STUDENT PERCEPTIONS OF COMPETENCY-BASED LEARNING IN AN ONLINE COLLEGE ALGEBRA COURSE

A Scholarly Research Project

Submitted in Partial Fulfillment of the Requirements for the Degree

Doctor of Education

Approved:

Dr. Scott Estes, Research Mentor

Dr. Jeffrey P. Bakken, Professor

Dr. Jana Hunzicker, Program Director

Dr. Anna Viviani, Department Chair

Dr. Kathy Shapley, Dean

Zachary Aaron Youmans

Bradley University

December 2024

ABSTRACT

Competency-based learning (CBL) is a grading strategy that emphasizes the mastery of content. At Middle Technical College (MTC), success rates in the college algebra class have decreased. This study will answer two questions: how will a CBL approach to learning affect student perceptions of their success and what are student perceptions of after taking the CBL courses versus what they think of as a traditionally graded classroom? This study's goal is to not only help increase success rates in the college algebra course at MTC, but to help students' math anxiety when entering and during the completion of the class. A convergent mixed method methodology was used to answer the research questions. The result will show that students in the MTC online college algebra course because of the implementation of CBL helped them increase their confidence, manage their time better, helped increase communication between instructor and student, and increased their overall understanding of the material. The results could inform other technical colleges on best practices for teaching math classes, help students entering a math course combat math anxiety, and bridge the gap between developmental coursework and students registering for a degree-level course.

Keywords: college algebra, competency-based learning, confidence, math anxiety, math education, technical college

DEDICATION

This research is dedicated to a few members of my family. First, to my wife, Kylie, my daughter, Aubree, and my son, Everett, you all have pushed me to be the best father and husband that I can be, and I could never imagine life without any of you. Another dedication goes to my unborn child who we lost in the middle of conducting this research. We will meet again one day. Finally, I dedicate this research to my grandparents, who have always been by my side no matter what struggles I have gone through. I am proud of being your grandson, and I can only hope I have lived up to your expectations.

ACKNOWLEDGMENTS

I would like to thank first my wife, Kylie, who has been my side throughout this complete process. In the last few years, we have gone through difficulties, but through it all, we have stuck together. I would never have made it to this point without your love and guidance.

I would like to thank Dr. Scott Estes, my research advisor, for his mentorship and guidance throughout this research. Although we may be 800 miles apart, your genuine love and support of your students burns bright.

To my cohort members, whether that be to those who are graduating in December 2024 or May 2025, I thank you for being there for me. You are all family to me, and I cannot wait to see where we all end up on our higher education journey. I am positive we will stay in contact even after graduation.

Thank you to my employer for allowing me and encouraging me to pursue this doctoral degree. To name a few, Vice President of Academic Affairs DeAnn Nester, Dean of General Education Shannon Durham, Assistant Vice President of Academic Affairs Dr. Al Harmon, and Division Chair of Math and Social Sciences Michael Repzynski, your guidance and support has made our college to be one of the best technical colleges in the country. I am proud to continue to be part of the team, and I hope by earning this degree to continue to help lead the charge in the future of technical education.

Finally, thank you to Dr. Zhaohu Nie, my advisor when completing my master of science in mathematics degree. I did not get to finish my Ph.D. in mathematics with you, but I hope you take solace in knowing that a large part of where I am today is because of you.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

FIGURES PAGE

Chapter 1

INTRODUCTION

Introduction

Imagine, twenty years out of school and Jacob wants to return to the local technical college because he is tired of his current job. His passion is to earn a degree in aviation maintenance technology, one of the many degrees, diplomas, and certificates that Middle Technical College (MTC) offers to its students. During the first meeting with his advisor when discussing what classes to take for his first semester, his advisor wants him to take college algebra. He wonders if he is truly ready for college algebra being that it has been almost two decades since he took a college math course. Further, Jacob must take the class online as he still wants to keep full-time employment as well as have time to spend with his family at home. Being an online class, Jacob is nervous that his math instructor will not communicate with him.

Although Jacob is a fictional student, students registered in mathematics classes at MTC feel unprepared when stepping inside a college algebra course. With an average enrollment of around 1,000 to 1,200 students every fall and spring term, college algebra is the most enrolled math course at MTC. In 2020 with the onset of COVID-19, MTC elected to disband placement exams for mathematics courses. MTC does offer a developmental mathematics course for those who feel like they need it. Still, since it is a non-credit class, many students understand that they can use the free tutoring on campus or online instead of paying tuition for the developmental course. Also, for those students who have been out of school or have not taken a mathematics course in a long while, there can be gaps in learning that students face inside the classroom that are hard to overcome in a 16-week semester. For these reasons and more, students are passing college algebra at lower rates than pre-COVID. With no hope in sight for placement exams to be

returned to MTC, a change inside the classroom may be needed to help fill the gaps in learning students are experiencing. While students take online and in-person classes at MTC, this study will focus on online students. Based on the factors listed above and the need for a change inside the classroom, a competency-based learning approach may be what online students need to better succeed in the college algebra course. The ultimate goal is to answer two questions: how will a competency-based learning approach to a mathematics classroom affect student perceptions of their success and what student perceptions are of competency-based learning versus what they may think of as a traditional classroom.

To begin answering these two questions, this introductory chapter will discuss three different topics. First, an overview of a technical college is given. Next, an overview of the college algebra course will be given. The chapter will close with a discussion on why a change may be necessary inside the classroom, a summary of this project's problem, purpose, and research questions, and a description of how this paper will be organized.

Literature Review

An Overview of a Technical College

A technical college is a higher education institution that prepares students for a specific trade or career (New England Institute of Technology, 2020). Additionally, MTC offers students an associate degree in general studies, which is designed for students to transfer to a 4-year university. (Middle Technical College, 2022). With the rising costs of tuition rates and the length it takes to complete academic requirements at universities, community colleges, technical colleges, vocational colleges, and other more affordable types of higher education are growing in popularity as other options perspective higher education students have available. For example, in the years 1978-1979, the average cost of tuition for a nonresident at a public research university

was $2,018 compared to 2008-2009 when the cost rose to $19,880 (Titus et al., 2015). Compare that to this study's research site, Middle Technical College, which in the 2022-2023 academic year had a nonresident tuition rate of $200 per credit hour (Middle Technical College, 2022). Financially speaking, 2-year colleges such as MTC are more affordable.

The mission of MTC is that the institution offers credit instruction and business training to promote community and workforce development (Middle Technical College, 2022). With workforce development being the primary role of the college, one goal of a technical college, in the opinion of this author, is to get students to graduate in as little time as possible so they can not only land their dream job but also produce for the local economy. As Qian et al. (2018) pointed out, "obtaining a college degree or an industry-recognized credential is necessary to obtain employment that affords the individual future career advancement and a livable wage" (p. 1). Obtaining a college degree or certificate can increase the salary of an individual in the age group of 25-34 by $7,300 a year over someone who has only a high school diploma. That number increases to $9,900 when they reach the ages of 45-54 (Pekow, 2006).

An associate's degree is a degree that generally takes less time than a bachelor's degree and is taken by students to achieve their academic and professional goals by helping them get qualified in entry-level careers such as healthcare and public service (Staff Writers, 2023). More specifically, Middle Technical College is a 2-year technical college that offers associate degrees, diplomas, and certificates. Students can choose 5 different programs of study: aerospace, trade, and industry, business and computer technologies, health sciences, public safety and professional services, and general studies (Middle Technical College, 2022). General education faculty, which includes the author, instruct students from most disciplines across the college as many programs on campus are designed to include general education classes such as math and English.

The degree is usually 2-years in length with a combination of general education classes such as mathematics, English, and humanities alongside core classes in their program of study (Middle Technical College, 2022). Articulation agreements exist between MTC and 4-year universities to provide a seamless transfer of credits when students graduate from MTC and transfer to a 4-year institution (Middle Technical College, 2022). A diploma, on the other hand, is shorter in length and will have fewer general education classes students must take to graduate. Students will typically still take a mathematics course as part of the general education core. Courses are generally not transferable (Middle Technical College, 2022).

Certificates are short programs usually with no general education requirements. Maxwell and Gallagher (2020) defined these shorter, workforce-oriented credentials as microcredentials. A microcredential is a "specialized credential that shows a mastery of one or more job competencies" (p. 9). Although the college algebra course in this study is a degree-level course, a student can earn microcredentials while still earning a degree. Microcredentials will be discussed further in chapter 2.

All students at Middle Technical College are offered a chance to take online coursework. However, in a mathematics classroom, math anxiety may be heightened due to it being online. Math anxiety is "the feeling of anxiety that one cannot perform efficiently in situations that involve the use of mathematics" (Furner & Marinas, 2016, p. 26). Just by opening a math textbook, students may feel nervous, nauseous, or have a migraine, all of which can be quite debilitating (Fergus & Smith, 2022). During one study, Perry (2004) found that 85% of students taking an introductory math class (and college algebra would be considered an introductory math class) felt mild math anxiety. Discussions on math anxiety and how competency-based learning can help ease it, especially in an online environment, can be found in chapter 2.

Since students want to graduate within a reasonable period, MTC offers classwork during the Spring, Summer, and Fall semesters. For the mathematics courses at MTC, students during the Fall and Spring can take a full 16-week semester or a shortened 8-week semester which still meets all the standards of the course. Students who take mathematics courses during the Summer take the 8-week version of the course.

MTC is an open-access institution. An open-access institution offers educational opportunities for students no matter their prior levels of academic achievement (Daugherty et al., 2019). Two-year colleges such as MTC have had a massive expansion, especially among students with financial constraints, academic difficulties, and other factors (Goldrick-Rab, 2010). According to Goldrick-Rab (2010), more than half of the students who enroll at 2-year community colleges are employed, more than that of a 4-year institution in which 37% of students are employed. This results in a diverse set of learners entering and studying at 2-year institutions like MTC.

Technical colleges are a wonderful place to turn for students who are looking to earn a degree that will transfer to a 4-year college, an individual wanting to further their career, or even someone who wants a different career path entirely. For many of these students, college algebra is a course they will need to take during their time of studying at MTC. If the technical college's goal is focused on workforce development, then that also means getting them to pass the college algebra course hopefully during their first time taking the course. The next section of this introduction will talk about the college algebra course and statistics surrounding the success rates of students taking the class.

The College Algebra Course

College algebra is a degree-level course that students often take to fulfill the general education requirements brought forth by their program of study. This course is also used in the health sciences as a selection course for competitive selection (Middle Technical College, 2022). Students at MTC in the health sciences must be accepted into many of their programs, and one of the measurements of acceptance is their grade in the college algebra course. For these students, this makes the pressure to succeed in a mathematics course even higher.

With the pressures to succeed high, students need to make sure they are ready to take college algebra based on the pre-requisite knowledge they have. Many schools require placement testing such as the COMPASS and the ACCUPLACER exams. As Moss et al. (2019) described, since 2-year colleges often admit nearly all students who apply, "institutions typically assess new students' skills . . . before placing them in the curriculum" (p. 738). More concretely, a placement test is administered as an admittance exam to make determinations about college readiness (Ngo et al., 2021). More information on placement scores and how they affect student success will be found in chapter 2, but it is important to note at the onset of COVID-19, MTC disbanded placement testing for students being admitted into the college. With no placement testing, students can register for college algebra, even though they may not be prepared for the coursework.

Each semester, the leadership team, which includes the author, at MTC gathers data about the success rates of students in the college algebra course. MTC defines the attainment rate to be the percentage of students earning an A, B, or C in the class divided by the total number of students receiving an A, B, C, D, or F. Withdrawals from the class do not count toward the attainment rate, nor will they be considered during this study. The attainment rate has seen a

decrease at MTC in the college algebra course since the onset of COVID-19. For example, in the Fall 2019 semester the attainment rate was 72% which dropped to 68% in the Fall 2022 semester. This could be because of several reasons including but not limited to COVID-19, the lack of placement testing, and the decreasing importance of a developmental math course such as intermediate algebra. These potential reasons for a decrease in attainment rates will be explored in chapter 2.

While contributing factors from outside the classroom may explain the decrease, it may be necessary that faculty at MTC develop a new method of instruction to try and provide equity in the classroom. One such technique is called competency-based learning (CBL). In the next section, CBL is defined and an example of CBL is given.

Competency-Based Learning

Traditionally, mathematics courses have used grading techniques that require students to perform successfully the first time they take an assessment. One may think of a traditionally graded classroom as one that assigns points or percentages for each assessment, and then all scores will be averaged together to calculate a final course grade (Knight & Cooper, 2019). At Middle Technical College, the college algebra course has 6 quizzes that students are allowed 2 attempts each, and a midterm and final that only have one attempt. Although the way the quizzes are administered is the beginning of competency-based learning, students still achieve the highest grade of the 2 attempts and unless for a good reason, will not get a third attempt.

Competency-based learning (CBL), sometimes called mastery-based learning or proficiency-based learning, is an approach to learning that emphasizes the mastery of skills and academic content (Patrick, 2021). Other approaches to learning exist and will be explored in chapter 2 (i.e., an inquiry-based learning classroom or a flipped classroom), ultimately the focus

will be on how CBL can positively impact a college degree-level classroom. More specifically, this study will focus on student perceptions of their success based on the implementation of CBL in the online college algebra course taught by the author.

Quizzes and exams are a form of assessment. Assessment is defined as a way to understand and improve student learning (Warren, 2011). Warren goes on to say that assessment is a way to "develop a deep understanding of what students know, understand, and can do with their knowledge as a result of their education experiences" (p. 724). In MTC's mathematics courses, assessments are used to see if students have achieved proficiency on the outcomes of a certain module. An outcome is a concise statement of what students will be able to do outside the classroom with what they have learned in the classroom (Warren, 2011). It is the overall hope that students will perform well on each outcome on the assessments so that the student will not only pass, but they can remember the information when they need it for future classes.

As this paper will discuss in chapter 2, competency-based learning, in the author's opinion, can be used to help students ease the gap in learning that students may experience when entering a college mathematics course. To give an example, the author taught Calculus I at a state university and used CBL. The author taught 2 semesters of Calculus I at the state university. While not getting into the details about how state university administered CBL in the course, taking a CBL approach to the Calculus I course was a major success. Here are some of the comments left by students (State University Office of Analysis, Assessment and Accreditation, 2022).

- "I loved CBEs instead of traditional tests because I felt I was able to demonstrate my knowledge better and they were less stressful."
- "I loved the infinite chances on CBEs."

- "I especially liked the CBE-based curriculum as opposed to the exam-based curriculum. I feel that it helped me focus in on each chapter and master the subject."
- "Having the CBEs be focused on passing them and understanding the material really helped me to understand it better."

Competency-based learning in a mathematics classroom is a concept that should be further studied. As Henri et al. (2017) argued, "There is an opportunity to quantitatively and qualitatively examine CBL programs and their impact on student performance" (p. 631). Although that article was based solely on engineering classwork and CBL, any time a success story can be published will further the trust that different approaches to learning rather than a traditional approach will be successful. A secondary goal of this research study is to do just that: publish a hopefully positive success story so that students in a mathematics course at a technical college will feel at ease and willing to learn while taking the class.

During chapter 2, strategies for creating a successful CBL environment will be shared including using a group-based mastery learning approach (Slavin, 1987). For now, the success story that was described at the state university is a fitting example of why CBL can be an effective method of teaching a mathematics course. This example, however, was at a 4-year public university. One of the goals of this report is to see the success of CBL at a 2-year institute such as Middle Technical College.

Summary of the Research Problem

To conclude, the highest populated mathematics course at MTC, college algebra, has seen a decrease in attainment rates. This could be for many reasons such as the lack of placement testing, COVID-19, or an overall gap in learning students may face. Because of the nature of a technical college, many students are taking courses in their majors with a mastery-based

approach to them. Further, learning support enrollment numbers have decreased as it is an optional class for students if they feel unprepared for college algebra. Altogether, Middle Technical College wants more students to succeed in college algebra despite many of the obstacles facing their students. A change inside the classroom may be necessary.

Summary of Research Purpose and Questions

Due to the decrease in attainment rates, the purpose of this study is to gather data and student thoughts on competency-based learning inside the college algebra course with the goal of increasing attainment rates. Student averages on quizzes will be gathered and compared to previous semesters. Three surveys will be conducted to gather participants' thoughts on the CBL approach. Two questions will be answered in this scholarly research project:

1. How will a competency-based learning approach to learning affect student perceptions of their success in the college algebra course at Middle Technical College?
2. What are student perceptions after taking the CBL course versus what they think of as a traditionally graded classroom?

These questions will be answered in chapter 4 and 5 of this report. In the end, this study will help not only the MTC's math and leadership team because of the hopeful increase in attainment rates, but students can feel less anxiety when stepping foot inside a mathematics classroom and leave knowing they are well on their way to graduation.

Significance of the Study

Overall, the author hopes that students will be more successful and less anxious about taking a mathematics course at Middle Technical College. If the hypothesis is that students would feel more comfortable and more successful in an online college algebra course through the CBL approach, this study can act as an example that will help future students not only at MTC

but technical colleges around the country learn and be successful in a mathematics course taught and graded in a non-traditional form. Even if unsuccessful, the mathematics classroom can and should be analyzed so that students can not only have a higher chance of passing but be better prepared for their major courses and life situations.

Organization of the Research Report

This chapter introduced the technical college, the college algebra course, and competency-based learning. There will be four other chapters following the introductory chapter. Chapter 2 will be an extensive literature review on CBL and its effects on the classroom. Chapter 3 will describe the focus of the study's research methodology and methods. It will explain what action research is, how a mixed-methods approach to this report was used, and how CBL took place at Middle Technical College. Chapter 4 will discuss the study's findings and results. Finally, chapter 5 will conclude by discussing different implications that can be used in practice and offer recommendations for future research.

Chapter Summary

It is the hope of this author that by creating a mastery-based approach inside of the college algebra classroom, students not only perform better on quizzes but also have less anxiety while taking a college-level mathematics course. This author has heard multiple times throughout his career the phrases "I hate math" or "I am super anxious for the upcoming math exam." With a decrease in math anxiety, it is the hope that students will be more confident when taking assessments and better understand the material.

Chapter 2

LITERATURE REVIEW

Introduction

Middle Technical College is seeing lower attainment rates in their college algebra course. There could be many reasons why students are failing in the college algebra course including but not limited to a lack of placement testing, COVID-19, and a gap in learning students may face, especially with a diverse population that 2-year colleges often experience. This study is important in that if students feel confident in their success inside the classroom, students may be more successful in the college algebra course at MTC, while at the same time experiencing a lesser level of math anxiety. We will begin by introducing and explaining four different classroom theories that are being used in modern education: a "traditional-style" classroom approach, an inquiry-based learning approach, a flipped classroom, and a competency-based learning approach. Based on this review, a competency-based learning approach was chosen for this study to gather students' perceptions of their success in the college algebra online classroom. Math anxiety will be discussed further which may be heightened by multiple sides such as COVID-19 and no placement testing. Finally, theories on competency-based learning and successful strategies will be introduced which will lead into chapter 3.

Literature Review

Classroom Theories

This section will outline four different classroom theories and their advantages and disadvantages. While research into these theories yields more than four types, it will be the goal of this study to show that competency-based learning is a potential best instructional practice in a mathematics classroom at a technical college.

Traditional-Style Classroom

Mathematics has often been taught as a drill-and-practice affair (Van Oers, 2001). As such, Van Oers (2001) described that the classical approach to communicating and teaching mathematics followed the sender-receiver model. This sender-receiver model is the idea that the teacher transmits mathematical content to the students without students discovering mathematical concepts on their own (Van Oers, 2001). This study will center around Knight & Cooper's (2019) definition of a traditional-style classroom which says that this approach assigns points or percentages for each assessment, and then all scores will be averaged together to calculate the final grade. In summary, students traditionally have learned mathematical concepts from the instructor using a sender-receiver model. Students are then expected to practice homework and demonstrate what they have learned on assessments. An overall grade is given to the student based on their performance on homework and assessments.

While the traditional method of teaching mathematics may be tried and true for some instructors, COVID-19 gave the mathematical world a reason to start recognizing and focusing on new styles of teaching. Rather than lecturing students by giving them facts to remember and skills to be acquired (Brunetto et al., 2021), active learning has been brought to the forefront. Active learning is a process that establishes long-term memories gained from experience (Missel et al., 2022). Missel et al. (2022) commented on a traditional-style classroom by saying that "the structure of active teachers and passive students has been the norm but there has been some disagreement on the efficacy of this approach" (p. 15). This disagreement, Missel et al. (2022) argued, began as early as 1910 when educator Edwin Slosson wrote:

> Lecturing is that mysterious process by means of which the contents of the notebook of the professor are transferred through the instrument of the fountain pen to the notebook of the student without passing through the mind of either (p. 15).

