.

If you wish to participate, please contact me at your earliest convenience to schedule the interview.

Thank you,

Alfredo León
APPENDIX B
INFORMED CONSENT FORM

I am a graduate student at the University of Florida College of Education enrolled in an online doctoral program in Educational Technology. As part of the dissertation component of my program, I am conducting an interview, the purpose of which is to learn about Active Learning Facilitated by Technology in STEM Lecture Courses in a Community College. Your responses will allow me to better understand what teaching practices are used the most at MDC STEM lecture courses, if these practices are facilitated by technology, how are these practices used in your classes, and what factors influence implementation.

The interview will last no longer than 45 minutes. You will not have to answer any question you do not wish to answer. Any mention of specific course and/or person will be removed from the final transcript and kept confidential. There are no anticipated risks, compensation or other direct benefits to you as a participant in this interview. You are free to withdraw your consent to participate and may discontinue your participation in the interview at any time without consequence. Your interview will be conducted after you sign a copy of this consent form. A second copy is provided for your benefit.

With your permission, I would like to audiotape this interview and our review of the course using the rubric. Only I will have access to the tape which I will personally transcribe or use the services of a professional transcriber, removing any identifiers during or after the transcription. The recording will then be erased. Your identity will be kept confidential to the extent provided by law and your identity will not be revealed in the final report I submit.

Furthermore, I would like to request you share with me access to instructional material displaying your use of technology and active learning. With your help, I would like to use the Technology Integration Matrix to review the level of integration of technology to the curriculum. Both the interview questions and the matrix are shared in this consent form.

If you have any questions about this research protocol, please contact me at 305-237-1016 (office), aleon6@mdc.edu or alfredeleon@ufl.edu, or my faculty supervisor, Dr. Swapna Kumar, at swapnakumar@coe.ufl.edu. Questions or concerns about your rights as a research participant may be directed to the IRB02 office and reference study IRB201700523, University of Florida, Box 112250, Gainesville, FL 32611; (352) 392-0433; 352-392-9234 (fax); irb2@ufl.edu You may also contact Rita Menéndez, IRB Chair, at IRB@mdc.edu; (305) 237-7488.

Signature of Interview Participant: __________________________ Date: _______________

Signature of Instructional Material Participant: ____________________ Date: ___________

Signature of Researcher: _____________________________ Date: _______________
APPENDIX C
UTAUT INTERVIEW GUIDE

1. What is your experience using technology to facilitate active learning?
   a) Tell me about advantages or disadvantages to using technology

2. Which factors/aspects influence your decision to continue using technology for active learning or not?
   (Probe: extent of choice or lack of choice using technology for active learning)

3. How did you get introduced to/begin using technology for active learning?

   Performance expectancy
4. What expectations did you have of the added value of using technology for active learning in the classroom? (E.g. increase productivity, accomplish tasks more quickly)

5. To what extent were your expectations met?

   Effort expectancy
6. Which expectations did you have of the effort needed learning to integrating technology for active learning?

7. How was your learning curve trying to integrate technology for active learning?

   Facilitating conditions
8. Do you believe you have the proper resources and knowledge to integrate technology in the classroom?
   a) Why? If not, could you ask someone for help?

9. How does technology integration fit with the other styles of teaching you use during your work? (Probe for active learning)

10. Did something change in your own behavior during the use of technology to facilitate active learning?
    a) What and why?

11. Were you involved in decisions related to technology adoption at the department? (Probe for perceptions)

   Social influence
12. What is the departmental and institutional culture regarding integration of technology?

13. How does your institution support your integration of technology for active learning in the classroom?
    (Probe for motivation/incentives/resources)
Behavioral intentions
14. Are you likely to continue integrating technology for active learning?
   (Probe for more, less, equal, quitting)

15. Would you recommend using technology in the classroom to another faculty?

This concludes our interview; would you like to add anything else?
LIST OF REFERENCES


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BIOGRAPHICAL SKETCH

Alfredo León attended the University of Puerto Rico focusing his education on biology. As a graduate student Alfredo, experienced science first hand during his master’s degree. The experiences in the laboratory and the techniques learned were instrumental for later work and teaching philosophy. After completing his studies, Alfredo taught middle and high school levels in Miami Florida where he was awarded “Rookie Teacher of the Year” during his first-year teaching, but his interest in higher education lead him to Miami Dade College.

Alfredo’s work at the institution started as an adjunct professor teaching biology courses, and later a laboratory manager at Wolfson Campus. As a manager, he worked with faculty to develop and establishing projects using the laboratory facilities that allowed students from science and mathematics courses to experience project-based learning. In 2013 Alfredo became a full-time biotechnology and biology faculty focusing on teaching and expanding on the opportunities provided to students through research projects.