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THE EFFECTS OF A MATHEMATICAL LITERACY COURSE ON ATTITUDES TOWARD MATHEMATICS: A COMMUNITY COLLEGE STUDY

by

Serine Ndiaye

Dissertation Committee:

Professor J. Philip Smith, Sponsor
Professor Erica Walker

Approved by the Committee on
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ABSTRACT

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Serine Ndiaye

As the high failure rate in developmental mathematics remains a national concern (Bonham et al., 2011), community colleges have begun experimenting with alternative delivery and design for remedial mathematics sequences. One approach was to implement mathematical literacy in their program, focusing on quantitative reasoning. *Mathematical Literacy* is an individual's ability to formulate situations and reason mathematically, employ mathematical tools, concepts and procedures as well as to explain, apply and evaluate mathematical results (OECD, 2017).

The intent of this study was to observe and evaluate learner attitudes regarding mathematics in a community college mathematical literacy course.

Two groups of students from two different courses were part of the study; one group was in a mathematical literacy course and another group in an elementary algebra course.

To measure students' growth in self-confidence and in the perceived value and usefulness of mathematics, quantitative data were collected with an anonymous pre- and post-mathematics attitudes survey from the mathematical literacy course and the elementary algebra course. In addition, qualitative data were gathered with an open-ended question administered to participants in the mathematical literacy sections during the last week of the semester to offer richer insights into the findings from the attitude survey.

Findings from the quantitative data revealed statistically significant effects for participants in the mathematical literacy course compared to their counterparts in the elementary algebra course in the area of attitudes regarding the perceived value and usefulness of mathematics, real-world problems, working in groups, as well as using computers in mathematics courses. Qualitative data were aligned with the findings from the quantitative data and indicated participants' positive views on working in groups, the usefulness of the mathematical literacy course, and improvement of their attitudes regarding mathematics thanks to the course. The study suggested further research to improve our understandings of mathematical literacy and its impact.

DEDICATION

My dissertation is dedicated to the followings:

Allah for giving me the courage, the power and possibility to make this happen.

My parents Serigne Amidou Ndiaye and Fatou Dame Ndiaye.

My grandmother Fatou Niang Ndiaye.

My oncle Alioune Ndiaye and wife Ndeye Ba.

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INTRODUCTION

Need for the Study

The study aims to investigate how a mathematical literacy course affects learners' attitudes regarding mathematics. The phrase "mathematical literacy" refers to "An aggregate of skills, knowledge, beliefs, dispositions, habits of mind, communication capabilities, and problem solving skills that people need in order to engage effectively in quantitative situations arising in life and work" (Alsina, 2002, p. 240). The literature uses other phrases such as mathematical proficiency, numeracy, quantitative literacy, as well as mathematical competence (Kilpatrick, 2001). While different education systems use each phrase differently, others use them interchangeably. For instance, in the United Kingdom and Australia, the term "numeracy" (Stacey, 2010) is preferred, while in United States, the expression "quantitative literacy" (Steen, 2001a) is used. In this study, "mathematical literacy" is used to represent all these phrases. Other authors, like Steen (2001a), define mathematical literacy in term of its relationship to real-world situations. Mathematical literacy requires learners to use the basic mathematical skills in analyzing problems in real-life (Ojose, 2011). According to Gillman (2004), mathematical literacy is "the ability to adequately use elementary mathematical tools to interpret and manipulate quantitative data and ideas that arise in an individual's private, civic, and work life" (p. 5). The Organization for Economic Co-operation and Development (OECD, 2003) defined mathematical literacy as follows:

> Mathematical literacy is an individual's capacity to identify and understand the role that mathematics plays in the world to make well founded judgements and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen. (p. 24)