Students who work under this model are then graded based on a point value or percentages based on material from the lecture and how they performed on the assessments.

Missel et al. (2022) focused on active learning strategies for engineering design graphics courses. The purpose of their article was to give insight and tips on how to promote active learning in the engineering design classroom. Active learning, they explained, is different than a traditional approach because active learning is student-focused, and active learning strategies develop long-term memory. Although being an article for engineers, mathematics and engineering go hand-in-hand. For example, Missel et al. (2022) explained that teaching engineering geometry using a traditional approach focuses heavily on figures and equations. In contrast, active learning challenges students to apply geometry to relevant engineering problems.

Focusing on short-term memory may result in lower assessment scores. Mathematics builds upon itself, like a story (Wickersham & Wang, 2022). This means that establishing long-term memories through active learning strategies to succeed in a mathematics class is necessary. By doing so, content becomes relevant through discovery which facilitates engaged learners (Missel et al., 2022).

The argument that students do not learn for the long term is a great start on why we should analyze our classrooms for change. However, faculty need the time and motivation to make changes in the classroom. One study done by Wickersham and Wang (2022) adopted a case study approach to studying how math contextualization has been identified as an effective teaching method in calls to reform community college math instruction. Contextualization is

defined as a set of approaches that connect applications that are of relevance to students to content, knowledge, and skills (Mazzeo, 2008; Wickersham & Wang, 2022). Wickersham and Wang (2022) drew upon multiple forms of data including interviews and observations of faculty from two large, comprehensive two-year colleges which offer both developmental and college math courses. One conclusion from the study was that faculty often feel "depleted of time and effort in their existing organizational contexts, especially toward evaluating and improving their teaching" (Wickersham & Wang, 2022, p. 24). Because of this, faculty, according to Wickersham and Wang (2022), should be given the freedom by leadership to cut back on meetings and duties so that they can focus on professional development, teaching practices, and faculty collaboration.

Patrick and Sturgis (2013) agreed with Wickersham and Wang when writing a state policymaker's guide to competency education. The authors explained that "leadership has the most influence and the greatest responsibility to bring forth a new education system by focusing in on student-centered systems" (Patrick & Sturgis, 2013, p. 4). Leadership must recognize the need for student-centered approaches to education, otherwise, our education system will be held back using 19th-century models of education (Patrick & Sturgis, 2013). Patrick and Sturgis (2013) further argued a movement toward a competency-based model of education will help modernize education as a competency-based system ensures that every student will become proficient and that CBL starts with a simple commitment to instructing students based on where they are in building skills. In all, leaders and faculty alike need to be willing and ready to change for the betterment of the classroom environment and student success.

Active learning strategies can still be used even in a lecture environment. Imran et al. (2022) conducted a cross-sectional study at a university in Saudi Arabia. In this study, 658

students were asked to explore the varied factors that disturbed their interaction during lecture and interfered with their active participation. Imran et al. (2022) concluded that "it is evident from the literature that students' active participation enhances their learning process" (p. 1946). Negative attributes of lecturing, according to Imran et al. (2022) included lack of eye contact, offending behavior, and speaking too fast. However, active learning strategies, such as competency-based learning, can be a better learning tool for many subjects (Imran et al., 2022). By focusing on a mastery-based approach rather than traditional grading, an instructor can still use active learning techniques while lecturing.

Creating a classroom environment that works well not only for the instructor, but the student is important so that all students have a chance to succeed. While a traditional-based classroom, alongside its grading style, has been most often used in the higher educational setting (Van Oers, 2001), it is time to think about other ways of learning and/or grading that have the potential to promote long-term success in and out of the classroom. These learning approaches will be explored in the next few sections of this review.

Inquiry-Based Approach

One aspect of active learning that can be used while lecturing to students is the use of more meaningful questioning techniques. The Merriam-Webster Dictionary (2023) defines inqure as "to search into" and to "seek information." Inquiry-based learning can not only keep mathematics relevant to the learner but also make learners stakeholders in their education (Pittman, 2011). Pittman (2011) used inquiry-based learning techniques in their classroom when having students build a school garden. Based on the student's experiences with applying mathematical concepts to the garden, they concluded that "providing opportunities to apply concepts and operations in meaningful and natural activities will reinforce students' skills,

provide more opportunities to experience success in math, and motivate students to continue to achieve" (Pittman, 2011, p. 4). Inquiry-based learning is a student-focused theory (Dorier & Maass, 2020). This idea is quite different than that of a traditional-style classroom.

Formally, inquiry-based learning is defined to be the "process of discovering new relations, with the learner formulating hypotheses and then testing them by conducting experiments and/or making observations" (Pedaste, et al., 2012, p. 82). This definition highlights the fact that inquiry-based learning is a student-centered approach to learning that emphasizes how mathematicians and scientists work (Dorier & Maass, 2020). The beginning of inquiry-based learning is attributed to John Dewey (Dorier & Maass, 2020; Blair, 2014). Pedaste et al. (2012) developed a web-based learning environment using inquiry-based learning techniques. One question they asked during their study was if this web-based environment improved students' inquiry skills. To develop this inquiry-based environment, Pedaste, et al. (2012) formulated 7 inquiry-learning stages: problem identification, research question formulation, hypothesis formulation, experiment planning, carrying out an experiment, analysis and interpretation of results, and drawing conclusions and presenting the findings (p. 82).

In problem identification, "students must observe carefully, take notes, identify similarities and differences, look for patterns, and understand the order in which the events take place" (Pedaste et al, 2012, p. 82). Instructors should give students open-ended questions with multiple solution strategies that can be experienced as real and/or scientifically relevant (Dorier & Mass, 2020).

By having students research the question formulation in the second phase, students start to discern between realistic questions and non-realistic questions (Pedaste et al., 2012). These questions will be the start of the process of forming a testable hypothesis.

Students in the third phase will formulate statements that can be tested through experiments or observations. Normally, these statements are based on observations, questions, and evidence (Pedaste et al., 2012).

Pedaste et al. (2012) described the experiment planning stage as students gathering evidence from research and previous data patterns. Then, students will be able to develop more useful and testable hypotheses. Once the students create a useful and testable hypothesis, they will move into carrying out the experiment phase.

In carrying out the experiment, students can now "get their hands dirty" and see if their hypothesis is true. Students will plan their steps to conduct the experiment, conduct the experiment, and then measure and gather data while controlling variables (Pedaste et al., 2012). Students can use their everyday experiences which reinforces their natural thinking process (Blair, 2014).

The sixth stage, analysis and interpretation of the results, requires students to think about how their data supported the hypothesis that was created (Pedaste et al., 2012). Students can question their results and fine-tune the hypothesis so that it makes sense to the reader.

Lastly, Pedaste et al. (2012) conclude the inquiry-base process with students having to demonstrate their new-found knowledge by choosing an appropriate way to transmit it to others in the classroom.

While inquiry-based learning is a great tool for educators to get students to question and formulate their ideas, there are some drawbacks. During their report, Blair (2014) explained why inquiry-based learning in a United Kingdom classroom develops independent learners and is compatible with teaching mathematics. Blair (2014) also listed three drawbacks to inquiry-based learning. First, many schools use exams to demonstrate proficiency; therefore, teachers do not

have the time to let students explore on their own. Second, students may not have the needed skills to inquire on their own. Finally, students need objectives and a set structure to keep them on-task, which results in them not being able to manage the open nature of inquiries. As discussed more in chapter 3 during the methodology chapter, MTC requires students in their college algebra class to have 6 quizzes and 2 exams. Therefore, an inquiry-based classroom may not work due to time constraints. Also, students may not be prepared to inquire about certain topics in the college algebra course. Therefore, this style of teaching, while it has great positives and should be studied further, will not be considered in this project.

Another reason inquiry-based learning will not be used is due to the technical college setting. The mission of Middle Technical College is to promote community and workforce development (Middle Technical College, 2022). Many of the students are in degree fields that their major courses are built upon a mastery-based approach.

For example, a microcredential is defined by Maxwell and Gallagher (2020) as "a specialized credential that shows a mastery of one or more job competencies" (p. 9). Maxwell and Gallagher (2020) reviewed in their article factors that drive interest in microcredentials and identified trends that community colleges should consider when building them. Maxwell and Gallagher argued that microcredentials should be awarded based on a student's knowledge of the competencies in their field. They name these competency-based credentials, which are given out based on how students' progress as they demonstrate mastery of content (Maxwell & Gallagher, 2020). In addition, these competency-based credentials would help with equality, as Maxwell and Gallagher argued that a credential could be earned from an Ivy League school or a community college. Finally, Maxwell and Gallagher (2020) argued that defining clear

competencies about credentialing better aligns with competency-based hiring practices done by employers.

Warren (2011) agreed in their article reviewing concerns associated with restructuring curricula, which may involve changing the curricula to outcome-centered learning. Warren (2011) argued that "curricula need to be continually restructured to fit today's demands for an 'educated workforce'" and that "the more that instructors and administrators know about different models of assessment, the better they will be able to design what will work for their particular institution" (p. 727). So, again, while inquiry-based learning is a great approach to learning, the author will be using competency-based learning as it, in the author's opinion, could work best for MTC and the college algebra classroom the best. Future research into student success in a mathematics classroom at a technical college may result in trying an inquiry-based approach.

Flipped Classroom

Historically, students are learning material in the classroom and applying that information to homework outside of class (Aidinpoloulou & Sampson, 2017). Students do not, Aidinpoloulou and Sampson (2017) argued, actively engage in course material inside the classroom based on the structure of the traditional classroom.

A flipped classroom, by definition, shifts direct instruction outside of class so that students have more practice opportunities inside the classroom (Zhao, et al., 2021). Forsey et al. (2013) agreed and added that the model is "committed to shifting the face-to-face engagement between student and teacher away from lectures to various forms of symposia actively engaging students in process of discovery and consolidation of knowledge" (p. 471). Flipped classrooms have multiple benefits, which include reasonings such as learning flips from teacher to student

(Zhao et al., 2021), the student is required to be prepared when coming to class so that they can be an active participant in discussions and other student-engaging tasks (Aidinopolou & Sampson, 2017), students can complete more exercises in the classroom, which results in teachers being able to quickly discover what difficulties the students are having in their learning (Zhao et al., 2021), and students have more opportunities to apply knowledge (Zhao et al., 2021).

There are some drawbacks to a flipped classroom environment. First, one study conducted by Strelan et al. (2020) showed through a meta-analysis of 198 studies involving flipped classrooms that although flipped classrooms are beneficial regardless of discipline, student learning performance tended to be better in the social science classroom. Also, students who do not have the proper guidance for a flipped classroom may have higher anxiety and lower achievement behaviors (Zhao et al., 2021). Finally, Zhao et al. (2021) explained that especially for mathematics content, students may not be able to master concepts on their own, and without the proper guidance, they may feel helpless during class. At Middle Technical College, another issue may arise with a flipped classroom. Forsey et al. (2013) explained that one issue with a flipped classroom in the social sciences is that students may feel they can pass the course without needing to listen to lecture videos online. Middle Technical College uses MyLab Math, which is an online homework management software that assigns students homework problems, quizzes, and exams. MyLab Math has multiple hints built in for students as they work on assignments such as a “View an Example” button and a “Help me solve this” button, which walks the student through the problem step-by-step. In a flipped classroom environment, a student may feel they can just do the homework on MyLab Math and get a good score without watching any videos created by the instructor.

With the rise of online education, a flipped classroom may be a great instructional model that benefits teachers and students alike. Studies do show that more research should be done on flipped classrooms to see their applications (Aidinpoloulou & Sampson, 2017). In this study, although a competency-based learning style is used exclusively, future research may combine competency-based learning and a flipped classroom to see if focusing on in-classroom activities, rather than lecturing, will help students with a mastery-minded approach.

Competency-Based Learning

Competency-based learning (CBL), sometimes called mastery-based learning, is an approach to learning that emphasizes the mastery of skills and academic content (Patrick, 2021). Rather than focusing on the course as a whole, instructors can take the different outcomes students should learn and reinforce them with students. Students, on the other hand, have multiple opportunities to show improvement to gain mastery of the subject.

There are three types of mastery learning: personalized system of instruction (PSI), continuous progress, and group-based mastery learning (Slavin, 1987). Slavin (1987) described PSI in his study as one that "allows students to take exams over pre-established learning objectives as often as they wish" (p. 1072). In the same article, Slavin went on to describe that students normally work at their own pace with self-instructional materials. Continuous progress is defined as a process where students "work on individualized units entirely at their own rate" (Slavin, 1987, p. 176). Harsy et al. (2021) went on to describe continuous progress as one in which if a student does not master the material the first time, the teacher will provide supplemental material. Middle Technical College does not have any self-study sections of college algebra in which the teacher provides individual supplemental material if the student does not gain mastery, therefore continuous progress will not be used in this project.

Group-based mastery learning was the last to be defined. Slavin (1987) defined group-based mastery learning as one in which "the teacher instructs the entire class at one pace" (p. 176). Then, at the end of each unit, an exam is given in which students need to get 80-90% of the questions correct to be considered having mastered the concepts. Corrective instruction is given to students who do not reach the benchmark. This corrective instruction, Slavin argued, may take the form of tutoring or small-group sessions where students are gaining information they may have missed from the teacher. In the end, if a student achieved mastery, they received a top score no matter how many tries it took for them to reach the score (Slavin, 1987). This form of mastery learning is not necessarily self-paced, so if some students do not master the topics, the class will still move on to new topics (Harsy et al., 2021).

There are quite a few advantages to a competency-based approach to learning. Harsy (2020) implemented mastery-based learning in their advanced math classrooms at a 4-year private university. Harsy (2020) further defined mastery-based grading, or mastery-based testing, as a way in which "students are graded using a mastery criterion and they have multiple opportunities to demonstrate master of course objectives throughout the course" (p. 849). Students were asked to provide responses to how they felt mastery-based testing eased their text anxiety, developed a growth mindset, and complaints about the course design. One important observation by Harsy (2020) is that "mastery-learning approaches seem to support changing how students view mistakes (p. 850). This is because mastery-based testing (MBT) reduced the penalty of mistakes by giving them multiple chances to re-evaluate and fully understand concepts that were previously missed (Harsy, 2020). Additionally, Harsy (2020) discovered that mastery-learning improved a student's self-efficacy. Self-efficacy is defined to be "the belief one has about his/her ability to perform specific tasks" (Harsy, 2020, p. 850). Harsy (2020) described

that by having an improved self-efficacy, students had increased motivation, improved feelings of self-worth, and that high self-efficacy was a positive predictor of performance.

Another study done at the same 4-year private university analyzed mastery-based testing in a variety of classes. Students were asked to answer surveys three times throughout the semester in response to their thoughts on math intelligence, study habits, and test anxiety (Harsy et al., 2021). They found that a mastery-based approach helped students alleviate test anxiety and stress as MBT helped student self-efficacy, motivation, and helped develop a growth mindset in students. Also, students could gradually learn the material at the same pace which helped decrease test anxiety (Harsy et al, 2021). This study was done at a four-year private institute, so it will be interesting to know what student perceptions are of a mastery-based approach at a two-year technical college.

Bell and Mitchell (2000) completed a study on technical education in Canada which focused on student enrollment in their pre-apprenticeship refrigeration mechanics courses. They surveyed students in both a competency-based program and a traditionally delivered, cohort-based program and wanted to see the different student experiences in each program. Overall, students in a refrigeration mechanics program had a positive outlook on competency-based education. Compared to a more traditional type of education which in their program emphasized the idea of theory and practice separately, students in the competency-based program did not see a distinction between the two (Bell & Mitchell, 2000). Further, students in the traditional program felt that earlier technical/mechanical experience or ability was essential; however, in the competency-based program, students felt that their success and learning were under their control. While this was done in a technical program, mathematics has both theory and practice. and

emphasizing mastery over a traditional grade may help students feel more successful because the learning is in their control.

Henri et al. (2017) gave three reasons why CBL has had heightened interest. First, departments have needed to improve recruitment and retention rates while appealing to a diverse population. Second, departments have been needing to improve student achievement. Last, given the technological advancements in recent years, it has been easier to implement CBL strategies. With the focus of this scholarly research project being online, Henri et al. (2017) responded to why CBL may work in an online learning environment. First, one student does not have to complete material at the same time as another does. Students can work at their own pace, and they can individually master the objectives without feeling pressure from others. Secondly, students can more quickly complete work based on already acquired skills, giving them time to focus on material they struggle with (Henri et al., 2017). Middle Technical College uses Pearson MyLab Math as an online learning management system. As Henri et al. (2017) described "modern learning management systems allow for interactive instruction that can provide instant feedback, direct students to relevant additional content based on responses, and allow them to advance to more difficult content only after competence has been shown" (p. 611). While MyLab Math doesn't quite escalate difficulty like Henri et al. described, it is still a useful tool for instant feedback for students.

Review of Classroom Theories

Four classroom theories were discussed in this section: traditional-style, inquiry-based, flipped classroom, and competency-based. The traditional style is the approach MTC is currently using where students take up to 2 attempts at a quiz, and the highest of the two scores is achieved. However, as Missel et al. (2022) argued, this type of learning only focuses on short-

term memory, and here at Middle Technical College, many students will be using information learning in college algebra in the future, especially if they are in the health science field taking the entrance exam to nursing (Middle Technical College, 2022). While students may be more familiar with a traditional-style classroom, success rates are decreasing at MTC. Therefore, a new style of classroom may be needed to help increase success rates.

Inquiry-based and flipped classrooms both bring in the idea of putting the learning onto the student. Pittman (2011) found that inquiry-based puts "students onto the path of becoming rational problem solvers and effective questioners" (p. 4) while Zhao et al. (2021) explained that in flipped classrooms, students need to have intrinsic accountability to watch videos outside of the classroom to prepare themselves for classroom activities.

Competency-based learning is the style that the author will use in this project to try and help success rates for the college algebra class at Middle Technical College increase. As said in previous sections, many of the other classroom theories may work as well; however, by analyzing MTC's needs and the idea that students often use a mastery-based approach in their technical courses, CBL was settled on for this project. Before diving into more of the literature surrounding competency-based learning, we will first discuss literature involving math anxiety and how CBL may help alleviate this anxiety.

Math Anxiety

Taking a mathematics class can be daunting for many students. This may hold true especially for those who may have been out of school for a long time or for those who have had previous negative experiences in a math classroom. As Geist (2010) argued in a study about combating math anxiety in the classroom, prior experiences are key regarding student attitudes toward mathematics. Math anxiety is defined to be the "feeling of anxiety that one cannot

perform efficiently in situations that involve the use of mathematics" (Furner & Marinas, 2016, p. 26). Furner and Marinas (2016) discussed in their report math anxiety and research-based practices to provide a solution for math anxiety. They stated that math anxiety is a "well-documented phenomenon . . . with little being done to address it in our classrooms or the way we teach math" (Furner & Marinas, 2016, p. 26). In the same article, they argued that because this is a critical issue, educators need to address it so that students have better success and go into careers that are STEM (Science, Technology, Engineering, and Math) related.

Fergus and Smith (2022) analyzed mastery-based learning in two middle school mathematics classrooms. They hypothesized that mastery-based learning could reduce the impact of a student's math anxiety because of the lower stakes of each assessment and that mastery-based learning promotes self-directed learning. Fergus and Smith (2022) described three factors that students face when dealing with math anxiety: environmental, intellectual, and personality. First, environmental factors can include but are not limited to a teacher's instructional practices and a teacher's own level of anxiety. Secondly, intellectual factors include spatial reasoning and general cognitive ability. Finally, personality variables include a person's attitude toward mathematics. Fergus and Smith (2022) agreed with Furner and Marinas (2016) that math anxiety can have an enormous impact on students. However, Fergus and Smith (2022) argued that proficiency-based learning is a system that may be effective at reducing math anxiety.

Math anxiety can also be high due to the high-stakes nature of taking a degree-level class. Beiter et al. (2015) argued in a study that investigated potential correlations between depression, anxiety, and stress in college students at a 4-year private university that an integral part of a college student's life is academics, and without a good attitude toward academics, students can feel stressed. Beiter et al. (2015) continued by saying that "academic pressures of meeting grade

requirements, test taking, volume of material to be learned and time management has been shown to be a significant source of stress for students" (p. 90). Since many students at MTC are taking college algebra for their degree programs, they innately want to do well in the course. With the pressures to succeed high, many students may feel anxiety when thinking about the daunting tasks that may await them when registering for the college algebra classroom.

Overall, this research supports that math anxiety is real, and the way we teach our classes can help alleviate this anxiety and increase student success. We will now describe factors contributing to math anxiety at MTC and what the literature says about these anxieties.

Placement Testing

At Middle Technical College, placement testing was suspended since the beginning of COVID-19 in 2020. A placement test is an admittance exam to make determinations about college readiness (Ngo et al., 2021).

Ngo et al. (2021) conducted a survey and semi-structured interviews with 21 math faculty in a community college classroom. Their goal was to "explore faculty views of high school transcript and placement test data, attributions made with the data, and beliefs about the extent to which these data are useful for instruction" (Ngo et al., 2021, p. 272). The authors argued that while placement tests can be an effective tool, research shows that using a multiple measures policy for college placement has "seen increases in access to and success in college-level courses" (p. 2). Ngo et al. (2021) went on to say that test-based placement may be problematic according to recent research. There are a few reasons for this according to Ngo et al. (2021). First, placement tests have been shown to place students incorrectly. Second, students are often not aware of the high-stakes nature of the placement test. Finally, faculty and administration rely on placement testing for its efficiency rather than its accuracy.

Bickerstaff et al. (2022) agreed with this in a report which summarized what is known about improving student outcomes in terms of innovations in developmental education. Rather than placement testing, students should be granted immediate access to college-level math courses without assessment data (Bickerstaff et al., 2022). Bickerstaff et al. (2022) argued that as long as some additional support is provided for some students, evidence suggests that "many more students would successfully pass introductory college-level courses if they avoided prerequisite developmental courses altogether" (p. ES-1). One reason this may be true is due to the different requirements that programs have in place. For instance, Moss et al. (2019) explained that placement testing in math will test readiness for college-level algebra, but that knowledge may not be required in all programs of study. Moss et al. (2019) argued that students do not adequately prepare for placement exams because they lack awareness of the true consequences of failure. Overall, using placement exams as the solitary way to gauge college readiness may be troublesome as students may not be as successful as having students be given immediate access to degree-level courses.

Although students may be more successful by being directly placed into a degree-level course, they still may not be prepared for the college-level work that is needed from them. Bickerstaff et al. (2022) found that to increase student access to these college-level courses, two mechanisms have been used: changes to placement policies and implementation of a corequisite support model. Bickerstaff et al. (2022) explained a few principles that could be used to alleviate the concern of students not being prepared. First, departments could provide targeted and tiered support to address students' academic and nonacademic needs. In addition, instructors can employ a contextualized curriculum that engages students in "authentic literacy and numeracy

tasks like those they will encounter throughout college" (p. ES-2). Finally, departments should use equity-minded approaches for the design and implementation of developmental support.

Finally, test anxiety is one other reason placement testing may be inaccurate to place students. In high school, students may have taken some mathematics courses and even remember most of what they learned. Perry (2004), however, described a scenario where students often report that while they may understand the class well, students experience anxiety during exams. As Perry (2004) quoted one student:

> I feel confident when the professor is reviewing . . . I think to myself, 'I got this stuff, this is easy.' But when it comes to me taking the test, I somehow forget most of the concepts that I had known so well. This causes me to panic (p. 2).

The student, influenced by math and test anxiety, may not have shown their best ability which then may cause a student to be misplaced.

By creating a mastery-based approach classroom for college algebra, it is hypothesized that students will have a decrease in math (and test) anxiety which will increase student perceptions of their success.

COVID-19

During the Spring of 2020, COVID-19 ravaged the world and in turn, created an almost seismic shift in how students learn and how teachers instruct. Instead of strictly taking in-person classes, students were and are still turning toward online education to get a higher education degree. Instructors had to quickly reinvent classroom culture and procedures to accommodate an online environment (Brunetto et al., 2021). With this shift toward remote learning, Lanius et al. (2022) stated that "it is vital to conduct research into issues of math anxiety and avoidance in science, technology, engineering, and mathematics (STEM) related degrees" (p. 149). This

research, in the author's opinion, should include how we are teaching students inside the mathematics classroom, whether that be online or in-person.

Lanius et al. (2022) completed a study that surveyed 6,761 undergraduate students who took a Spring 2020 math course at the University of Arizona. They asked the students how COVID-19 affected math anxiety, especially about online education. For example, if students did not have access to the internet or computer, students had an increase in anxiety. Additionally, math anxiety increased with the lack of communication from the instructor some students had and still experience while taking an online course. This lack of communication included the availability of the instructor to answer questions outside of class.

Brunetto et al. (2021) used a questionnaire to report university professors' thoughts on how their teaching had changed during the COVID-19 lockdown and consequently the move toward online education. In their study, 48 professors from 13 different countries responded. One important discovery was that by transitioning online, some instructors created an environment where the active participation of students was replaced by transmissive lessons (Brunetto et al., 2021). Transmissive lessons are defined as those in which the instructors focus on mathematical content rather than the way mathematical concepts are shared and used by learners (Brunetto et al., 2021). However, if an instructor believed in the importance of student-to-teacher communication and the acquisition of technological knowledge, students' voices and ideas turned out to count more than what was believed at the beginning of the semester (Brunetto et al., 2021)

With the shift toward online education after COVID-19, Lanius et al. (2022) addressed further research that should be studied. They argued that "there is a potential for online education to decrease math anxiety for some students" and that the question that could be asked is "what

aspects of the online environment can alleviate anxiety?" (p. 168). The author hopes that this study will show that a competency-based approach to a mathematics classroom taken online will help alleviate anxiety and increase success rates.

Learning Support

Learning support, or sometimes called developmental support, exists to help students achieve their goals (Bonham & Boylan, 2011). Bailey et al. (2010) explained that "students who arrive unprepared for college are provided instruction to bring them up to an adequate level" (p. 255). This unpreparedness is exacerbated at 2-year institutions since many 2-year colleges are open access institutions, which are those institutes that offer education opportunities for students no matter their prior levels of academic achievement (Daugherty et al, 2019). However, literature shows that there is more to the story than just "bringing them up to speed." As Bonham and Boylan (2011) argued, "there is considerable public debate about the underpreparedness of students entering colleges today and the efficacy of responses to this underpreparedness" (p. 2). The debate around learning support and its usefulness is argued through a few points. First, students are prevented from achieving and have a diminished view of their education goals by taking developmental math courses (Bonham & Boylan, 2011; Royer & Baker, 2018). Second, experts disagree on what it means to be college-ready (Bailey et al. 2010). Third, students, especially men, older students, African American students, part-time students, and students in vocational programs, are less likely to progress through their full remedial sequences (Bailey et al., 2010; Kosiewicz et al., 2016).

Sometimes, students must take multiple learning support courses before they can enter the degree-level class. As Royer and Baker (2018) argued, "these courses are very 'leaky' with multiple points of exit for students" (p. 33). Often, because of these multiple exit points and the

extended length of time a student will be completing their degree (Kosiewicz et al., 2016), students are prevented from achieving their academic goals. Instead of working on coursework toward their degree, students are instead forced to take classes that only prepare them for the degree-level class.

Multiple studies across literature present data surrounding the ineffectiveness of developmental education. Bailey et al. (2010) found that 33% of students who were referred to three or more levels of developmental math courses completed the remedial sequence in their Achieving the Dream program. They further found that 11% of those taking a developmental math course exited the sequence not having failed the course. In another study, Attewell et al. (2006) found through a study of students who provided college transcript data through the National Educational Longitudinal Study that only 30% of students pass all developmental math courses in which they enroll. Kosiewicz et al. (2016) agreed that these developmental courses are difficult to pass in the fact that while over 60% of community college students are registered for a developmental class, only a small percentage of students reach the degree-level class that may be required for an associate or bachelor's degree.

For these reasons, a change could make a substantial difference in the learning experience for these students. As Kosiewicz et al. (2016) argued, "Community colleges across the United States are developing new or alternative methods of delivery" (p. 206). The same article further said that these developmental courses are "traditionally administered as a series of lecture-based, semester-long courses" (p. 206). While this project is focused on a degree-level college algebra course, further research into competency-based learning may look at how CBL can help students in a developmental math course successfully pass and register for college-level coursework.

Review of Math Anxiety

Math anxiety is a real phenomenon that many students all around the country face when stepping inside the classroom. Students may be facing math anxiety for several reasons including a lack of placement testing, learning support, COVID-19, and those who are in a dual-enrollment program. The literature showed, however, that just taking these reasons at face value is not the full story. Especially with learning support, data showed that letting the students directly into the college algebra course at MTC may be the right step.

More on Competency-Based Learning

Now that we have developed why, through literature, competency-based learning was chosen as a focus for this study, we will discuss more on competency-based learning. This section of the literature review will define growth mindset, how CBL provides equity in the classroom, the effect of CBL on a student's time management skills, and how further research should depend on the collaboration between different academic departments (e.g., the mathematics department and the automotive technology department) to promote a student-centered learning environment.

Growth Mindset

One way to learn and grow in mathematics is to make mistakes (Knight & Cooper, 2019). The idea that one can be successful through effort and learning is called a growth mindset (Dockterman & Blackwell, 2014). This contrasts with a fixed mindset, Dockterman and Blackwell (2014) explained, in that a fixed mindset "reflects a belief in natural talent: one is either good at something or is not" (p. 1). As an example, students will say statements such as they are not math people (Dockterman & Blackwell, 2014). This is a fixed mindset because it

makes the student believe that math is a natural talent, not one that is learned through hard work and determination.

Literature shows that by practicing and making mistakes, students can grow in their mathematical ability and ease their math anxiety. Knight and Cooper (2019) explored high school teachers' perceptions of the effects of standards-based grading on planning, instruction, assessment, classroom management, and student behaviors. They defined standards-based grading as having components such as "basing grades on proficiency of specific standards, removing behavior factors from academic grades, and allowing multiple opportunities to reach proficiency" (Knight & Cooper, 2019, p. 66). They interviewed and observed seven high school instructors throughout five high schools. They found that standards-based grading "emphasizes learning over grading" and that "reassessment opportunities are intended to 'keep hope alive' for struggling students, foster a growth mind-set, and improve long-term learning and responsibility" (pgs. 67-68). Ultimately, they discovered that SBG created a learning environment that was conducive to learning and thus mistakes became more acceptable in the learning process.

Francome and Hewitt (2020) studied two schools in the United Kingdom. The authors studied student beliefs and teacher beliefs and practices when it comes to teaching mathematics in the classroom. Francome and Hewitt (2020) discovered that many of the math instructors and students had a growth mindset. It was also shown that using mistakes as a tool for learning increased mathematics attainment as by having a growth mindset, students valued learning from mistakes.

Harsy (2020) stated that opportunities for learning and growth happen through mistakes. However, "students routinely regard making mistakes as demonstrating a lack of competency"

(Harsy, 2020, p. 850). By creating a structure of multiple opportunities, students can re-evaluate and fully understand previous concepts (Harsy, 2020).

Attitudes that students have toward mathematics have been shown to affect learning performance. In a study on measuring student attitudes toward calculus, Huang and Lin (2015) reported that "with mathematics in particular, researchers have suggested that poor attitudes toward content can result in poor learning and performance" (p. 109). In fact, Orhun (2007) found that student perceptions about their confidence in learning mathematics are directly affected by their attitude toward mathematics. However, building a growth mindset may change the way that students think about mathematics which will in turn help their perceptions of how successful they are in their math class.

Having a growth mindset is essential to a competency-based learning classroom. By making mistakes and learning from them, students should not necessarily worry about getting a good grade on assessments but rather achieving mastery of the subject.

Equity in Assessment Practices

By using group-based mastery learning, assessments provide a sense of equity in the classroom. Patrick and Sturgis (2013) defined e*quity* as "a way to ensure that all students are given the right to be held responsible and supported in pursuit of high expectations that will ensure they are truly ready for next steps building on the foundation of the Common Core State Standards" (p. 10). As De los Santos et al. (2020) expressed in a literature review on how the term equity is used in education, "today's society . . . requires concrete actions to achieve a truly inclusive education that offers equal opportunities for all students regardless of their ethnic background, socio-economic class, or gender" (p. 13). To promote equity in education, De los

Santos et al. (2020) argued that students should be allowed equal opportunities and equal access to higher education, no matter what gender or socio-cultural background the student comes from.

Competency-based learning, as argued by Patrick and Sturgis (2013), is one way to provide equity when assessing students. To promote competency-based learning, Patrick and Sturgis (2013) gave five key elements: students will advance upon mastery, to empower students, we can use competencies that include explicit, measurable, and transferable learning objectives, assessment is meaningful and students feel it is a positive learning experience, timely, differentiated support is given to students based on their individual learning need, and learning outcomes emphasize competencies. These elements, Patrick and Sturgis (2013) argued, "ensures that every student will become proficient" (p. 6). Competency-based education meets students where they are at in their learning process, and by doing so, helps them achieve their potential (Patrick & Sturgis, 2013).

Knight & Cooper (2019) agreed with Patrick and Sturgis on the notion that competency-based, or in their eyes a standard-based approach, helped with equity. In their model, students were allowed multiple attempts on assessments to demonstrate proficiency. By designing components such as multiple attempts and focusing grading on standards, Knight and Cooper (2019) argued these components increased the validity, reliability, and equity of grades which improved student learning. An improvement in student learning-would also help ease math anxiety for the individual student.

Knight and Cooper's report which showed this increase in validity, reliability, and equity of grades ties back into math anxiety. Students come from diverse backgrounds. Some students may have taken a learning support class while others may have been out of college for many years. Some students may have been affected by COVID-19 and have been forced to take an

online mathematics class. Participants in Knight and Cooper's study praised standards-based grading (SBG) because it accepted mistakes and unacceptance of failure. As Knight and Cooper (2019) wrote, "every participant believed reassessment opportunities helped students reach challenging learning goals" (p. 80). By using the SBG, general academic achievement improved.

A couple of gaps in the literature appear in this section which is explained by Patrick and Sturgis. First, competency-based education, according to Patrick and Sturgis (2013) "can find a safe place to develop in areas of the system where students' needs are not being met, including increasing access to education through online learning" (p.8). Second, according to Patrick and Sturgis (2013), "states need to be able to point to schools that are effectively using competency-based approaches that are benefiting students" (p. 15). Any time a success story can be published will further the trust that educators have for using different approaches in the classroom.

Time Management

Research has shown that by offering a competency-based classroom, students are more likely to be in control of how they manage their time while working in the class. For example, in a study comparing competency-based learning versus traditional learning in a pre-apprenticeship refrigeration mechanics course at a community college in Canada, Bell and Mitchell (2000) found that students have greater control of the pace of their learning in addition to how they are learning when experiencing a CBL classroom.

With MTC being a 2-year college, students have other obligations besides the class material. According to the Community College Research Center (2024), nearly 75% of students in the year 2019-2020 worked while they were enrolled in college with 46% of students working a full-time job. In addition, this study is being done in an online environment. Arens (2023) stated in a study at a 4-year public university asking students about their experiences with online

courses that online classes provide a convenience to deal with obligations such as careers and family. In fact, according to the National Center for Education Statistics (2015), those who have careers or those who have dependents are more likely to be taking online courses.

With other obligations besides coursework, students may procrastinate on class material. One way to combat this issue is by creating a well-structured learning environment. This learning environment, according to Selcuk et al. (2021) in a study surrounding adolescents' reasonings into why they procrastinate, would help students have higher levels of competence, effort, and persistence. Selcuk et al. (2021) went on to say that "the more students are involved and engaged in their class-related duties, the less likely they procrastinate" (p. 1785). In Harsy et al.'s (2022) study, they found that students' responses reflected that CBL helped self-efficacy and motivation. It is hoped that CBL will help the participants of this study manage their time effectively and procrastinate less.

Collaboration with Other Departments

Competency-based education may also be useful to those students who are getting degrees in a technical field. In an article about experiences about development education and how students who test at low levels receive support throughout the Texas community college system, Daugherty et al. (2019) stressed the idea that cross-departmental collaboration is critical to the success of many programs. The authors argued that "as is true with many programs and initiatives within colleges, successful roll-out requires a coordinated effort that involves instructional departments, advising departments, and other departments within the college" (Daugherty et al., 2019, p. 20). Further research may show a positive correlation between having the student face a similar experience in their general education courses such as math and English as they face in their technical courses.

Review of Competency-Based Learning

Making mistakes while working on mathematical problems is an essential part of learning (Knight & Cooper, 2019). By developing a growth mindset and taking on a competency-based learning style on quizzes in the college algebra online classroom, students will be able to take these mistakes and apply them to additional chances on quizzes. Instead of focusing on learning the material for a grade, students can instead focus on growth. Finally, competency-based learning can provide a sense of equity in the classroom so that all students have the chance to succeed no matter what background they come from. It is the hope of the author that by taking a CBL approach to learning in the online college algebra environment, students will feel like they are more successful in the classroom and demonstrate that other teaching styles, not just a traditional style, are effective in the mathematics classroom.

Summary of the Literature Review

Education is ever-changing. From a traditional style to having a flipped classroom or a mastery-based approach, the way mathematics is taught inside the classroom can and should be viewed as a fluid process. While traditional approaches to learning such as the pure lecture-based have been the time-tested method of teaching inside the college math classroom, new ways such as inquiry-based, a flipped classroom, and competency-based learning are taking the forefront. At the heart of each style is the importance of student-centered learning. The literature revealed that while all styles of teaching can be useful, competency-based learning may be the most useful in terms of calming math anxiety and increasing student success.

Wide beliefs shared by faculty at MTC suggest that the lack of placement testing is a major concern for the success of the student. With the lack of placement testing, they argue, students may be placed in a course they are not prepared for. However, the literature painted a

different picture. If a student was placed in a developmental math course, they were less likely to succeed and more likely to drop out of the remedial work. In fact, students who are granted access to the degree-level course immediately upon entering college may have better success (Bickerstaff et al., 2022). COVID-19 may have heightened math anxiety by forcing students to go online and more research should be done on best teaching practices for online students in a math college classroom, hence this study.

Lastly, by using a group-based mastery learning method as described by Slavin, the author hopes that college algebra will be more equal in terms of assessing students. This methodology will be better described in chapter 3. By creating a growth mindset in the classroom, students can have unlimited access to complete assigned assessments, which will make sure, according to Patrick and Sturgis (2019), that students are met where they are in their learning and help them achieve their academic potential. It is the hope that students feel less anxious and feel like they were more successful while taking college algebra.

Summary of Research Purpose and Questions

Due to the decrease in attainment rates in college algebra at Middle Technical College, the purpose of this study is to gather data and student thoughts on competency-based learning inside the online college algebra course with the goal of increasing attainment rates. Three surveys will be conducted to gather students' thoughts on the CBL approach. Two questions will be answered in this scholarly research project:

1. How will a competency-based learning approach to learning affect student perceptions of their success in the college algebra online course at Middle Technical College?
2. What are student perceptions after taking the CBL course versus what they think of as a traditionally graded classroom?

Chapter Summary

This chapter presented information about different classroom theories, math anxiety, and further information regarding competency-based learning. Overall, while several types of classroom approaches are available, it has been decided to use a competency-based approach for this study. The next chapter of this project will deal with this study's research methodology and methods.

Chapter 3

RESEARCH METHODOLOGY AND METHODS

Introduction

Due to the decrease in attainment rates in college algebra at Middle Technical College (MTC), the purpose of this study was to gather data and student thoughts on competency-based learning inside the online college algebra course with the goal of increasing attainment rates. Three surveys were conducted to gather students' thoughts on the CBL approach. Two questions will be answered at the conclusion of this scholarly research project:

1. How will a competency-based learning approach to learning affect student perceptions of their success in the college algebra online course at MTC?
2. What are participants' perceptions after taking the CBL course versus what they think of as a traditionally graded classroom?

Chapter 3 will begin by describing the research methodology. The research methodology will include explanations on conducting an action research-oriented mixed methods project alongside details surrounding designing the competence-based learning grading system. Secondly, the research context will be analyzed by describing the research setting, participant selection, participants, and researcher positionality. The chapter will conclude with an explanation of how the data was collected and analyzed.

Research Methodology

A Mixed Methods Approach

To answer the research questions, a mixed methods approach was used. A mixed methods approach integrates both quantitative and qualitative data within the same study (Mertler, 2018; Gurenlian, 2023; Shorten & Smith, 2017; Creswell & Creswell, 2018). One

advantage of using a mixed-methods approach, according to Shorten and Smith (2017) is that it allows researchers to "explore diverse perspectives and uncover relationships that exist between the intricate layers of . . . multifaceted research questions" (p. 74). Another advantage to mixed methods is that it neutralizes the weaknesses of using only quantitative or qualitative data (Creswell & Creswell, 2018; Shorten & Smith, 2017). Mixed methods allow researchers "to view their study from a broader perspective and integrate multiple data sources to study complex problems" (Gurenlian, 2023, p. 70). Mixed methods approaches can also allow participants to have a strong voice and share their experiences across the research process (Shorten & Smith, 2017).