To better understand the importance of mathematical literacy, it would be useful to examine the characteristics of a mathematically literate person. Along with a positive disposition toward a serviceable knowledge of mathematics, a mathematically literate person is able to gather meaningful information from a problem, compute the mathematics, check whether the solutions make sense and are generalizable, and reflect on the results (Madison & Steen, 2009). The mathematically literate person is able to understand the quantitative elements of daily situations, including the skills to read and understand everyday newspapers (Trefil, 2008; Watson, 2004). In defining mathematical literacy, mathematics educators such as Kilpatrick (2001) emphasize competences or proficiencies, whereas Ojose (2001) focuses on knowledge and skills. The National Research Council (NRC, 2012) declared that the importance of knowledge can be transferred to novel situations, and many competences in the 21st century, such as critical thinking, problem solving, decision making, communication, media literacy, and information literacy, are directly related to mathematical literacy. A mathematically literate person is able to face authentic quantitative situations with skill and confidence.

The need for mathematical literacy was established in reports from the American Mathematical Association of Two-Year College (AMATYC) and the Mathematical Association of America (MAA) (Briggs, Sullivan, & Handelsman, 2004), and national focus groups such as the National Numeracy Network (NNN) and Special Interest Group of the MAA on Quantitative Literacy (SIGMAA-QL) (Gillman, 2004). Mathematical literacy leads to social changes (Moses & Cobb, 2001) and is necessary for personal, social, and economic well-being (OECD, 2003), as well as for personal and national empowerment (Skovsmose, 1994). According to Schoenfeld (2002), "Mathematical Literacy should be a goal for all students" (p. 13). Supporting Moses's ideas (1994) who stated that “the ongoing struggle for citizenship and equality for minority people is now linked to an issue of mathematics literacy” (p. 107), Schoenfeld equated mathematical literacy to a different way of civil rights.

Mathematics Illiteracy, a National Concern

The National Council of Teachers of Mathematics (NCTM, 2000) reflected concerns that learners in America are not mathematically literate and often are incapable of connecting the mathematics learned in class to real-life situations. Reports revealed that only “13 percent of adults are deemed proficient in quantitative literacy, 33 percent perform at intermediate levels, 33 percent at basic levels, and 22 percent are below basic” (Kutner et al., 2007). In the 2015 Program International Students Assessment (PISA) reports about performance in mathematics literacy, the United States average was smaller than in more than 50% of the other education systems (36 of 69) as well as the Organization Economic Cooperation Development (OECD) average (OECD, 2016). In 2015, the rate of United States 15-year-olds performing in mathematical literacy at proficiency levels greater or equal 5 was only 6%, lower than the rate in 36 countries. (OECD, 2016). The report revealed that the rate of United States lower performers was greater than in more than 50% of the other countries. According to D’Ambrosio (1999), learners taking mathematics lessons should ask questions, make assumptions, collect and manipulate information, make conclusions, assess the practicability of a solution, ascertain the generalizability of a solution, and make additional inquiries. He uses the term “matheracy” to refer to such skills.

In most mathematics classes, instructors lack a research-based curriculum design and are unfamiliar with pedagogical aspects that help in nurturing better learning and commitment from the learners (Mesa, 2011). Knowledge transmission was the preference in traditional developmental mathematics courses as compared to a hands-on approach

(Edwards, Sandoval, & McNamara, 2015). Consequently, the learners are unable to perform critical analysis on numerical information.

High Failure Remedial Mathematics, a Growing Concern

The role played by community colleges is important in supporting higher education in America. Statistics from the American Association of Community Colleges (2008) revealed that around 46% of students at the undergraduate level in America pass through two-year community colleges. The basic step for a learner is to choose a suitable program to major in. It is common for learners to fail at this step, frequently because they never completed the remediation programs. A total of 222,000 learners enrolled for a remedial mathematics program at some four-year institutions in 1995; ten years later, the number of students had reduced to 201,000, but in 2010, the number rose to 334,000. The total number of learners enrolled for a remedial mathematics program in a two-year institution was 799,000 in 1995. In 2005, the number had risen to 964,000, and in 2010, there were 1,150,000 students (Blair, Kirkman, & Maxwell, 2013; Lutzer, Rodi, Kirkman, & Maxwell, 2007). These statistics tell us that the number of students enrolled for the remedial mathematics programs in two-year community colleges is about four times the number of those enrolling in other institutions.