The practice of completeness was used in this mixed methods study. Bryman (2006) referred to completeness as the notion that "the researcher can bring together a more comprehensive account of the area of inquiry in which he or she is interested if both quantitative and qualitative research are employed" (p. 106). A mixture of Likert scale questions and open-ended discussions were implemented in the survey. By asking both quantitative and qualitative type questions, a richer picture of the participants' perceptions before, during, and after completing the college algebra course using a competency-based learning grading technique can be gathered.

Convergent Mixed Methods

Creswell and Creswell (2018) described three mixed methods designs: convergent mixed methods, explanatory sequential mixed methods, and exploratory sequential mixed methods. For this study, a convergent mixed methods design was used. A convergent mixed methods approach is "a form of mixed methods design in which the research converges or merges quantitative and qualitative data in order to provide a comprehensive analysis of the research problem" (Creswell

& Creswell, 2018, p. 15). To complete the approach, the researcher will gather both quantitative and qualitative data at the same time and then integrate the information into the interpretation of the overall results (Creswell & Creswell, 2018).

Convergent mixed methods contrast both explanatory sequential and exploratory sequential as both explanatory and exploratory methods happen sequentially rather than at the same time (Creswell & Creswell, 2018; Gurenlian, 2023). For example, Gurenlian (2023) described the explanatory sequential type as "occur[ing] when the quantitative data are collected and analyzed first" and then the qualitative data is gathered afterward to help explain the quantitative results (p. 71). For this study, survey instruments asked both quantitative and qualitative data at the same time.

Survey Design

Three surveys were given throughout the semester to students participating in an online college algebra course. An explanatory survey was conducted as this type of survey is "devoted to finding casual relationships among variables" (Malhotra & Grover, 1998, p. 409). To complete the explanatory survey, a longitudinal design was implemented. Longitudinal designs "are appropriate for studying phenomenon that change . . . by collecting data in the same organization at two or more points over time" (Malhotra & Grover, 1998, p. 410). Students were given these surveys at the beginning, middle, and end of the semester having to agree to an informed consent before being considered a participant in this study.

The decision to implement a longitudinal, explanatory survey was borrowed from a study conducted by Harsy et al. (2021) which analyzed mastery-based grading in the authors' math courses at a private 4-year university. In the study, Harsy et al. (2021) created three surveys and administered them throughout the semester: one on the first day of the semester, one at

midterms, and one at finals. Questions asked students to answer a mixture of Likert scale and open-ended discussion questions ranging from math intelligence, study habits, and test anxiety. The study at MTC focused on questions such as math anxiety and overall feelings about the competency-based learning style as compared to a traditionally graded classroom.

Action Research

Action research is defined by Fraenkel et al. (2012) as research "conducted by one or more individuals or groups for the purpose of solving a problem or obtaining information in order to inform local practice" (p. 589). This study is classified as action research as research is being done locally at MTC to obtain information about student perceptions of their success in the college algebra course. Action research often uses a mixed-methods design because this type of research often uses both quantitative and qualitative data (Mertler, 2020). The advantages of action research include ideas such as action research can improve education by incorporating change, educators can work together to improve their practice, and classroom teachers who perform action research have direct access to research findings (Mertler, 2020; Rogers et al, 1990).

Another advantage that action research offers is the idea of communicative competence. Communicative competence is defined as "the ability to participate in the discussion about what should be maintained and what should be changed in our culture" (Rogers et al., 1990, p. 182). By developing communicative competence, Rogers et al. (1990) argued that teachers will better understand themselves, their colleagues, and their practice. In all, teachers who perform action research can decide to conserve as well as change themselves or their teaching.

Action research is divided into four steps: identifying an area of focus, collecting data, analyzing and interpreting the data, and developing a plan of action (Mertler, 2020; Fraenkel et

al., 2012). First, identifying the research question or area of focus involved examining the situation and identifying a problem (Fraenkel et al., 2012, p. 593). At MTC, attainment rates were low in the college algebra courses, therefore it was decided to study how a different learning and grading technique affects students' perceptions of their own success. Second, gathering necessary information is needed so that the researcher can "decide what sorts of data are needed and how to collect them" (Fraenkel et al., 2012, p. 593). Since this study was completed for online coursework, a survey was decided upon as the best way to gather both quantitative and qualitative data. Third, by analyzing data, "participants can decide what the data reveal" (Fraenkel et al., 2012, p. 594). Finally, an action plan should be created so that changes discovered through the findings can be implemented (Fraenkel et al., 2012).

Practical Action Research

This study used practical action research. Practical action research addresses a specific problem or needs in a classroom, school, or similar community (Fraenkel et al, 2021; Mertler, 2020; Newton & Burgess, 2008). The primary focus of practical action research is "to improve practice in the short term as well as to inform larger issues" (Fraenkel et al, 2021, p. 592). For this study, the specific problem that was addressed was the low attainment rates in the college algebra class. The hope is to improve success rates in the short term by implementing a competency-based learning strategy in the college algebra classroom. In the long term, this action research study will help inform MTC faculty how best to administer exams in all math courses being offered.

Competency-Based Learning Design

Competency-based learning, sometimes called mastery learning, is a grading scheme with an emphasis on the mastery of skills and academic content (Patrick, 2021). To assess students

using a group-based mastery learning scheme, a teacher will instruct the entire class at one pace. An assessment is then given at the end of each unit, which Slaven (1987) argued that to achieve mastery, a student should earn a grade of at least 80-90%. A student who does not reach competency will receive corrective instruction, thought of as tutoring. The cycle of taking the quiz to reach the mastery criterion and corrective instruction is repeated until a student reaches mastery. Students who reach mastery are given an A on the unit, no matter how many tries it took the student to reach mastery (Slavin, 1987).

Research Context

Research Setting

This survey-based, practical action research, convergent mixed methods study will take place at Middle Technical College. MTC is a 2-year technical college. The total enrollment of the college at the time of research is approximately 10,000 students with 42% of students identified as White and approximately 51% of students identified as Black or African American. MTC offers both online and in-person classes. Approximately 55% of students at the institution took an in-person class while 39.7% of students took an online asynchronous class. The college algebra class used for this research is an online asynchronous class. Asynchronous online courses "enables groups that are separated in time and space to engage in the active production of shared knowledge" (Gunawardena et al, 1997, p. 410). Students will complete the college algebra course by using a combination of Blackboard and Pearson MyLab Math mixed with lecture videos created by the instructor.

Blackboard is a learning management system (LMS) used at MTC. An LMS is "a software application or web-based technology used to plan, implement, and assess a specific learning process" (Alias & Zainuddin, 2005, p. 28). According to Alias and Zainuddin (2005),

instructors use an LMS to create and deliver content, monitor student participation, and assess student performance online. Further, students can use an LMS to have discussions, video conferences, or complete assessments (Alias & Zainuddin, 2005). Blackboard is used in the college algebra course for students to view their grades, complete class requirements, and access Pearson MyLab Math.

Pearson MyLab Math, sometimes called MyMath Lab (MML), is a homework management system (HMS). Sometimes referred to as web-based homework, an HMS is used as an alternative to paper-and-pencil homework which provides instantaneous feedback on students' answers (Serhan, 2019). The goal of using such systems is "to enhance students' understanding and engagement in classroom discussion" (Serhan, 2019, p. 61). In Serhan's (2019) study which centered around student perceptions of web-based homework systems, students felt that an HMS had a positive influence on their learning in the classroom. At MTC, homework, quizzes, and exams are administered through MML.

Participant Selection

Participants were selected using convenience sampling. Convenience sampling is a sampling technique used when participants are convenient and easily accessible (Sedgwick, 2013). Students register for the college algebra course by themselves or through their advisor. When registering, a note on three college algebra online classes taught by the author stated that a CBL study was being conducted in the course. One week before and one day before the semester started, a CUHSR-approved email was sent to all students in the online courses detailing the study and how students benefitted from being a part of the study. All students who registered for the college algebra online course taught by the author were therefore eligible to participate in the study.

MTC has a high enrollment of dual-enrolled students. However, dual-enrolled students (those who are high-school students taking degree-level courses for college credit), are excluded from the study and are not allowed to enroll in the three online sections.

Participants

Three online sections of college algebra taught by the author were targeted for the CBL study. Enrollment in the three sections is 77 students during the first survey, 74 during the second survey, and 69 during the third survey. The decrease in enrollment per survey was due to withdrawals initiated by the student. To be eligible to participate in this study, a student had to answer at least one of three anonymous and confidential surveys throughout the semester. Students were given the chance to take part in the surveys through links provided throughout the Blackboard course. Before becoming a participant and answering survey questions, students had to agree to the informed consent available on each survey which was approved by the Committee on the Use of Human Subjects in Research (CUHSR) at Bradley University. To agree to the informed consent, participants clicked "I Agree" before the survey software allowed responses to any other question on the survey. Following the informed consent, two pieces of identification were asked of respondents: their age and their gender. The summary for each identification piece of the survey is listed in Table 1 and Table 2.

Table 1
Number (n) of Student Participants by Age

Survey	18-25	25-35	35-45	45-55	55+	n
Survey 1	28	13	5	3	0	49
Survey 2	10	6	1	2	0	19
Survey 3	4	2	1	0	0	7

Table 2

Number (n) of Student Participants by Gender

Survey	Male	Female	Prefer Not to Answer	n
Survey 1	11	37	1	49
Survey 2	14	3	1	19
Survey 3	3	4	0	7

Researcher Positionality

An action researcher needs to describe the positionality the researcher is taking while conducting a study. According to Herr and Anderson (2015), "Your positionality as a researcher means asking the question, Who am I in relation to my participants and my setting?" (p. 37). Herr and Anderson described both the insider and outsider positions in relation to action research. Being that this study was practical action research, Herr and Anderson (2015) argued that those who use practical action research are insiders and "often want to study the outcomes of a program or actions in their own setting, much like an internal evaluation study" (p. 42). The author of this study is an insider. While those who take part in action research need to be careful about potential biases, it is important to remember that action research is just as important as other types of research. Herr and Anderson (2015) explained:

> This type of action research dissertation is more than an amateur researcher demonstrating a certain level of competency in doing research. It is an account of how one practitioner goes about learning his or her craft and what was learned in the process. Such insider accounts generate important knowledge to be shared among practitioners (p. 44).

While the author of this study is the same as the one who is teaching and assigning grades to students based on mastery, certain procedures were in place to try to regulate bias. First, all surveys were voluntary and anonymous. Students were free to respond how they feel, and the author was not able to use potential negative attributes to influence a student's grade. In addition, CUSHR-approved scripts were created that were sent out to students throughout the semester reminding them to take the voluntary and anonymous survey.

Research Methods

Data Collection

Strategies/Instruments

To implement competency-based learning, Harsy (2020) argued that it is vital to vary the questions as students may mimic the answers on an earlier attempt on the quiz. For this study, each attempt at the quiz is randomized so that the question the student sees on one attempt is not the same question on subsequent attempts.

Harsy et al. (2021) researched student perceptions of competency-based learning at a 4-year private institution. To complete the research, Harsy et al. (2021) used 3 surveys to gather student feedback: one given to students at the beginning of the semester, one given at midterms, and one given after taking the final exam. The study done at MTC offers students the chance to take an anonymous and voluntary survey three times throughout the semester like that of Harsy et al.

Google Forms is used to deliver the three surveys given to participants. Bradley University pays for and grants access to the Google Suite (i.e., Gmail, Google Drive, Forms) for all faculty, staff, and students. The password needed to access the Google suite is only known by the author. To maintain anonymity, Google Forms allows the creator of the form to turn off

collecting email addresses, which it was turned off for this study. In addition to Google Forms, all data is transferred to a flash drive which is locked in a closet with the key only given to the author of this study and the maintenance crew at MTC. After completion of the study, students will not be re-contacted. All quiz data and survey links will be stored both in Blackboard and MyLab Math, both of which are password-protected and only the author at MTC administration. MyLab Math and Blackboard data are typically available for up to 2 years before being permanently deleted. All information that was collected during this study was de-identified.

Each survey was divided into four parts. The first part required participants to agree to the informed consent before moving on to the content of the survey. The second part gathered demographic information from the participants that kept their anonymity. The third and fourth parts of each survey asked a mixture of Likert scale and free-response questions ranging from their earlier experiences in math courses and participants' perceptions of their success while taking the CBL course. Refer to Appendix A for the content of each survey.

Procedures

One week before and one day before the semester started, participants were sent an email informing them of the study. They were also given a date to withdraw in case they did not want to be graded based on mastery. Students were graded based on mastery no matter if they were participants or not. Since all surveys were anonymous, students who did not participated had no punitive action taken against them.

During the first week of class, students accessed Blackboard to start on the course. Before being granted access to MyMath Lab, students complete a mandatory assignment, called the First Assignment, that all students at MTC must complete. During this assignment, students were given the choice to take the first survey. After completion of the First Assignment, students

registered for MML and completed the 6 modules of the class throughout the 16-week semester. Students in an online class work at their own pace and deadlines for each module are approximately 2 to 3 weeks apart.

At the end of each module, there was one quiz. Each quiz had a time limit of 2 hours. After a student submitted the quiz, they instantaneously received a numerical score. If a student received an 80% or higher, mastery was achieved, and the instructor changed their score in the grade book to 100%. If a student received lower than 80%, mastery was not achieved, and the student had a chance to retake the quiz as many times as needed until an 80% was obtained. The time limit for each subsequent attempt was 2 hours.

As Slavin (1987) described, if a student does not achieve mastery, corrective action should be taken. For this study, after 3 attempts at the quiz and if the student had not achieved mastery, students were locked out of taking another quiz attempt until they had attended a tutoring session with the instructor. The instructor then opened 3 more attempts at the quiz. This process was then repeated until the student reached mastery. Mastery must be obtained by the due date, in which a calendar of due dates was provided to the students throughout the semester in Blackboard. If a student did not show mastery at the due date but at a later time in the semester, a 5% deduction per week the quiz was late was assessed. If a student did not achieve mastery by the end of the semester, their initial score beneath 80% was recorded in the gradebook. If they did not complete the quiz at all, a 0% was entered in the gradebook.

During midterm and finals week, students were given a midterm survey and a final survey. All three surveys were estimated to take approximately 20 minutes to complete. As the instructor, the author provided feedback on each quiz using the add comment feature in MyMath Lab. The author also provided lecture videos that were approximately 15 minutes in length on

each section taught in the class that students had the choice to watch. Announcements were posted throughout the semester reminding students about due dates and the surveys. The middle-of-the-semester and final survey links were listed on Blackboard for students before each respective midterm and final exam.

Timeline

Table 3 offers an in-depth analysis of the timeline that this study followed.

Table 3

A Timeline of Events

Date	Activity
August 14, 2023	Invitation to Participate was sent out to online college algebra students registered for the author's classes.
August 15, 2023	The First Assignment opened to students which provided informed consent as well as the first survey link.
August 28, 2023	The first survey closed.
August 2023 – early December 2023	Students worked on class material involving 6 modules with 6 individual quizzes graded on the mastery approach.
October 2, 2023	The midterm survey opened.
October 22, 2023	The midterm survey closed.
Late November 2023	The final survey opened.
December 8, 2023	The final survey closed.

Data Analysis

Research Question 1

Both qualitative and quantitative data were collected to answer the first research question. The first research question was: How will a competency-based learning approach to learning affect student perceptions of their success in the college algebra online course at MTC? To

answer the question quantitatively, Likert scales were given to students. To answer the question qualitatively, open-ended questions were given.

One potential barrier to the student's perceptiveness of their success was the length of time it has been since the student took a math course. In the beginning-of-the-semester survey, questions 3 and 4 gauged how long it had been since their last math course was taken and if students felt math anxiety when they registered for the college algebra course. In addition, a Likert scale question asked if simply registering for a math course created a sense of math anxiety which might prohibit the student from being successful.

Furthermore, the beginning-of-the-semester survey in questions 6, 7, and 8 asked students to gauge their perception of CBL from reading the syllabus and the initial email sent by the author explaining the study in the course. Lastly, a free-response question was asked in question 9 to get a sense of other obstacles students might face that would prohibit them from being successful. Student responses were grouped to form themes using inductive coding, and similarly to Harsy et al. (2021), student quotes from the survey were used to reinforce those themes. No questions in survey 1 are related to research question 2 as research question 2 asked students' perceptions of CBL after completing the course, and survey 1 was completed at the beginning of the course.

The mid-semester survey, besides the two demographic questions, also focused on the first research question. Questions 3, 4, and 5 were a mixture of Likert scales and free response to gauge student's anxiety at the middle part of the semester. More specifically, questions 4 and 5 focused on whether CBL has helped ease that anxiety. Question 6 on the mid-semester survey was similar to that of Question 7 of the beginning-of-the-semester survey in that it used a Likert scale to have students' rate if they felt that the CBL style has helped them be more or less

successful in the course. Question 8 gathered a qualitative response to gain a full picture of why students at this point in the semester felt they were more or less successful due to CBL. The mid-semester survey had no questions related to the second research question as research question 2 asked student perceptions of CBL after completing the course, and survey 2 was completed in the middle of the course.

The final survey asked a mixture of Likert scale questions and free-response questions to gauge student perceptions of their success after the semester ended. Question 3 was designed to gauge if students have experienced CBL before the study, and it was reported as a bar graph. Question 4 was designed as a way for students to reflect on their feelings of anxiousness after learning about how quizzes were structured using the CBL approach. Question 5 is like Question 4 in asking if the CBL approach helped ease their anxiety while taking quizzes. Question 6 was an open-ended response to their feelings about the CBL approach easing their anxiety. To compare answers on whether students felt CBL helped them be successful in the class, questions 9 (a Likert scale) and 10 (a free response) were asked.

To complete the qualitative data analysis, inductive coding was used. Inductive analysis is an approach that uses "detailed readings of raw data to derive concepts, themes, or a model through interpretations made from raw data by an evaluator or researcher" (Thomas, 2006, p. 238). Thomas (2006) argued that this approach allows researchers to discover significant themes inherent in raw data without the restraints imposed by structured methodologies.

Quantitatively, because questions 4 and 5 on the mid-semester and final survey, respectively, and questions 6, 6, and 9 are similar on the beginning, middle, and final survey, respectively, a chi-square test was completed to compare the results. According to Creswell and Creswell (2018), a Chi-square test is a way to test an association between two variables

measured by categories. To measure students' responses on Likert scales throughout the 3 surveys, Harsy et al. (2021) also used a chi-square test. To complete the Chi-square test, IBM's SPSS statistical software was used.

Research Question 2

The second research question was: what are student perceptions after taking the CBL course versus what they think of as a traditionally graded classroom? Question 7 on the final survey asked students if they would have preferred a more standard approach to the quizzes that are taken at MTC or if they preferred the CBL approach. Question 8 asked students to provide a written explanation of why they preferred one approach over the other. Question 7 will be presented as a bar graph in chapter 4, while question 8 will be grouped by themes and student responses will be given similar to that of Harsy et al. (2021).

Chapter Summary

Chapter 3 discussed the research methodology and methods of this scholarly action research project. First, the research methodology was introduced by discussing the mixed methods approach, the survey design, action research, and the competency-based learning design. Then, the research context was given which included the research setting, participants, and the researcher's positionality. Finally, data collection and analysis were discussed in the research methods section. Chapter 4 will be a discussion of the results which will answer this study's research questions.

Chapter 4

RESULTS

Introduction

To gather participants' perceptions of CBL in the online college algebra course at MTC, three anonymous surveys were given at the beginning of the course, at midterms, and during the final week. Chapter 4 will present the findings to the following two questions:

1. How will a competency-based learning approach to learning affect student perceptions of their success in the college algebra online course at MTC?
2. What are participants' perceptions after taking the CBL course versus what they think of as a traditionally graded classroom?

During chapter 4, both quantitative data and qualitative data will be combined to form themes based on participant answers to each survey. After sharing the findings, chapter 4 will progress by discussing each theme and the connections each has to literature. Chapter 4 will conclude by giving a summary of the chapter and a preview of chapter 5.