The rate of failure amongst students in these programs is very high (Bailey, Jeong, & Cho, 2010; George, 2010; Howell, 2011). Only 38% of students across community colleges at the City University of New York (Office of Institutional Research and Assessment, 2015), or 44% of developmental mathematics students (Mejia, Rodriguez, & Johnson, 2016) complete the developmental mathematics programs, and the probability of such learners finishing their degree programs is very low (Bailey, 2009). According to Mejia et al. (2016), only 27% of learners who enroll in a developmental mathematics course eventually complete a college mathematics course with a grade of “C” or better. This high failure rate in remedial mathematics education costs $435 to $543 million per year to colleges and universities (Howell, 2011). For learners enrolling in a two-year public college in the U.S., around 68% have to take at least one mathematics remedial course before entering college-level mathematics, and 28% of those students graduate within 8 years (Jaggars & Stacey, 2014). This is equivalent to an average of 10 credit hours of remedial college mathematics (Bonham & Boylan, 2011). Of this number, the percentage of learners who successfully complete the programs is 62%, and the percentage of learners who complete remediation and other two-year programs offered in college is 22.3%. The path followed by learners into programs of study is usually affected by the traditional remediation programs. Learners often fail to progress into their programs of study as freshmen. A report from CUNY's Office of Institutional Research and Assessment (2015) revealed that in fall 2014, 76% of new freshmen students at New York City public community colleges were placed into developmental mathematics. Graduation rates among the learners are highly affected by the ability to complete mathematics remediation programs successfully (Complete College America, 2011).

To improve developmental mathematics education, the Carnegie Foundation sponsored and piloted the QuantWay program in 2011-2012 by choosing a small group of community colleges where:

> students will focus on understanding and applying the mathematical concepts needed to facilitate their quantitative literacy rather than memorizing seemingly disconnected processes and procedures, as is often the case now. In this non-STEM (science, technology, engineering, mathematics) pathway, students who place into elementary algebra will go to and through a college level quantitative reasoning course in one year. Students will use numerical reasoning for decision-making, argumentation and sense making about real world questions, problems and contexts of personal, social and global importance. (Carnegie Foundation, n.d.)

To address these major problems and help learners experience success when taking traditional remedial mathematics, many community colleges' developmental mathematics programs are facing reforms and redesigns to improve their curriculum and instruction. Most of the community colleges offering remediation programs use teaching methods like traditional lecturing characterized by rote learning and “a passive, rigid, and routine knowledge transmission” (Heather et al., 2002, p. 70) to equip the learners with basic skills. This may partly be the reason why many learners fail to complete the remediation programs. Such methods are ineffective for promoting active learning and engagement with the presented subject matter (Bligh, 2002; Curtis, 2006).

Community colleges have now begun shifting from the traditional remedial programs due to poor learner performance. Alternative delivery and design for the developmental programs are being introduced and tested in the community colleges in order to tackle student needs differently and to allow more learners to complete the remedial programs successfully. An example of the new approaches is to give the learners a chance to progress in case they demonstrate some level of proficiency in specific mathematics areas. Such an act would motivate the learner, save on time and money, and also improve the pass rates in a particular course. Another alternative for addressing the non-completion problem in college mathematics is to involve a mathematical literacy program focusing on quantitative reasoning.

For instance, the Department of Education of Arkansas added Mathematical Literacy to its program as an alternative to college algebra courses for non-STEM majors. Similarly, Borough of Manhattan Community College includes Mathematics Literacy in its program, which can be taken by learners as an alternative to remedial algebra for non-STEM majors.