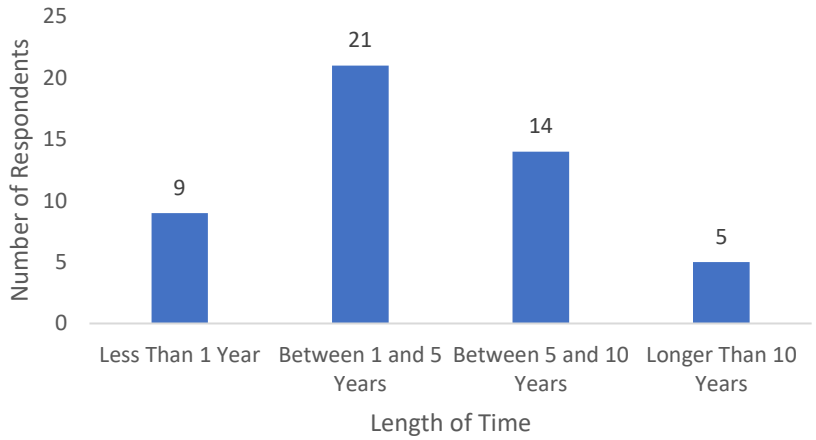
Results

Quantitative Data

The beginning-of-the-semester survey, which will be referred to as survey 1, began by asking participants about their perceptions of their success based on the length of time since their last math course and their math anxiety when registering. Figure 1 shows the number of respondents based on whether they have taken a math course within the last year, between 1 and 5 years, between 5 and 10 years, and longer than 10 years.

Figure 1

Length of Time Since Last Mathematics Course

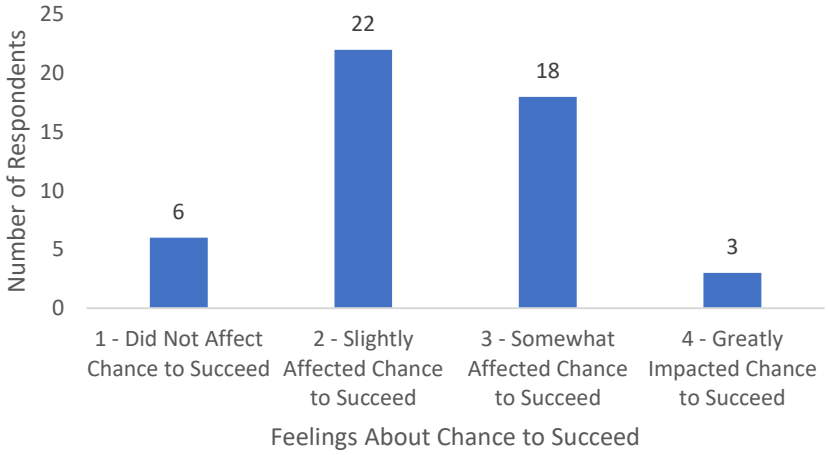


Note. The average response was 2.31 where 1 refers to a student last taking a math class less than 1 year ago and 4 being that the last math class was longer than 10 years ago.

With the average response being 2.31, participants' last time since they took a mathematics course was approximately between 1 and 5 years ago. As mentioned in chapter 1, 2-year institutions such as MTC have a great diversity of students who enroll at the college due to it being open-access. This often means that students have not taken academic classes in quite some time. So, it is no surprise that many students in this study identified that it had been longer than 1 year since they had last taken a mathematics course. Participants were then asked to decide whether they thought the length of time since taking their last math course affected their chance of success in the online college algebra course.

Figure 2

Length in Time Since Last Math Course and Feelings about Success

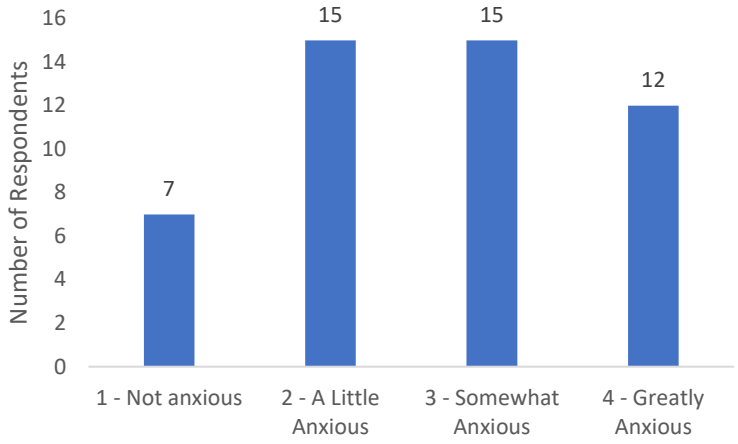


Note. The average response was 2.37.

Being that the average response was 2.37, participants felt that the length of time since their last math course would, on average, slightly affect their chance of succeeding. When completing a Chi-square test to determine if there is a significant difference in the number of years since a math course versus student perceptions of their success, the test resulted in a *p*-value of .069 and χ^2 of 15.887. While this test showed that there was no significant difference between a participant's chance of success versus the length of time it has been since their last math course, research does back the idea that prior experiences do impact student attitudes toward mathematics (Geist, 2010). With that in mind, it is not surprising that many participants in this study felt slightly affected by their chance to succeed based on their last math course, especially if they had an unpleasant experience in their previous course. Figure 3 shows the results when participants were asked to rate their feelings of math anxiety when registering for the college algebra online course.

Figure 3

Participant Perceptions of Their Math Anxiety When Registering for College Algebra



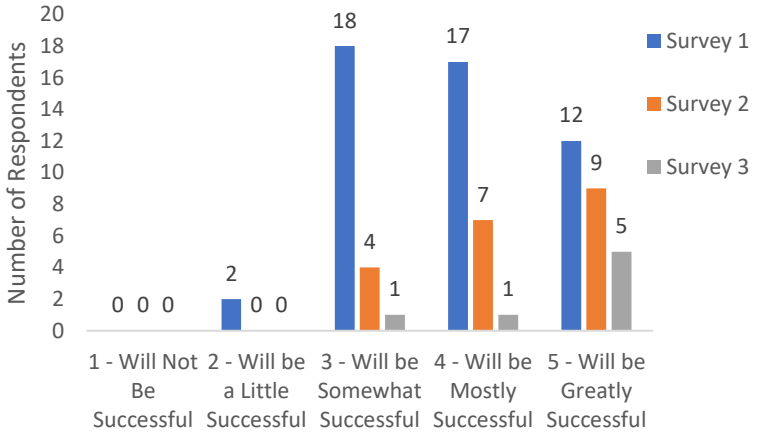
Note. The average response was 2.65.

By having an average response of 2.65, participants on average felt they were somewhat anxious when registering for college algebra. Figure 3 further pushes the narrative that prior experiences in math affect a person's feelings about mathematics. With 42 out of 49 (85.7%) of participants feeling at least a little anxious when registering for the course, by just knowing that they were about to enroll in and participate in a math class, participants felt anxious.

Survey 1 asked students if they thought they would be more or less successful because of the implementation. Surveys 2 and 3 (the middle-of-the-semester and the end-of-semester surveys, respectively) followed up this question by asking students if they still thought that the implementation of CBL was helping them be successful in the course. The results across all three surveys are shown in Figure 4.

Figure 4

Participant Perceptions of Their Success Based on the Implementation of CBL

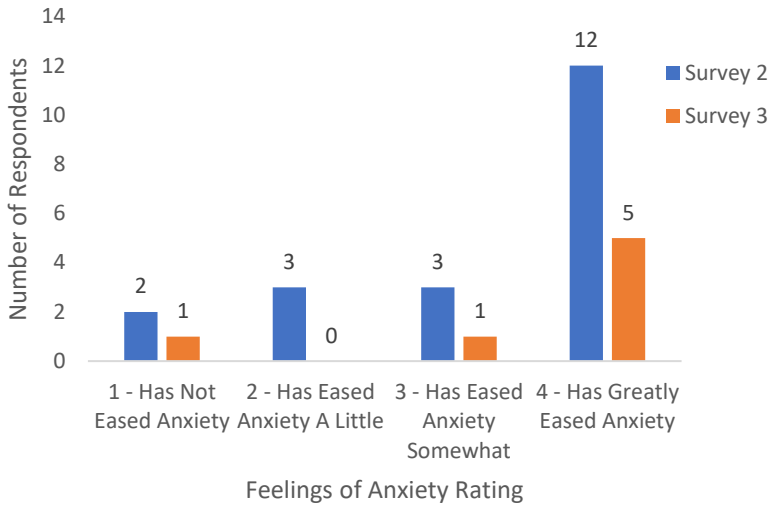


Note. Completing a Chi-square test results in a *p*-value of 0.188 and $\chi^2 = 8.747$.

Comparing participant perceptions from the beginning of the semester to the end of the semester resulted in the finding that there was no significant difference. Based on the quantitative data, participants felt early on that CBL would be helpful to them in passing the course, and that opinion did not change throughout the semester. Figure 5 shows students' perceptions of their anxiety and whether CBL had helped that anxiety at the midpoint of the semester and the end of the semester.

Figure 5

Participant Perceptions of Their Anxiety Based on the CBL Approach



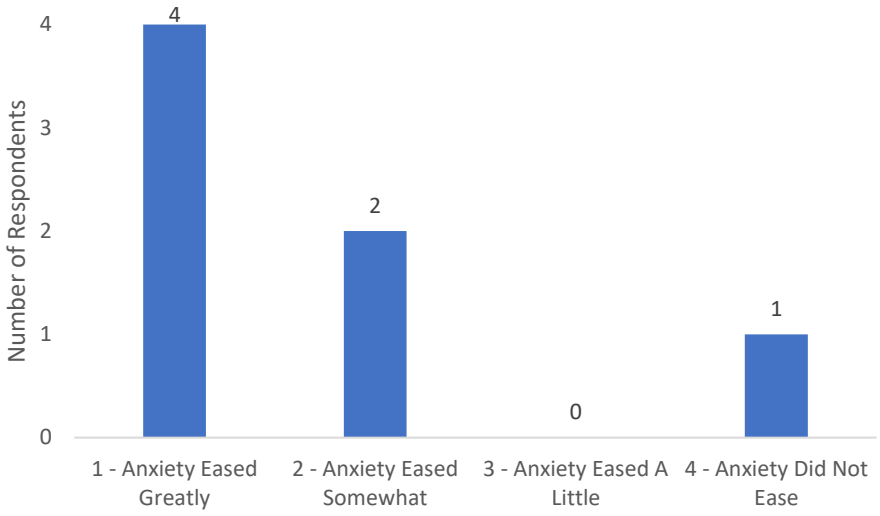
Note. Completing a Chi-square test results in a *p*-value of 0.742 and $\chi^2 = 1.245$.

No significant difference was calculated in students' perceptions of their anxiety throughout the course. Participants in survey 2 recognized that CBL helped ease their anxiety, and their responses did not change throughout the semester which was reflected in survey 3.

Participants in survey 3 were asked if they had ever experienced CBL in any setting. Out of the 7 respondents, 6 of them had not experienced CBL before taking the online college algebra class and 1 responded that they did take a CBL course during high school. Participants were also asked on survey 3 if after learning about CBL, their feelings of anxiousness were eased. The results are shown in Figure 6.

Figure 6

Participant Perceptions of Their Anxiousness After Learning About CBL

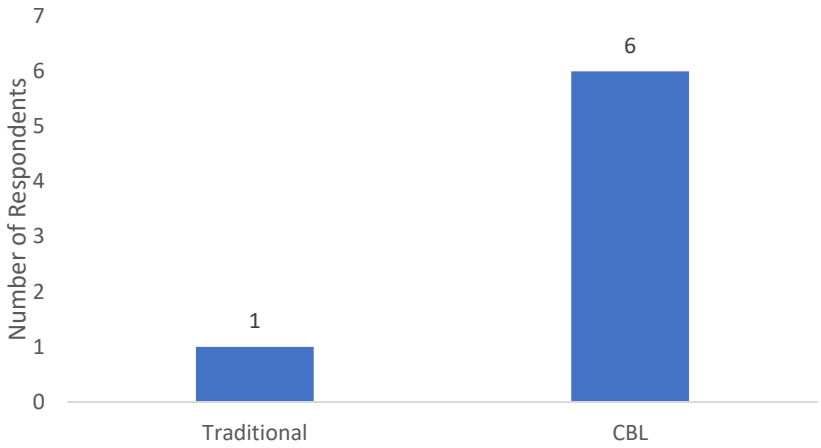


Note. The average response rate was 1.71.

By having an average response rate of 1.71, Figure 6 shows that on average participants felt that their anxiety was mostly eased because of the CBL. While having low participation in survey 3, Figure 6 shows that participants did feel that CBL would help ease their anxiety at the beginning of the course which is in line with findings in Figure 4 and Figure 5. Figure 7 shows whether a participant preferred the CBL approach or the traditional approach. Six out of 7 (85.7%) students preferred the CBL approach over the traditional approach.

Figure 7

Participants' Preference of CBL versus a Traditionally Graded Classroom



Qualitative Data

While comparing quantitative data may have shown no significant differences, participants' qualitative responses painted a different story which will be explored more in detail during the discussion part of this chapter. Starting with research question 1, four main themes arose throughout the three surveys on how CBL affected participants' perception of their success: confidence, time management, communication, and understanding.

Each theme had its unique answers from participants. Confidence answers included those participants who felt that CBL helped their overall confidence when taking quizzes, reduced stress and test anxiety, and overall lessened the pressures to succeed during their assessment. Time management included answers such as the self-paced nature of the online course and procrastination. Communication included answers such as how the instructor communicated with the students of the class, communicated in an online environment versus in-person, and technology. Finally, participants answered with many suggestions that CBL helped increase their understanding of the concepts and helped level the playing field.

To break down each theme by the number of respondents, Table 1 shows the frequency at which each theme was answered by a participant in each of the three surveys.

Table 4

Survey 1 Frequency Distribution on Themes for Research Question 1

Theme	Survey 1	Survey 2	Survey 3
Confidence			
Feelings of Doubt	10	2	2
Getting a High Grade	4	7	4
Text Anxiety	2	6	1
Stress Management	2	0	0
Pressures to Succeed	0	2	2
Time Management			
Work at Own Pace	7	4	0
Procrastination	3	1	0
General Time Management	2	0	0
Communication			
Instructor Communication	2	0	0
In-person versus Online	3	1	0
Technology	3	2	0
Understanding			
Level the Playing Field	4	1	0
General Understanding	9	6	1

Throughout the three surveys for research question 1, confidence was highly answered by participants. Survey 1 had multiple participants express feelings of doubt toward mathematics, which further explains the idea that participants were anxious when entering the class. In addition, participants expressed that they felt less anxious due to the higher grades they were achieving throughout the class, making them more confident when taking assessments. Furthermore, some participants recognized that their test anxiety decreased based on the idea that grades were built upon mastery. Harsy et al. (2021) reported that many students also had a decrease in test anxiety due to mastery-based learning. Harsy et al. (2021) also found that participants in their study thought mastery-based learning helped them understand the material more deeply. In all three surveys in this study, participants also noted that their general understanding of the material increased.

Participants further said early on that time management could be an issue including feelings of procrastination and the fact that by being online, participants could work at their own pace. As Slavin (1987) mentioned in the definition of group-based mastery learning, students should be given multiple tries to achieve mastery. If a student is given ample time to reach mastery, they may wait till the last minute to take the assessment. Finally, participants, especially during survey 1, were worried about the technology involved in taking the math course online and the fact they were not in the classroom. As one participant said, “I think something will prevent me is not being in person. I tend to learn better in person with visual demonstrations when it comes to algebra.” These feelings seemed to ease throughout the semester, as participants got used to how the class was structured.

Research question 2 had 3 themes that arose: confidence, equity, and time management. Table 2 shows the frequency at which participants answered with these themes.

Table 5

Survey 3 Frequency Distribution on Themes for Research Question 2

Theme	Frequency
Confidence	
Getting a High Grade	3
Text Anxiety	1
Time Management	
Work at Own Pace	1
Equity	
Level the Playing Field	1

Participants in this last survey recognized that CBL helped them be more confident when taking assessments since they saw their grades increase. Because of this, many participants stated they preferred CBL over a traditionally graded classroom. One participant recognized that CBL helped level the playing field for students taking a math course. By focusing on mastery rather than a "one-and-done" assessment, they stated that "CBL is a better system" because "it evens the playing field between people that have test anxiety and people who don't." With the addition of the quantitative data, participants in survey 3 felt that they preferred CBL over a traditionally graded classroom.

Discussion

Research Question 1

Confidence

During survey 1, many participants answered that they felt that CBL would help them become more confident in their own abilities. For example, one participant stated that "I was scared at first, but after reading through what CBL means from the syllabus it makes me feel more confident!*"* Many others wrote that they felt that they were either terrible at math or had not done well in earlier math courses. For example, one participant stated, "I'm truly terrible at math and especially how my high school teachers taught it so maybe this approach will be more understanding for my brain." Another wrote that "I feel it [CBL] would decrease my anxiety about math as I already have tried and not done well in math classes." A fourth participant on survey 1 mentioned "I feel like I'll be more successful because of the chances we are given to make a good grade on a quiz."

Especially when registering for the math course, many students felt at least some anxiety about having to take a math course. In this study, it is seen that students already felt anxiety about the class based on prior learning experiences in a math classroom. This echoes Geist's (2010) study that prior learning experiences are key toward their feelings about mathematics. However, as seen in chapter 2, Fergus and Smith (2022) argued that CBL would help in reducing math anxiety, and even within the first survey participants in this study felt that CBL would help them ease their anxiety and be more confident when entering the class.

During surveys 2 and 3, confidence answers increased, which may be because of the pressures to succeed in the college classroom. Looking at survey 2 first, one participant answered why they feel more or less successful because of CBL by stating "I feel more successful, because

I make the grades to pass but it's an even better feeling on confidence when you see that boost to your grade!" Along those same lines, another participant in survey 2 stated that CBL "gives you the opportunity to learn from your mistakes." Survey 2 also had a response related to test anxiety and CBL in that they said, "I think that it takes some of the test anxiety away, knowing that if you don't do well, you will get another shot." Participants in this study at the midpoint part of the semester recognized that their grades mattered and that by being given multiple chances to succeed, they felt less anxiety. One participant said that they like the CBL approach because "not all students are good test/quiz takers and this approach help ease the mind of trying to achieve a passing grade."

Survey 3 had similar responses when it came to confidence. One participant mentioned that "the CBL approach eased my anxiety because I didn't have to worry about a 'one take and done' quiz. It is also extremely helpful because I only needed to reach a high grade for the each [sic] quiz and not have to worry about my grade dropping from certain amount of points." Furthermore, another participant said that "it made the test anxiety go away almost completely. Knowing that if I didn't pass I'd get another shot."

Participant responses in this study about their confidence in taking mathematics back up the results that Beiter et al. (2015) showed. Beiter et al. (2015) reported that the pressure of meeting graduate requirements is one factor in a college student having stress. Participants in this study throughout the second and third surveys constantly referred to the fact the CBL helped them feel more confident as CBL gave them multiple opportunities to perform well on the assessment. Harsy (2020) reported comparable results in their study that mastery-based learning helped students with their test anxiety. In Harsy's study, students reported that it helped with anxiety because they would get more chances to achieve mastery thus alleviating stress.

The pressure to succeed is high in any college environment whether it is in an online college algebra course at a 2-year technical college or an in-person class at a 4-year university. However, it is important to remember that at a 2-year technical college, the majority of students are not in a math course to eventually major in mathematics. They want to complete degree requirements on their way to becoming, for example, nurses, mechanics, or even a hairdresser. This leads to many students coming into the 2-year college with different feelings toward mathematics. By focusing on mastery, students felt throughout the course more confident in their ability to perform well on quizzes, which led to their perceptions of their success to increase.

Time Management

Being that this study was done in an online class, many participants during the first survey brought up that they are happy that CBL gets to let them work at their own pace. For example, one participant stated that CBL helps in that "it lets us tell you what we have learned and its at my own pace." Another participant in survey 1 said that "when I truly wish to learn something, I like to spend time also teaching myself how to do something in order to master it." In terms of managing time, one participant in survey 1 said that they predicted that CBL would help them be more successful as "to help me learn how to manage my time better and learn to be more comfortable with learning topics I struggle with." Like understanding, by the student having control of what and how they learn, they get to practice more on their weaknesses to grow to mastery level.

Survey 2 brought up some negative comments toward CBL when it comes to time management. One participant stated that "the quizzes are quite complex, it is very challenging preparing for them while working a full-time job as well as taking care of a family."

In response to why CBL has not eased this participant's anxiety, they said that "I typically take the test 4 hours before the deadline due to my work and family schedule."