Attitudes Regarding Mathematics

Attitude toward mathematics is defined by Haladyna, Shaughnessy, and Shaughnessy (1983) as a “general emotional disposition toward the school subject of mathematics” (p. 20). The authors distinguished this definition from “attitudes towards the field of mathematics, or towards some specific area within mathematics” (p. 20). They declared that positive attitudes about mathematics are important because students with positive attitudes tend to choose further mathematics courses or enter mathematical careers.

According to Karaçalli and Korur (2014), attitude is defined as "someone's tendency to consider an object, a case, and a person in a positive or negative manner" (p. 225). Pyzdrowski et al. (2013) declared, "Attitude can be thought of as beliefs with an added value laden or evaluative dimensions" (p. 532).

Many researchers and mathematics educators have reported a growth of negative attitudes regarding mathematics in students the longer they are in school.

> Student attitudes towards mathematics have been the focus of literature and research for decades. When students are in younger grades, they find mathematics enjoyable. However, as learners progress through grade levels, their interest in mathematics begins to decline. By the time they reach college, few students pursue a mathematics degree. Others take mathematics course only because it is a requirement to graduate from college. (Curtis, 2006, p. 147)

According to Tapia (1996), "declining national test scores in mathematics and dislike of mathematics have increased attention to students' attitudes since these attitudes are important in the students' achievement and performance" (p. 8). Pyzdrowski et al. (2013) stated, "Negative attitudes towards mathematics are quite common among Americans, with 93 percent indicating they experience some kind of negative attitudes toward learning mathematics" (p. 542).

Students' negative attitudes regarding mathematics have been blamed as one of the causes for the low achievement and decreasing national and international test scores of learners. According to Edwards and Rules (2013), "attitudes are particularly important because they carry a mental state of readiness, directing the learner's attention through the educational experience and thereby affecting learning outcomes" (p. 57). A study conducted by Karaçalli and Korur (2014) revealed that "students' achievement increases by increasing their desire to learn sciences" (p. 225). According to Kargar, Tarmizi, and Bayat (2010), positive attitudes motivate learners to put extra effort into their courses while reasoning mathematically as well as understanding the content. A positive correlation exists between performance in mathematics and students' attitudes regarding mathematics (Ho et al., 2000). According to Tapia (1996), "research has indicated that attitudes towards mathematics are very important in the achievement and participation of students in mathematics" (p. 5).

By attempting to investigate the main causes of such negative attitudes, teaching methods and curriculum were the primary items to pay attention to. In this modern world characterized by sophisticated technology, a traditional curriculum is not responding to learners' needs. Traditional teaching methods and curriculum are not fulfilling learners' needs (Curtis, 2006). Curtis called for modifying the ways instructors teach mathematics from modeling procedures and expecting learners to memorize and copy their methods to assist students in building their knowledge of the concepts using reasoning. Chang (2010) stated, "Repeatedly showing students what we want them to know will not automatically help students to translate the knowledge into their own" (p. 247). According to Alsup (2005), "teachers cannot transmit mathematical knowledge directly to students, but students construct it by resolving situations they find problematic" (p. 3).

The call for innovation has been focused on using real-world problems through reasoning to teach various mathematical concepts. Fennema et al. (1996) declared, "The gains in students' concepts and problem-solving performance appeared to be directly related to changes in teachers' instruction" (p. 430). Solving real-world problems has the potential of making mathematical concepts relevant to students and helping them construct their knowledge in a way that cannot be achieved through a more traditional approach. In his research on freshmen learners in colleges, Walmsey (2000) found that negative attitudes may be improved by the following:

- Provide extra supports in terms of computer or tutors
- Use students centered approaches in the classroom
- Incorporated applications when teaching to emphasize relevance. (p. 49)

Purpose

The intent of conducting this study was to observe and evaluate learner attitudes regarding mathematics in a community college mathematical literacy course. This study sought to answer the following research questions.

1. How are attitude toward self-confidence and ability of doing mathematics, as well as the value and usefulness of mathematics, affected by taking a mathematical literacy course?
2. What are the views of students concerning their experiences in a community college mathematical literacy course?