As instructors, we want students to be diligently studying and working on homework. However, for this participant and many other students in both online courses and at technical colleges, they simply do not have time to spend hours on the material. As chapter 2 described, students taking online classes deal with obligations such as careers and family (Arens, 2023). Furthermore, students have other extracurricular activities they may be involved in such as sports and clubs. Due to the multiple chances that CBL allows, a student may not have the time to develop mastery in certain areas, as this participant pointed out that they take the test 4 hours before the deadline. Any instructor needs to take to take into consideration not only the time it takes for students to achieve mastery but also the time students spend on material outside the classroom. Creating smaller assessments so the students have less to study and be assessed on may be beneficial to help overcome the vast amounts of information a student is exposed to throughout the class.

In addition to other obligations as a barrier to achieving mastery, one student pointed out during survey 2 that due to the nature of CBL, it was easy to procrastinate. They stated that "as I thought, I procrastinated quite a bit on assignments, but it was rather easy to catch up when I finally started doing my work." Survey 1 also offered some insights into participant concerns about procrastination. One participant was quoted as writing that "I wouldn't have to rush myself to do assignments and thus less stress about it, but I did take one point off simply because I have a feeling that there is a chance I would procrastinate on certain assignments because of this flexibility. I hope I don't actually do so, but the possibility is still there." Another participant on survey 1 stated that "I haven't taken a math course in quite some time, so the unlimited number

of retries on quizzes sound like they will be helpful early on in the course while I am still getting back into the swing of things."

Being in an online class may provide difficulties for students to stay actively engaged in the coursework. To create an online course that is actively engaging especially for those designing a CBL classroom, it is suggested to constantly provide feedback on student work, send out announcements to the entire class to remind them of upcoming deadlines, and create a space for students to ask questions as needed similar to office hours in-person.

While the last comment doesn't necessarily speak to procrastination, it is important to recognize that students enter any class with varying backgrounds. So, while the student may not be procrastinating, it may still take them some time to get used to being in a college classroom or get used to the college-level material. Many students in survey 1 had not taken a math class in quite some time. Again, creating a well-structured learning environment so that all students have the chance to succeed is essential so that students do not fall behind trying to learn pre-requisite material alongside new material.

No responses were given in terms of time management on survey 3. It is suspected that by the end of the class, most students who responded were more concerned with their grades rather than managing their time since the final exam had already been completed by these students.

Overall, a well-designed classroom should help students who feel they might procrastinate during the semester. While instructors cannot have control of external factors in a student's life, they can be accommodating in case factors such as full-time jobs or children take the forefront of a student's learning experience. In the end, data from chapter 4 showed that students felt more successful and had less anxiety because of CBL, and one reason offered by

student respondents was because of time management in the sense that the online course offered a chance for self-paced work. By being able to learn at their own pace, participants used that time to try and achieve mastery on each of the six quizzes presented to them during this study which helped them boost their confidence when taking assessments.

Communication

Being that this study was completed in an online course, instructor communication is vital to the success of students. During survey 1, some participants noted that they were worried about the technology and growing accustomed to taking an online course. When asked about other obstacles that will prevent them from being successful, one participant answered that one obstacle is "not being the best with technology." Another participant said that "my lack of knowledge on blackboard and this being my first year in college" would prevent them from being successful. One other participant answered that "Relying mostly on technology and internet forums for learning and teaching tools to communicate and complete assignments I feel can be compromising."

Communication between the college and the instructor is equally as important to make sure that students are aware of the technology that they will be faced with and then comfortable with using said technology. For example, MTC offers a phone number to call in case students have questions about Blackboard. Instructors in math courses at MTC offer multiple guides on how to register for and complete assignments in MyMath Lab. In addition, students can drive to the MTC campus to get help from faculty, the library, or other academic services.

Communication can also come in the form of how the instructor is delivering online content. For example, one participant during survey 1 stated "I think something that will prevent me is not being in person. I tend to learn better in person with visual demonstrations when it

comes to algebra." On the same question, another participant shared that "I would say make sure I ask for help when I need instead of waiting to the last min." Further, one participant on survey 2 when asked why they feel more or less successful because of CBL stated "I feel like I do better in person with math instead of online but as far as learning something I feel like I've learned a little bit of things not as much as I think I would've in person."

This discussion goes back to the advice of Selcuk et al. (2021) that creating a well-structured learning environment is essential to student success. In this study's online classroom, videos talking about and visualizing concepts taught in the college algebra were posted and narrated by the instructor. Before starting graded assignments, students had to complete a MyMath Lab orientation assignment walking them through how to properly use MyMath Lab. In addition, the instructor had online and face-to-face office hours so that students could get help if needed. Providing a line of communication for online students will help them feel more at ease and ready to study the curriculum itself rather than be faced with anxiety regarding technology issues.

Utilizing technology and helping ease the anxiety brought on by online coursework showed up in survey 2 as well. For example, one participant responded by saying that "The homework is interactive in a great way, so if I don't understand a problem it will walk me through something similar, greatly helping with the problem at hand." By survey 3, no participants commented on the technology potentially showing that they were used to how the class and MyMath Lab operated.

The combination of math anxiety plus having to learn the technology can be overwhelming to students taking an online college algebra course. Instructors, no matter the type of classroom, should be responsive to students' needs, questions, and concerns throughout the

class. Speaking specifically about CBL, Slavin (1987) stated that by using group-based mastery learning, those who do not reach mastery should be given corrective instruction which may take the form of tutoring. Communicating these corrective actions is imperative so students feel less anxious about not only the math but also the overall pressures to succeed in the class.

Understanding

Harsy (2020) explained that one big advantage of mastery-based learning (MBL) that participants recognized was that MBL "helped them with their understanding of course objectives" (p. 865). Even before participants in this study experienced CBL, many answered during survey 1 that their initial thoughts on CBL were that it would help increase their understanding of the material. One participant argued that "Instead of punishing people for not knowing the material, it [CBL] seems like it pushes everyone to learn it." Another participant recognized "that it was a way to make sure students genuinely understand the material." In addition, a third respondent on survey 1 responded by saying "I hope that this concept can be used to further someone's education at the point they have mastered the knowledge needed versus just moving along."

During survey 2, some participants answered that the CBL has helped them better understand the material presented in college algebra. One participant responded by saying that CBL "has been great so far and I feel like I'm actually learning the problems and how to solve them." Another responded by saying that CBL "gives you the opportunity to learn from your mistakes."

In survey 3, only one participant mentioned that CBL helped them better understand the material. On how CBL helped the participants ease their math anxiety, this participant answered that "Better understanding on areas I need help."

While it may seem disappointing that not many mentioned understanding at the end of the class, as suggested during the time management discussion, many participants focused on the fact that CBL helped their grades increase. When asked about why they thought they were more or less successful with CBL on survey 3, one participant offered that they were "guaranteed 100% if I make at least 80 on quizzes." Another argued that "It forced me to reach 80% while giving me the chances. Finally, one participant suggested that "I feel my grade would have suffered severely" if it was not for the CBL implementation.

Harsy (2020) had related results in that participants in that study stated that MBT helped with their text anxiety. As one student in Harsy's (2020) study stated:

> A major strength of this class is the mastery-based testing because the fact that you can retest on concepts throughout the semester helps relieve students of text anxiety and allows time for the student to truly learn the concept and be able to master it in the end (p. 863).

During Harsy et al.'s (2021) study, participants mentioned that "MBT helped them focus on understanding the course material since MBT forced them to go back and continue working on objectives" (p. 1083). In addition, participants in Harsey et al's (2021) study helped them not feel discouraged as "if they didn't understand a course concept right away . . . they could continue to work on it until they fully understood the concept" (p. 1083). For this study, CBL certainly helped participants ease their anxiety. Based on participant responses on why so, by focusing on understanding and mastery versus a "one-and-done" assessment, students felt that their grades increased.

By focusing on understanding, some participants noticed that CBL helped "level the playing field" for students who may not be as prepared for college algebra as others. As one

student answered when asked on survey 1 their initial thoughts on CBL, “It seems to put everyone on a level playing field.”

Another participant on survey 1 stated when asked about their initial thoughts on CBL that “I honestly think it’s a great idea so students can see where they are, where they should be and what they should be looking for.” A third participant said that “I don’t know much about it [CBL] but it sounds like it would help based on the individual’s needs.” During survey 2 when asked about current thoughts on the CBL approach, one participant answered, “I like this approach because not all students are good test/quiz takers and this approach help ease the mind of trying to achieve a passing grade.”

One principle that Bickerstaff et al. (2022) suggested when colleges think about reforming developmental education is to use an equity-minded approach. While this idea will be discussed during the review of research question 2, one way to promote an equity-minded approach according to Bickerstaff et al. (2022) is to use student-centered pedagogy. As Patrick (2021) argued, “a competency-based structure is built upon personalized learning experiences tailored to each student’s strengths, needs, and interests and requires student voice and choice in what, how when, and where they learn” (p. 23). As both researchers show and how participants in this study responded, competency-based learning helps improve equity in the classroom by being student-centered and helping those who struggle with topics in the college algebra course focus on mastering the material rather than being anxious about a “one-and-done” exam. Especially at MTC where anyone can register for the degree-level course, it is vital to have policies in place that promote a growth mindset.

Review of Research Question 1

The first question was how would a competency-based learning approach to learning affect student perceptions of their success in the college algebra online course at MTC? Participants felt that their anxiety decreased because of CBL and that they felt more successful because of the implementation of CBL. Participants' anxiety decreased and they felt more successful because CBL gave participants more confidence when taking the assessments, they could learn the material at their own pace, the technology and the instructor communicated to participants' clear instructions on how to improve, and ultimately CBL helped them increase their understanding of the material.

Overall, CBL was successfully implemented in the college algebra online class at MTC with many participants feeling like they were more successful due to its implementation.

Research Question 2

Confidence

In chapter 4, 6 out of 7 students preferred CBL over a traditionally graded classroom. Out of the 6 that answered positively about CBL, 3 of them answered that they preferred CBL because it helped increase their confidence. On their thoughts on which approach they preferred, one participant answered that "with the numerous attempts, I feel more confident and comfortable about being able to reach the proficiency mark." Another stated that "I prefer the competency-based approach simply because it helps my confidence when taking a test."

Throughout the study, it was clear that participants' attitude toward mathematics greatly impacted their confidence as if they saw their grades increase, they became more confident when taking a test. Attitudes such as having a growth mindset and being more confident make a significant difference in assessment performance. As suggested by Orhun (2007), student

perceptions regarding their confidence in learning mathematics are directly affected by their attitude toward mathematics. In participant responses during this study, students felt more confident when taking quizzes because of the CBL approach.

One participant answered that they preferred the traditional approach. On why they preferred the traditional approach, they stated that they "prefer the traditional-approach because I think that'll give students more time to get the help that they need, as well as giving them multiple chances to do it correct." While this response seems counter to what the research shows about CBL, instructors still should take the time to communicate why CBL can and should be effective. During this study, the benefits of participating in the study were given during the invitation to participate, which was sent to students one day and one week before the semester started. In addition, statements on how the assessment would be taken and graded were published under the course announcements in the online course and on the syllabus. At least for the purposes of this study, giving explicit reasons why CBL was beneficial could influence the responses of the students. Therefore, no reasons why CBL may or may not be beneficial to students were given to students in hopes of having unbiased responses from students.

In addition to increasing confidence based on giving participants multiple chances on assessments, this participant mentioned that CBL will "give students more time to get the help that they need." This brings up time management as a theme, which others have mentioned while answering research question 1. While this participant is referring to a more traditional approach, the author believes that CBL would give more time for students to get help with what is needed. While there are still deadlines to meet, CBL gives any student the chance to make mistakes and retry an assessment multiple times to achieve mastery. Ultimately, the student is in control of their own pace at which they master the material using CBL, especially during an online course.

Equity

One participant in survey 3 brought up the fact that CBL helped "level the playing field." They argued that "if it's supposed to be about learning, CBL is a better system. Because it evens the playing field between people that have text anxiety and people who don't."

This comment brings to light the idea that CBL can help provide equity in the classroom. As mentioned in chapter 2, De los Santos et al. (2022) argued that students should be allowed equal opportunities and equal access to higher education. In response to reforming developmental education, Bickerstaff et al. (2021) stated that "institutions should seek to identify and address institutional- and classroom-level structures, policies, and practices that create or maintain racial or economic inequities in access to and completion of introductory college-level courses" (p. ES-3). This principle, according to Bickerstaff et al. (2022) means that institutions should design and implement policies and practices using an equity-minded approach. Even Patrick (2021) defined part of CBL as "strategies to ensure equity for all students are embedded in the culture, structure, and pedagogy of schools and education systems" (p. 24). As MTC is an open-access institution, students from all backgrounds can attend and take classes at MTC. It is vital that institutions, especially those that are open access, provide a classroom in which learners from all backgrounds can grow and succeed. Research shows and participants in this study recognized that CBL helps all students in completing and succeeding in their math courses.

Review of Research Question 2

The second research question asked what participants' perceptions are after taking the CBL course versus what they think of as a traditionally graded classroom. Six out of 7 participants answered that they preferred CBL, and qualitative responses were positive toward CBL because of the confidence increase it provided and how it provided more equity when

taking assessments. Confidence increased in participants because they saw the benefits of multiple tries leading to a better grade. Equity was enhanced as CBL helped level the playing field for those who may not be ready for a college math class. To conclude, students preferred the CBL class over what they thought of as a traditionally graded classroom.

Chapter Summary

Chapter 4 presented both the qualitative and quantitative data for this mixed-methods study. The results showed that students while quantitatively there was no significant difference throughout the semester on participants' perceptions of their success and math anxiety, qualitatively participants felt that both their feelings of success increased, and their anxiety decreased. In addition, the majority of students felt that they preferred CBL over a traditionally graded classroom. Chapter 5 will conclude this scholarly action research project by discussing implications for practice and offering recommendations for future research.

Chapter 5

CONCLUSION

Introduction

This action research project gathered participants' perceptions of CBL in an online college algebra course at MTC. Three anonymous surveys were given at the beginning of the course, at midterms, and during the final week to gather participants responses to the following two research questions:

1. How will a competency-based learning approach to learning affect student perceptions of their success in the college algebra online course at MTC?
2. What are participants' perceptions after taking the CBL course versus what they think of as a traditionally graded classroom?

Chapter 5 will begin by discussing the results from chapter 4 and fully answering this study's research questions. Then, implications for practice and the limitations of the study will be explored. The chapter will end with suggestions for future research.

Answers to the Study's Research Questions

The first question of this research asked how a competency-based learning approach to learning affects student perceptions of their success in the college algebra online course at MTC. The data showed that participants felt they were more successful in the online college algebra course because of the implementation of CBL. Qualitatively, participant responses showed four major themes surrounding their feelings toward CBL: confidence, time management, communication, and understanding. For confidence, participants felt that their grades were higher because once they reached mastery, their grades were boosted to an A. In addition, participants felt less anxious and stressed while taking assessments in the class as they had

multiple opportunities to reach mastery. Overall, participants' confidence increased due to the implementation of CBL.

Next, participants felt that they could manage their time better as they could spend the time needed to gain mastery of the course standards. However, students need to understand that getting to the level of mastery may take multiple attempts at an assessment, time in which some students do not have. This held true especially with this study being conducted at the 2-year technical college level since many students come from varying backgrounds and may have other responsibilities outside the classroom including a full-time job, other classes they are taking, or providing for their families. Students may also procrastinate in taking assessments, but clear communication from the instructor can help remedy that concern. In this study, participants felt they could manage their time better to try and achieve mastery on each of the 6 quizzes.

With communication, participants were worried about taking the course online as some stated in the qualitative response of survey 1 that they were not the best with technology. As argued by Selcuk et al. (2021), instructors must create a well-structured learning environment for student success. In addition to being well-structured, instructors should take the time to communicate with students about how the class is structured. This can be done by creating announcements in the course, outlining the structure via the syllabus, or crafting a before-the-semester starts e-mail discussing CBL. Especially in online classes, instructors should create videos, provide online office hours, and provide constant feedback on assessments to promote learning experiences from students' mistakes. Overall, communication with students should be a high priority for any online instructor wanting to use CBL in their classroom.

Finally, participants felt that their chance of success increased due to CBL because their overall understanding of the material increased. This was because of multiple factors which

included leveling the playing field for those who did not feel they were adequately prepared for a degree-level course and a decrease in test anxiety. By giving participants multiple chances to master course objectives which in turn helped understanding, participants felt more prepared to be successful in the college algebra online course. Through confidence, time management, communication, and understanding, participants throughout the study felt more successful because of the implementation of CBL.

The second question of this research asked what participants' perceptions were after taking the CBL course versus what they think of as a traditionally graded classroom. Quantitatively, 6 out of 7 students preferred CBL over a traditionally graded classroom. Two themes were prominent in why they preferred CBL in that it helped increase confidence and provided equity in the classroom. The increase in confidence was often attributed to the increase in grades participants experienced after earning mastery. Similar to that of Harsy's (2020) study which showed that anxiety decreased due to having more chances to achieve mastery, participants in this study recognized that CBL offered multiple chances to earn an A. By seeing an increase in their grade, participants felt more confident when taking a future assessment.

CBL promoted equity in the classroom as no matter what pre-requisite knowledge a student entered the class with, they had multiple opportunities to achieve mastery of course standards. Middle Technical College is an open-access institution that offers educational opportunities for students no matter their prior levels of academic achievement (Daugherty et al., 2019). Multiple participants recognized that by allowing multiple opportunities, students could focus on their deficiencies. This idea aligns with Patrick (2021) arguing that the competency-based structure is built to tailor to student's strengths, needs, and interests. No matter what level of academic achievement a student brings to the classroom, a CBL classroom would offer them a

way to develop the competencies needed to be successful either in future coursework or on the job. Students ultimately preferred the CBL classroom over a traditionally graded classroom both in their quantitative and qualitative responses.

Implications for Practice

CBL and Technical Education

The mission of Middle Technical College, and many other technical institutes like it, involves workforce development. According to the Office of Disability Employment Policy (n.d.), two skills that are needed for workforce readiness include professionalism or work ethics and critical thinking or problem-solving skills. These soft skills needed for workforce readiness can be taught and reinforced by implementing CBL on activities such as the quiz as students use what they learn from earlier failing attempts on the quiz to gain a better understanding of the material and apply their new-found knowledge on future attempts.

For example, the health sciences department at MTC has some of the more popular programs with approximately 1,800 students enrolled in a degree, diploma, or technical certificate program. Taking the associate degree in nursing as an example, in the field, a nurse will engage with a patient, document a list of concerns and symptoms, and work alongside doctors to administer medication and monitor patient recovery (Mayo Clinic, n.d.). It may take a student multiple opportunities to master job responsibilities such as administering the correct medication, inserting an IV, or checking blood pressure.

The development of these necessary critical thinking skills and work ethics in instructors' students can carry over into a mathematics course. The student may get a wrong answer a few times, but after hard work and dedication to understanding the content and concepts, mastery of the standard is possible. By beginning to teach students a growth mindset while taking their math

requirement, students may be more confident to embrace failure in their program classes with the knowledge that failure leads to growth, experience, and success in not only those classes but also in future job requirements.

If the goal of technical education is workforce development, CBL is a great idea for colleges to discuss to see if they want to implement it in their programs. CBL could be implemented throughout the program to build not just mastery in the content area, but the essential soft skills needed for the workforce.

Math Anxiety

Both Harsy et al. (2020) and this study showed the participants' responses indicated they had a decrease in math anxiety due to the implementation of CBL. In fact, the data showed that often, a participant already experienced math anxiety when registering for the college algebra course. To combat this anxiety, Fergus and Smith (2022) represented that CBL could help. For many participants in this study, CBL did just that by giving participants opportunities to learn from their mistakes and get another opportunity if the assessment was not passed.

As with one participant who could only take the assessment at certain times of the day, it is essential that the instructor communicates the importance of completing work in a prompt fashion. Math anxiety could potentially increase for a student in a CBL classroom if, for example, that student was stuck on mastering certain standards and was unable to move on in the class due to a failure to reach the appropriate level of mastery in the key assessment for the content. In addition, multiple attempts without success may lead the student to quit. In these scenarios, it is recommended that the instructor impose a cap on the number of attempts a student can take the assessment until an intervention has occurred (such as meeting with the instructor

during office hours or tutoring). In this study, the cap was three attempts, but as will be discussed in the limitations section, it is believed that two attempts are sufficient.

Developmental Education

With placement testing at MTC not being required as an admissions requirement, developmental education has seen a decrease in enrollment. As an example, in the fall 2020 semester when placement testing was needed, 115 students were enrolled in a math developmental education course. In the fall 2023 semester with no placement testing requirements, 9 students were enrolled in a developmental education course. This is because developmental math courses that were required based on the placement test score are now optional for students to register for no matter what background or skill level they are entering college.

This study has shown that by implementing CBL in a degree-level math course, students who are not quite ready for the degree-level class have multiple attempts on each assessment to earn mastery to move on to the appropriate course level. Participants in this study felt that their confidence and understanding of the material increased, which helped level the playing field for those who are entering the class with a lower math skill.

Following the advice of Bickerstaff et al. (2022), students should be allowed to take degree-level classes immediately. Colleges should employ contextualized curriculum that "engages students in authentic literacy and numeracy tasks like those they will encounter throughout college, foregrounding higher level competencies that students need to master to be successful in college-level courses" (Bickerstaff et al., 2022, p. ES-2). In addition to contextualized curriculum, colleges should focus on student-centered pedagogy such as CBL, which Bickerstaff et al. (2022) argued is particularly important for math.

With enrollment in developmental education at MTC at an all-time low, it will become increasingly important for MTC math faculty to analyze their degree-level courses for inequities in the curriculum. This study showed that CBL could be a strong resource to engage student learners as well as equal the playing field for students who feel underprepared to take a degree-level math course.

Limitations

Office Hours Limitations

In describing group-based mastery learning, Slavin (1987) mentioned that students who did achieve competency should receive corrective instruction. Especially given that CBL allows multiple opportunities for students, corrective instruction is needed so the student does not get frustrated if they require multiple attempts to get to mastery. In this study, to combat that idea, a limit of 3 attempts was given to students, and after the third attempt, they had to attend office hours with the instructor to receive extra assistance on mathematical content and concepts being taught at that time before earning more attempts at the assessment.

Over the course of the semester, no students attended office hours with the instructor to open more attempts. A couple of theories on why no students participated in office hours include time and their overall grade. As mentioned by one participant, they did not have the time to take the assessment multiple times to try and earn mastery. If an instructor wants to use CBL in their online classroom, it is recommended to communicate to students the importance of managing their time throughout the week so that they spend the time needed to master the content and the idea that the multiple attempts on the assessments are encouraged as a way to not only improve on their grade but help build confidence and understanding in the material. In addition, the class is conducted over 16 weeks; therefore, if a student does not reach mastery after the first or

second attempt, they may decide to just keep moving forward in the class rather than falling behind.

This idea leads to another theory in that some students were not concerned with their overall grade in the sense that even if they did not reach the mastery criterion of 80%, there was a lack of motivation to improve their content mastery further. In this study, if a student did not reach 80%, the grade that they earned was entered into the gradebook.

With relation to office hours, as stated previously, it is highly recommended to make sure the instructor communicates the idea of CBL and its benefits to learning throughout the semester. In addition, putting holds on the number of attempts before a student can earn additional attempts is recommended so that corrective instruction can commence. Instead of capping the number of attempts at 3, it is recommended that students must attend office hours after their second attempt at the quiz to receive corrective instruction.

Limitations on Time Constraints

This study was only able to be conducted for one semester. Ideally, CBL in the algebra courses at MTC could be expanded into not only the author's sections but in all other online sections taught by any instructor employed by MTC across multiple semesters. In addition, students taking a math class in person rather than online could have provided an even deeper understanding of the effects that CBL has on math anxiety, confidence, and the overall understanding of course content.

Survey 3 Sample Size Limitations

Unfortunately, only 7 students participated in survey 3. While conclusions could be made based on the larger sample sizes from survey 1 and survey 2, it is still disappointing that very few students registered in the course participated in survey 3. One such reason this could be the

case is because participant responses throughout the 3 surveys showed that they were highly motivated by their grades increasing, which makes sense through research by Orhun (2007) which showed that student perceptions of their confidence were directly affected by their attitude toward mathematics and Beiter et al. (2015) which stressed that meeting graduate requirements is a factor of a college student having stress. It is theorized that because of the higher grades, students in the online algebra class were either happy with their grade or were not in a position to pass the course, which both resulted in a lack of responses being that it was the end of the semester. This study used a mixed methods study, which was advantageous in that a fuller picture could be gathered without having to use only 7 data points for survey 3.

Suggestions for Future Research

Technical Education

The author believes that instruction in technical education is a world that should be studied further. Considering that the cost of earning a higher education degree is on the rise, earning either a technical certificate, diploma, or degree from a technical college can help students from all backgrounds graduate and fulfill their professional dreams.

From a math education standpoint, instructional culture and practice in the math classroom must be studied to increase the number of students who can experience success in their program coursework. One future study could determine how many students take the next-sequenced math course that would historically be taken after the one they originally took. If the results from that study discovered that students generally only take one math course while earning their college degree, it may be more beneficial for students to learn applications of the math they are learning rather than mathematical theory. If the emphasis was on mathematical

applications, classroom theories such as CBL could help train students to develop the mathematical skills needed for the workforce.

In addition to math education, the concept of developmental education should be further explored at the technical college level. Enrollment in developmental coursework at MTC is at an all-time low. The effectiveness of developmental education and some research indicates that students should be granted immediate access to degree-level coursework (Bickerstaff, et al., 2022). In addition, with workforce development at the core of the technical college mission, students seem to want to expedite graduation which contradicts the idea of taking multiple developmental classes as taking these classes extends the length of the program of study to complete their degree (Kosiewicz et al., 2016). This study showed that CBL could be a great possibility for degree-level classes to help students from all backgrounds be prepared for the rigorous material that students will see in a degree-level math course. However, more work needs to be done with development support, so all students have a chance to graduate and realize their dreams.

Longitudinal Study

Many students at MTC take their general studies classes such as math and English before enrolling in their program-specific courses. Introducing students to CBL in their general education classes could develop students' skills earlier in their college careers. These skills would support student future success in the workplace, such as the development of a growth mindset and enhancing critical-thinking skills, which could bode well for performance in their program-specific courses.

One such research project could track students over time from their general studies courses through their program-specific courses to see how CBL affects their learning and their

success. It could be interesting to track students after graduation to see if the skills they learned in their math class from CBL are translated into the workforce. Gauging student perceptions of how they feel about their learning could show dividends in how instructors teach both general education classes and program-specific classes.

Other Classroom Types

Both inquiry-based learning and flipped classrooms could be alternatives when trying to create student-centered classrooms. In that MTC is focused on workforce development, it is essential to study the curriculum so that it fits today's demands for an educated workforce (Warren, 2011). As Warren (2011) argued, the more instructors know about the several types of models, they will be able to better design what will work for their institution. Future research with inquiry-based learning, flipped classrooms, and other student-centered approaches could find that one or more of these approaches benefit students in the classroom, get them to graduation, and be successful in the workforce.

Math Course Success

As seen in the research and in this study, math anxiety is real and can affect a student's perception of their success by making them feel less confident and have a negative attitude toward learning mathematics. It would be interesting to study how many students would be satisfied with "just passing" a mathematics course even if CBL was implemented giving a student multiple opportunities to earn an A. If a student was happy with earning a C, they would feel no need to take an assessment multiple times to earn the 80% needed to reach mastery. This idea is emphasized at a 2-year technical college like MTC where the focus is centered on workforce development and having a deep understanding of mathematics may not be necessary to be successful in the workforce. It was found in this study that by using the CBL approach,

participants were more confident in taking assessments and minimized math anxiety due to the rise in the grades that they experienced by reaching mastery. If a future study found that students using a more traditional approach to learning were satisfied with just passing the class rather than earning an A, it could be seen whether a student-centered approach like CBL could persuade students to achieve a higher goal such as earning an A.

Conclusion

Students like Jacob from the introduction are not rare. Technical colleges like MTC enroll students of all backgrounds, many of which may not feel prepared for degree-level classes such as college algebra. This study was completed to determine if students' perceptions of their success in college algebra would increase if the focus of assessing students was built upon mastering the material rather than a "one-and-done" approach. In the end, participants felt more confident, had better management of their time, communication increased between students and instructor, and their overall understanding of the material increased.

While this study was overall successful in its implementation in the college algebra online class, more work is needed to be done to ensure student success both in their math courses and their overall program of study at the technical college level. The author hopes that other technical colleges discuss their student needs to see if CBL can be implemented in their classes. By beginning the conversation, math educators can transform the classroom into one where students may enter with math anxiety but leave knowing that they overcame challenges, developed a growth mindset, and are set up to graduate and realize their dreams.

REFERENCES

Aidinopoulou, V., & Sampson, D.G. (2017). An action research study from implementing the flipped classroom model in primary school history teaching and learning. *Educational Technology & Society, 20*(1), 237-247.

Alias, N.A. & Zainuddin, A.M. (2005). Innovation for better teaching and learning: Adopting the learning management system. *Malaysian Online Journal of Instructional Technology, 2*(2), 27-40.

Arens, Z. (2023). The reasons undergraduates take online courses differs by classification. *Quarterly Review of Distance Education, 24*(2), 13-21.

Attewell, P., Lavin, D., Domina, T., & Levey, T. (2006). New evidence on college remediation. *Journal of Higher Education, 77*(5), 886-924. https://doi.org/10.1080/00221546.2006.11778948

Bailey, T., Jeong, D.W., & Cho, S. (2010). Referral, enrollment, and completion in developmental education sequences in community colleges. *Economics of Education Review, 29*(2), 255-270. https://doi.org/10.1016/j.econedurev.2009.09.002

Beiter, R., Nash, R., McCrady, M., Rhoades, D., Linscomb, M., Clarahan, M., & Sammut, S. (2015). The prevalence and correlates of depression, anxiety, and stress in a sample of college students. *Journal of Affective Disorders,* 173, 90-96. https://doi.org/10.1016/j.jad.2014.10.054

Bell, J.S. & Mitchell, R. (2000). Competency-based versus traditional cohort-based technical education: A comparison of students' perceptions. *Journal of Career and Technical Education, 17*(1), 5-22. http://doi.org/10.21061/jcte.v17i1.589

Bickerstaff, S., Beal, K., Raufman, J., Lewy, E.B., Slaughter, A. (2022). *Five principles for reforming developmental education: A review of the evidence.* https://ccrc.tc.columbia.edu/publications/five-principles-reforming-developmental-education.html

Bonham, B. & Boylan, H. (2011). Developmental mathematics: Challenges, promising practices, and recent initiatives. *Journal of Developmental Education, 34*(3), 2-10.

Brunetto, D., Bernardi, G., Andrá, C., & Liljedahl, P. (2022). Teaching as a system: COVID-19 as a lens into teacher change. *Educational Studies in Mathematics*, *110*(1), 65-81. https://doi.org/10.1007/s10649-021-10107-3

Bryman, A. (2006). Integrating quantitative and qualitative research: How is it done? *Qualitative Research, 6*(1), 97-113. https://doi.org/10.1177/1468794106058877

Blair, A. (2014). Inquiry maths: An idea whose time has come. *Mathematics Teaching, 1* (240), 32-35.

Community College Research Center. (2024). *Community College FAQs.* Columbia University. Retrieved March 22, 2024 from https://ccrc.tc.columbia.edu/community-college-faqs.html#:~:text=How%20many%20community%20college%20students%20work%20while%20in%20college%2C%20and,federal%20data%20from%202019%2D20.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage Publications.

Daugherty, L., Miller, T., Carew, D.G. (2019). *Supporting college enrollees who test at the lowest levels of readiness: Lessons from Texas Community Colleges*. https://www.rand.org/pubs/research_reports/RR2938.html

De los Santos, P.J., Moreno-Guerrero, A. -J., Marin-Marin, J. -A., Costa, R.S. (2020). The term equity in education: A literature review with scientific mapping in web of science. *International Journal of Environmental Research and Public Health, 17*(1), 1-17. https://doi.org/10.3390/ijerph17103526

Dockterman, D. & Blackwell, L. (2014). *Growth mindset in context: Content and culture matter too.* International Center for Leadership in Education. https://kmhs.typepad.com/files/growthmindset-1.pdf

Dorier, J.-L., Maass, K. (2020). Inquiry-based mathematics education. *Encyclopedia of Mathematics Education*. https://doi.org/10.1007/978-3-030-15789-0_176

Fergus, S., & Smith, C. (2022). Characteristics of proficiency-based learning and their impacts on math anxiety in the middle grades. *Research in Middle Level Education Online, 45*(4), 1-19. https://doi.org/10.1080/19404476.2022.2045810

Forsey, M., Low, M., & Glance, D. (2013). Flipping the sociology classroom: Towards a practice of online pedagogy. *Journal of Sociology, 49*(4), 471-485. https://doi.org/10.1177/1440783313504059

Fraenkel, J., Wallen, N. & Hyun, H. (2012). *How to design and evaluate research in education* (8th ed.). McGraw Hill.

Francome, T. & Hewitt, D. (2020). "My math lessons are all about learning from your mistakes": How mixed-attainment mathematics grouping affects the way students experience mathematics. *Educational Review, 72*(4), 475-494. https://doi.org/10.1080/00131911.2018.1513908

Furner, J., & Marinas, C. (2016). Mathematics anxiety in society: A real phenomena and a real solution. *Transformations, 1(1)*, 24-36.

Geist, E. (2010). The anti-anxiety curriculum: Combating math anxiety in the classroom. *Journal of Instructional Psychology, 37*(1), 24-31.

Goldrick-Rab, S. (2010). Challenges and opportunities for improving community college student success. *Review of Educational Research, 80*(3), 437-469. https://doi.org/10.3102/0034654310370

Gunawardena, C. N., Lowe, C. A., & Anderson, T. (1997). Analysis of a global online debate and the development of an interaction analysis model for examining social construction of knowledge in computer conferencing. *Journal of Educational Computing Research, 17*(4), 397–431. https://doi.org/10.2190/7MQV-X9UJ-C7Q3-NRAG

Gurenlian, J. (2023). Mixed methods or mixed up? *Journal of Dental Hygiene, 97*(4), 70-72.

Harsy, A. (2020). Variations in mastery-based testing. *PRIMUS, 30*(8-10), 849-868. https://doi.org/10.1080/10511970.2019.1709588

Harsy, A., Carlson, C., & Klamerus, L. (2021). An analysis of the impact of mastery-based testing in mathematics courses. *PRIMUS, 31*(10), 1071-1088. https://doi.org/10.1080/10511970.2020.1809041

Henri, M., Johnson, M., & Nepal, B. (2017). A review of competency-based learning: Tools, assessments, and recommendations. *Journal of Engineering Education*, *106*(4), 607-638. https://doi.org/10.1002/jee.20180

Herr, K., & Anderson, G. L. (2015). *The action research dissertation: A guide for students and faculty.* Sage Publications.

Huang, Y. -C. & Lin, S. -H. (2015). Development and validation of an inventory for measuring student attitudes toward calculus. *Measurement and Evaluation in Counseling and Development, 48*(2), 109-123. https://doi.org/10.1177/0748175614563314

Imran, M., Baig, M., Murad, M.A., & Almurashi, S. (2022). Factors disturbing undergraduate students' interaction during lectures: A university-based survey. *Pakistan Journal of Medical Sciences, 38*(7), 1945-1951. https://doi.org/10.12669/pjms.38.7.5101

Inquire. *Merriam-Webster.com*. In *Merriam-Webster.com*. Retrieved January 6, 2023. https://www.merriam-webster.com/dictionary/inquire

Knight, M. & Cooper, R. (2019). Taking on a new grading system: The interconnected effects of standards-based grading on teaching, learning, assessment, and student behavior. *NASSP Bulletin, 103*(1), 65-92. https://doi.org/10.1177/0192636519826709

Kosiewicz, H., Ngo, F., & Fong, K. (2016). Alternative models to deliver developmental math: issues of use and student access. *Community College Review, 44*(3), 205-231. https://doi.org/10.1177/0091552116651490

Lanius, M., Jones, T.F., Kao, S., Lazarus, T., Farrell, A. (2022). Unmotivated, depressed, anxious: Impact of the COVID-19 Emergency Transition to Remote Learning on Undergraduates' Math Anxiety. *Journal of Humanistic Mathematics, 12*(1), 148-171. https://doi.org/10.5642/jhummath.202201.11

Malhotra, M. & Grover, V. (1998). An assessment of survey research in POM: From constructs to theory. *Journal of Operations Management, 16*(4), 407-425. https://doi.org/10.1016/S0272-6963(98)00021-7

Maxwell, N., & Gallagher, S. (2020). Drivers for change in higher education. *New Directions for Community Colleges, 189,* 9-22. https://doi.org/10.1002/cc.20394

Mazzeo, C. (2008). *Supporting student success at California community colleges: A white paper.* Career Ladders Project for California Community Colleges.

Mertler, C. A. (2020). *Action research: Improving schools and empowering educators* (6th ed.). Sage Publications.

Middle Technical College. (2022). [Information collected via institutional website].

Missel III, F., Ernst, J., Kelly, D., Schettig, E., & Clark, A. (2022). Active learning strategies and applications for engineering design graphics courses. *Technology & Engineering Teaching, 82*(4), 15-20.

Moss, B., Bahr, P., Arsenault, L., & Oster, M. (2018). Knowing is half the battle, or is it? A randomized experiment of the impact of supplemental notification letters on placement exam participation, preparation, and performance. *Research in Higher Education, 60*(6), 737-759. https://doi.org/10.1007/s11162-018-9536-9.

National Center for Education Statistics (2015). Demographic and Enrollment Characteristics of Nontraditional Undergraduates: 2011–12. https://files.eric.ed.gov/fulltext/ED581707.pdf

New England Institute of Technology. (2020, October 29). *What is a technical school?* NEIT. https://www.neit.edu/blog/what-is-a-technical-school

Newton, P. & Burgess, D. (2008). Exploring types of educational action research: implications for research validity. *International Journal of Qualitative Methods, 7*(4), 18-30. https://doi.org/10.1007/978-94-6300-438-1_3

Ngo, F., Velasquez, D., & Melguizo, T. (2021). Faculty perspectives on using high school data in an era of placement testing reform. *Community College Review, 49*(3), 290-313. https://doi.org/10.1177/00915521211002896

Office of Disability Employment Policy. (n.d.). *Soft skills: The competitive edge.* U.S. Department of Labor. https://www.dol.gov/agencies/odep/publications/fact-sheets/soft-skills-the-competitive-edge

Orhun, N. (2007). An investigation into the mathematics achievement and attitude towards mathematics with respect to learning style according to gender. *International Journal of Mathematical Education in Science and Technology, 38*(3), 321-333. https://doi.org/10.1080/00207390601116060

Patrick, S. (2021). Transforming learning through competency-based education. *State Education Standard*, *21*(2), 23-29.

Patrick, S. & Sturgis, C. (2013). *Necessary for success: Building mastery of world-class skills.* CompetencyWorks, International Association for K-12 Online Learning. https://files.eric.ed.gov/fulltext/ED561282.pdf

Pedaste, M., Mäeots, M., Leijen, Ä., & Sarapuu, T. (2012). Improving students' inquiry skills through reflection and self-regulation scaffolds. *Technology, Instruction, Cognition and Learning, 9*(1-2), 81-95.

Pekow, C. (2006, November 20). Report: 2-year degree pays for itself quickly. *Community College Week*, *19*(7), 5.

Perry, A. (2004). Decreasing math anxiety in college students. *College Student Journal, 38*(2), 321-324.

Pittman, J. (2011). Inquiry-based math in school gardens. *Connect Magazine, 24*(5), 4-7.

Qian, X., Clary, E., Johnson, D., & Echternacht, J. (2018). The use of a coaching model to support the academic success and social inclusion of students with intellectual disabilities in community and technical college settings. *Journal of Postsecondary Education and Disability, 31*(3), 193-208.

Rogers, D., Noblit, G., & Ferrell, P. (1990). Action research as an agent for developing teachers' communicative competence. *Theory Into Practice, 29*(3), 179-184. https://doi.org/10.1080/00405849009543452

Royer, D. & Baker, R. (2018). Student success in developmental math education: Connecting the content at Ivy Tech Community College. *New Directions for Community Colleges, 2018*(182), 31-38. https://doi.org/10.1002/cc.20299

Sedgwick, P. (2013). Convenience sampling. *BMJ*, 347. https://doi.org/10.1136/bmj.f6304

Selcuk, S., Kocak, A., Mouratidis, A., Michou, A., & Sayil, M. (2020). Procrastination, perceived maternal psychological control, and structure in math class: The intervening role of academic self-concept. *Psychology in the Schools, 58*(9), 1782-1798. https://doi.org/10.1002/pits.22542

Serhan, D. (2019). Web-based homework systems: Students' perceptions of course interaction and learning in mathematics. *International Journal on Social and Education Sciences*, *1*(2), 57-62. https://doi.org/10.46328/ijonses.18

Shorten, A. & Smith, J. (2017). Mixed methods research: Expanding the Evidence Base. *Evidence-Based Nursing, 20*(1), 74-75. https://doi.org/10.1136/eb-2017-102699

Slavin, R. (1987). Mastery learning reconsidered. *Review of Educational Research, 57*(2), 175-213. https://doi.org/10.2307/1170235

Staff Writers. (2023, July 20). *What is an associate degree?* TheBestSchools.org. https://thebestschools.org/degrees/what-is-an-associates-degree/

State University Office of Analysis, Assessment and Accreditation. (2022). [Unpublished raw data on the Qualitative Analysis of the Author's Course Evaluations].

Strelan, P., Osborn, A., & Palmer, E. (2020). The flipped classroom: A meta-analysis of effects on student performance across disciplines and education levels. *Educational Research Review*, *30*. https://doi.org/10.1016/j.edurev.2020.100314

Thomas, D.R. (2006). A general inductive approach for analyzing qualitative evaluation data. *American Journal of Evaluation, 27*(2), 237-246. https://doi.org/10.1177/1098214005283748

Titus, M., Vamosiu, A., & Gupta, A. (2015). Conditional convergence of nonresident tuition rates at public research universities: a panel data analysis. *Higher Education, 70*(6), 923-940. https://doi.org/10.1007/s10734-015-9883-9

Van Oers, B. (2001). Educational forms of initiation in mathematical culture. *Educational Studies in Mathematics, 46*(1-3), 59-85. https://doi.org/10.1007/0-306-48085-9_2

Warren, J. (2011). Changing community and technical college curricula to a learning outcomes approach. *Community College Journal of Research & Practice, 27*(8), 721-730. https://doi.org/10.1080/713838247

Wickersham, K. & Wang, X. (2022). Making sense to make change: How community college faculty perceptions of math contextualization shape instructional change. *Community College Review, 50*(1), 3-29. https://doi.org/10.1177/00915521211047671

Zhao, J., Hwang, G.-J., Chang, S.-C., Yang, Q.-F., Nokkaew, A. (2021). Effects of gamified interactive e-books on students' flipped learning performance, motivation, and meta-cognition tendency in a mathematics course. *Education Tech Research & Development, 69*(6), 3255-3280. https://doi.org/10.1007/s11423-021-10053-0

APPENDIX A

INVITATION TO PARTICIPATE

Hello all,

Welcome to College Algebra! I am extremely excited to have you in class this semester.

My name is Zachary Youmans, and I will be your instructor this semester. Alongside being your instructor, I am also an Ed.D. candidate at Bradley University doing research on different approaches to learning in a mathematics classroom. By registering for this online course, you have a great opportunity to help shape research regarding learning and assessing mathematics.

This semester, I will be utilizing a competency-based learning approach to the six different quizzes that you will take throughout the semester. Competency-based learning is an approach to learning that emphasizes mastery. In other College Algebra sections, students will be taking the same 6 quizzes as you but only having 2 attempts with the highest grade being recorded. In our class, you will have unlimited attempts to reach an 80% or above proficiency on each quiz. More information on how this will work is given in the attached informed consent and the attached syllabus.

Three anonymous and voluntary surveys will be given throughout the semester. If you wish not to complete these surveys, it will not be held against you by your instructor. Surveys will ask you a mixture of Likert scale and open-ended responses based on your experiences with math anxiety and competency-based learning. They will take approximately 20 minutes a piece to complete.

If you wish to be a part of a course section that does not grade on mastery-based learning, you are free to move sections without penalty until [date]. Please contact your instructor if this is the case.

Please read the following Invitation to Participate as it provides critical information on the study.

INVITATION TO PARTICIPATE
You are invited to participate in a study being conducted at Central Georgia Technical College (CGTC). This research is in conjecture with Bradley University and is being done under Dr. Scott Estes in the Department of Education, Counseling, and Leadership at Bradley University. The title of the study is “Student Perceptions of Competency-Based Learning in an Online College Algebra Course.”

The purpose of this study is two-fold: to see how will a competency-based learning (CBL) approach to learning affect student perceptions of their success in the college algebra course at CGTC and what are student perceptions after taking the CBL course versus a traditionally-graded classroom.

You are eligible to participate in this study as a student registered in a Mr. Youmans' college algebra online section at CGTC. Participation on the surveys given throughout the semester is voluntary. By signing up for Mr. Youmans' sections, you will be graded using the mastery-based approach. If you wish to be graded upon a more traditional approach, please switch sections, which you are allowed to do so without penalty until [date]. If you have any questions, please contact the researchers which their contact information will be below.

You will be asked to complete 6 quizzes, just like any other College Algebra course, throughout the 16-week semester. Each quiz will have a time limit of 2 hours to complete. Each additional attempt to reach mastery on each quiz (which will be set at 80% or above) will also have 2 hours. Three times throughout the semester you will be asked to complete an anonymous, voluntary survey which will take approximately 20 minutes to complete. The study starts on the first day of class which is Tuesday, August 15th and ends on the last day of class, Friday, December 8th.

There are no incentives or compensation being offered for participating.

We thank you for your time, and I look forward to your participation.

Student Principal Investigator
Zachary Youmans
zyoumans@mail.bradley.edu
478-471-5186
Ed.D. Candidate
Department of Education, Counseling, and Leadership
Bradley University

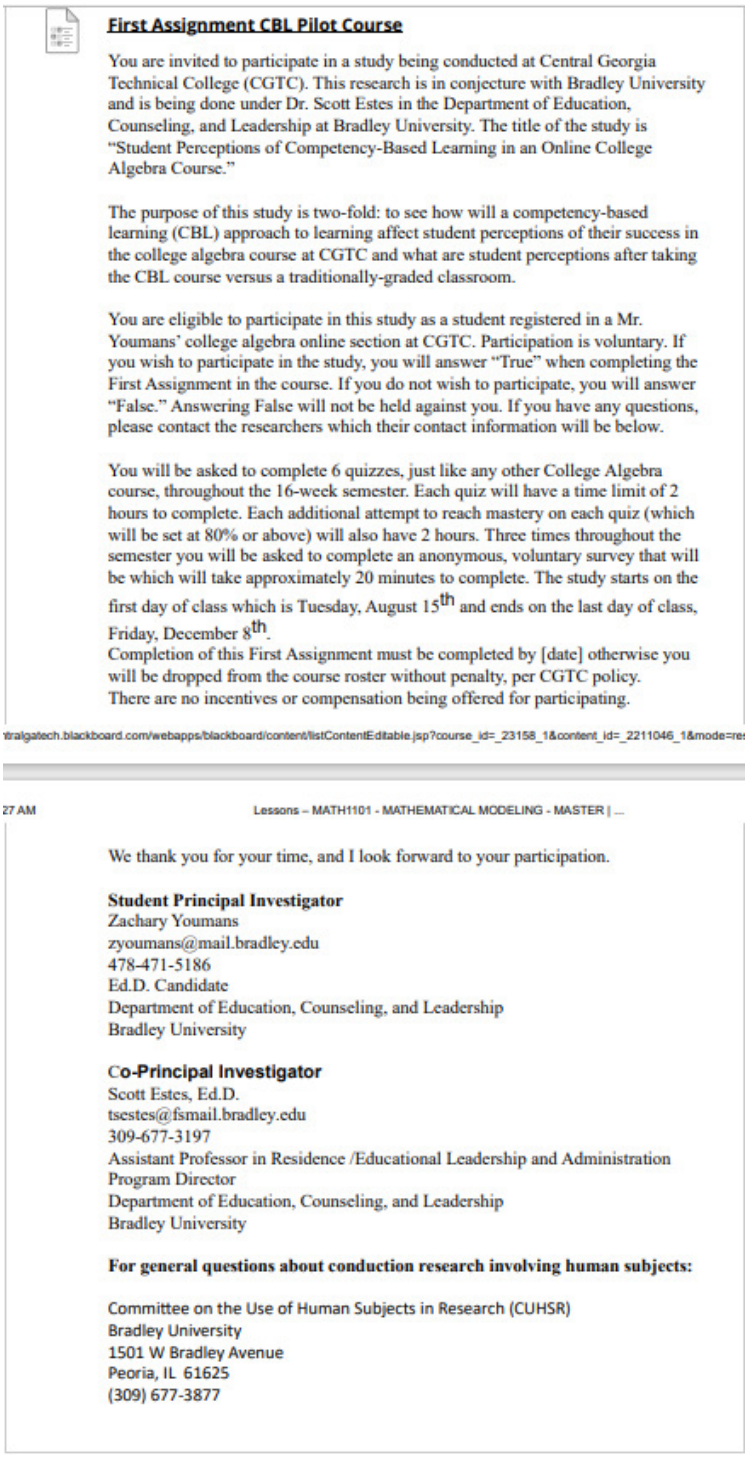
Co-Principal Investigator
Scott Estes, Ed.D.
tsestes@fsmail.bradley.edu
309-677-3197
Assistant Professor in Residence /Educational Leadership and Administration Program Director
Department of Education, Counseling, and Leadership
Bradley University

For general questions about conduction research involving human subjects:

Committee on the Use of Human Subjects in Research (CUHSR)
Bradley University
1501 W Bradley Avenue
Peoria, IL 61625
(309) 677-3877

APPENDIX B

INFORMED CONSENT



First Assignment CBL Pilot Course

You are invited to participate in a study being conducted at Central Georgia Technical College (CGTC). This research is in conjecture with Bradley University and is being done under Dr. Scott Estes in the Department of Education, Counseling, and Leadership at Bradley University. The title of the study is "Student Perceptions of Competency-Based Learning in an Online College Algebra Course."

The purpose of this study is two-fold: to see how will a competency-based learning (CBL) approach to learning affect student perceptions of their success in the college algebra course at CGTC and what are student perceptions after taking the CBL course versus a traditionally-graded classroom.

You are eligible to participate in this study as a student registered in a Mr. Youmans' college algebra online section at CGTC. Participation is voluntary. If you wish to participate in the study, you will answer "True" when completing the First Assignment in the course. If you do not wish to participate, you will answer "False." Answering False will not be held against you. If you have any questions, please contact the researchers which their contact information will be below.

You will be asked to complete 6 quizzes, just like any other College Algebra course, throughout the 16-week semester. Each quiz will have a time limit of 2 hours to complete. Each additional attempt to reach mastery on each quiz (which will be set at 80% or above) will also have 2 hours. Three times throughout the semester you will be asked to complete an anonymous, voluntary survey that will be which will take approximately 20 minutes to complete. The study starts on the first day of class which is Tuesday, August 15th and ends on the last day of class, Friday, December 8th.
Completion of this First Assignment must be completed by [date] otherwise you will be dropped from the course roster without penalty, per CGTC policy.
There are no incentives or compensation being offered for participating.

We thank you for your time, and I look forward to your participation.

Student Principal Investigator
Zachary Youmans
zyoumans@mail.bradley.edu
478-471-5186
Ed.D. Candidate
Department of Education, Counseling, and Leadership
Bradley University

Co-Principal Investigator
Scott Estes, Ed.D.
tsestes@fsmail.bradley.edu
309-677-3197
Assistant Professor in Residence /Educational Leadership and Administration Program Director
Department of Education, Counseling, and Leadership
Bradley University

For general questions about conduction research involving human subjects:

Committee on the Use of Human Subjects in Research (CUHSR)
Bradley University
1501 W Bradley Avenue
Peoria, IL 61625
(309) 677-3877

APPENDIX C

BEGINNING-OF-THE-SEMESTER SURVEY

Competency-Based Learning Beginning Survey

Your instructor, Zachary Youmans, is an Ed.D. candidate at Bradley University working under Dr. Scott Estes in the Education, Counseling, and Leadership Department. The goal of the study is to two-fold: to see how will a competency-based learning (CBL) approach to learning affect student perceptions on their success rates in the college algebra course and what are student perceptions after taking the CBL course versus what they think of as a traditionally graded classroom.

Completion of this survey will take approximately 20 minutes. This survey is only being taken by students in Mr. Youmans' college algebra courses and your participation in this survey is completely anonymous and voluntary. In no way will your completion of this survey affect your grade in the course. If identifying information in a short-answer section is given, your answer will either not be published or redacted so that the identifying information is not shown.

We greatly appreciate your time and effort in completing this survey. If you would like more information on the study, please feel free to contact your instructor, Zachary Youmans, at zyoumans@mail.bradley.edu, or the principal investigator, Dr. Scott Estes, at tsestes@fsmail.bradley.edu

Student Principal Investigator
Zachary Youmans
zyoumans@mail.bradley.edu
Ed.D. Candidate
Department of Education, Counseling, and Leadership
Bradley University

Co-Principal Investigator
Scott Estes, Ed.D.
tsestes@fsmail.bradley.edu
Assistant Professor in Residence /Educational Leadership and Administration Program Director
Department of Education, Counseling, and Leadership
Bradley University

* Required

1. Please state your age *

Mark only one oval.

- ◯ 18-25
- ◯ 25-35
- ◯ 35-45
- ◯ 45-55
- ◯ 55+

2. Please state your gender. *

Mark only one oval.

- ◯ Male
- ◯ Female
- ◯ Prefer not to say

3. How long has it been since you have taken a mathematics course? *

Mark only one oval.

- ◯ Less than 1 year
- ◯ Between 1 and 5 years
- ◯ Between 5 and 10 years
- ◯ Longer than 10 years
- ◯ Other: _____

4. Do you feel that the length in time since you have taken a mathematics course has affected your chance to succeed in this course? Please rate your feeling from 1 being that it did not affect your chance to succeed to 4 being it affected your chances greatly. *

Mark only one oval.

Did not affect

1 ◯

2 ◯

3 ◯

4 ◯

Greatly affected

5. Math anxiety is defined to be the feeling that one cannot perform efficiently in situations that involve the use of mathematics. When registering for College Algebra, were you anxious over the fact of having to take a mathematics course? Rate your feeling of anxiousness when entering the course on a scale of 1 being the least anxious and 4 being the most anxious. *

Mark only one oval.

Less anxious

1 ◯

2 ◯

3 ◯

4 ◯

More anxious

6. Competency-based learning (CBL) an approach to learning that emphasizes mastery of content. Please describe your initial thoughts on CBL as described to you via the syllabus and the informed consent document read in the First Assignment. *

7. Do you feel as if you will be more successful or less successful because of the implementation of CBL in this class? Please rate your feeling of successful with 1 being the least successful and 5 being the most successful. *

Mark only one oval.

	Least successful
1	◯
2	◯
3	◯
4	◯
5	◯
	Most successful

8. Why do you feel you will be more or less successful? *

9. If any, please describe other obstacles you think will prevent you from being successful in the course.

APPENDIX D

MIDTERM SURVEY

Competency-Based Learning Mid-Semester Survey

Your instructor, Zachary Youmans, is an Ed.D. candidate at Bradley University working under Dr. Scott Estes in the Education, Counseling, and Leadership Department. The goal of the study is to two-fold: to see how will a competency-based learning (CBL) approach to learning affect student perceptions on their success rates in the college algebra course and what are student perceptions after taking the CBL course versus what they think of as a traditionally graded classroom.

Completion of this survey will take approximately 20 minutes. This survey is only being taken by students in Mr. Youmans' college algebra courses and your participation in this survey is completely anonymous and voluntary. In no way will your completion of this survey affect your grade in the course. If identifying information in a short-answer section is given, your answer will either not be published or redacted so that the identifying information is not shown.

We greatly appreciate your time and effort in completing this survey. If you would like more information on the study, please feel free to contact your instructor, Zachary Youmans, at zyoumans@mail.bradley.edu, or the principal investigator, Dr. Scott Estes, at tsestes@fsmail.bradley.edu

Student Principal Investigator
Zachary Youmans
zyoumans@mail.bradley.edu
Ed.D. Candidate
Department of Education, Counseling, and Leadership
Bradley University

Co-Principal Investigator
Scott Estes, Ed.D.
tsestes@fsmail.bradley.edu
Assistant Professor in Residence /Educational Leadership and Administration Program Director
Department of Education, Counseling, and Leadership
Bradley University

1. Please state your age. *

   Mark only one oval.

   - ◯ 18-25
   - ◯ 25-35
   - ◯ 35-45
   - ◯ 45-55
   - ◯ 55+

2. Please state your gender. *

   Mark only one oval.

   - ◯ Male
   - ◯ Female
   - ◯ Prefer not to say

3. Now that we are at midterms, what are your current thoughts about the competency-based learning (CBL) approach we are taking to quizzes? *

_____

_____

_____

_____

_____

4. Has the CBL approach to quizzes eased your anxiety coming into the class? Please rate your feeling of anxiety from 1 being that the approach has not eased your anxiety to 4 being it has greatly eased your anxiety *

Mark only one oval.

Not eased anxiety

1 ◯

2 ◯

3 ◯

4 ◯

Greatly eased anxiety

5. Please give an explanation on your answer above to whether or not the approach has eased your anxiety. *

6. At this point in the semester, do you feel as if you have been more successful or less successful because of the implementation of CBL? Please rate your feeling of successfulness on a scale from 1 to 4, with 1 being the least successful and 4 being the most successful. *

Mark only one oval.

Least successful

1 ◯

2 ◯

3 ◯

4 ◯

Most successful

7. Why do you feel more or less successful? *

APPENDIX E

FINAL SURVEY

Competency-Based Learning End-of-the-Semester Survey

Your instructor, Zachary Youmans, is an Ed.D. candidate at Bradley University working under Dr. Scott Estes in the Education, Counseling, and Leadership Department. The goal of the study is to two-fold: to see how will a competency-based learning (CBL) approach to learning affect student perceptions on their success rates in the college algebra course and what are student perceptions after taking the CBL course versus what they think of as a traditionally graded classroom.

Completion of this survey will take approximately 20 minutes. This survey is only being taken by students in Mr. Youmans' college algebra courses and your participation in this survey is completely anonymous and voluntary. In no way will your completion of this survey affect your grade in the course. If identifying information in a short-answer section is given, your answer will either not be published or redacted so that the identifying information is not shown.

We greatly appreciate your time and effort in completing this survey. If you would like more information on the study, please feel free to contact your instructor, Zachary Youmans, at zyoumans@mail.bradley.edu, or the principal investigator, Dr. Scott Estes, at tsestes@fsmail.bradley.edu

Student Principal Investigator
Zachary Youmans
zyoumans@mail.bradley.edu
Ed.D. Candidate
Department of Education, Counseling, and Leadership
Bradley University

Co-Principal Investigator
Scott Estes, Ed.D.
tsestes@fsmail.bradley.edu
Assistant Professor in Residence /Educational Leadership and Administration Program Director
Department of Education, Counseling, and Leadership
Bradley University

* Required

1. Please state your age. *

   Mark only one oval.

   - ◯ 18-25
   - ◯ 25-35
   - ◯ 35-45
   - ◯ 45-55
   - ◯ 55+

2. Please state your gender. *

   Mark only one oval.

   - ◯ Male
   - ◯ Female
   - ◯ Prefer not to say

3. Competency-based learning is a strategy that was used for administering quizzes during the college algebra course. The approach emphasized mastery of the subject matter rather than a more traditional-approach of taking an exam for a certain amount of points. Before taking this college algebra course, have you ever experienced competency-based learning in the past? *

   Mark only one oval.

   - ◯ Yes, during high school.
   - ◯ Yes, in another college class.
   - ◯ No, I have not experienced CBL before.

4. After learning about how quizzes would be structured, was your feeling of anxiousness eased? Please rate your feeling of anxiousness when learning about the quiz structure on a scale of 1 being less anxious and 4 being more anxious. *

Mark only one oval.

Less anxious

1 ◯

2 ◯

3 ◯

4 ◯

More anxious

5. After completing the course, do you feel that the competency-based approach to quizzes eased your math anxiety? Please rate on a scale of 1 to 4 with 1 being it did not ease your math anxiety and 4 being the CBL approach helped extremely in your math anxiety. *

Mark only one oval.

Did not help

1 ◯

2 ◯

3 ◯

4 ◯

Extremely helped

6. Please give your thoughts on how the CBL approach eased your anxiety. *

7. Ultimately, would you have preferred a more standard approach to the quizzes that CGTC offers where 2 attempts are given on the quizzes and the highest attempt of the two is recorded in the gradebook? Or, did you prefer the CBL approach of trying to reach proficiency (80%) in each topic in the class by having as many attempts as needed? *

Mark only one oval.

- ◯ I prefer the traditional-approach.
- ◯ I prefer the competency-based approach.

8. Please provide a written response on why you prefer the traditional-approach or the competency-based approach. *

9. Do you feel that you were more successful in this class because of CBL? *

Mark only one oval.

- ◯ Yes
- ◯ No

10. Why do you feel that you were either more successful or less successful? *

11. Are there any other comments, concerns, or suggestions you would like to add?