Procedure of the Study

The research was conducted in an accredited two-year public college in the greater New York City area. To evaluate the effects of a mathematical literacy course on students ‘attitudes, two groups of students were surveyed, one group from a mathematical literacy class and another group from an algebra class. A total of 79 students responded to the pre-survey, and a total of 68 responded to the post-survey.

A mixed-methods study was selected to address the research questions of this study. A convergent mixed approach design was utilized, which is “a kind of design in which both quantitative and qualitative data are collected simultaneously, analyzed separately and then merged” (Creswell, 2018, p. 18).

During the first and last week of the 2017 fall semester, a survey of 14 questions (Appendix A) was administered to students in the mathematical literacy and elementary algebra course. One of the purposes of the survey was to earn some insight into the change of student attitudes regarding mathematics. Items 1 through 5 measured the value and usefulness of mathematics, while items 6 through 10 measured mathematics self-confidence. Items 11 through 14 on the mathematics attitude survey were of particular importance to mathematical literacy and were added to measure student attitudes toward enjoying real-life world problems, group work, using computers, and finally, a willingness to take further mathematics courses. In addition, an open-ended survey of five questions (shown in Appendix D) was given to students after completing the mathematical literacy course.

To answer question 1, the pre- and-post-surveys were given to students to examine if any relationship existed between the mathematical literacy course and student growth in mathematics self-confidence, and between the mathematical literacy course and student growth in the perceived value and usefulness of mathematics. The value and usefulness of mathematics and mathematics self-confidence subscales included five items each. A composite score was calculated as the total of the five items and could range from 5 to 25, with larger scores indicating a more positive attitude.

All subsequent analyses about the mathematics attitude surveys were conducted using a descriptive statistic, SSPS and t-tests (Creswell, 2018). To answer research question 2, open-ended survey questions were given to students after the mathematical literacy course. Responses were coded as useful, not useful, or neutral for usefulness of working in groups, as yes, no, or blank for students' attitudes toward the mathematical literacy course, and were coded as indicative of a positive change, a negative change, or no real change for students' attitudes toward mathematics.

The reason for collecting both quantitative and qualitative data was to merge quantitative measures with qualitative experiences to show how the data converge or diverge for the possibility of providing both breadth and depth of understanding and corroboration (Creswell, 2018).

Significance of the Study

Researching the topic of mathematical literacy is of importance to administrators, instructors, and researchers because of the low completion rates in college-level mathematics and remedial mathematics education. This study of mathematical literacy is important, as it may inform community college developmental mathematics programs and instructors about the value of incorporating mathematical literacy courses into instructional practices for addressing the non-completion problem in college mathematics. This study will provide additional evidence to the literature that teaching mathematical literacy improves students' attitudes.

In addition, this study advances the literature because the mathematics education system will earn insight into ways that might enhance the teaching outcomes and learning outcomes. The in-depth open-ended questions will clarify students' point of views regarding mathematics, provide deeper insight into students' responses to the pedagogy of the mathematical literacy course and will propose ways that instructors in colleges can improve learners' performance and attitudes regarding mathematics. This study will fill a gap by being one of a few that utilizes a mixed-methods approach that provides a more in-depth understanding of the effects of mathematical literacy on students' attitudes regarding mathematics.

Finally, this study could affect pedagogy in the sense that instructional strategies proposed by the literature will be updated.

Organization of the Report

This report consists of five chapters. The need for the study, purpose, and research questions have been presented in Chapter I. A comprehensive analysis of the literature available is presented in Chapter II. Chapter III contains details about the overview of the pedagogy of the mathematical literacy course, the setting, the survey, and data collection.

In Chapter IV, the outcomes and deliberations on the findings from the data gathered and questionnaires are explained. Finally, Chapter V presents the summary, conclusions, and recommendations.

Chapter II

LITERATURE REVIEW

This literature seeks to examine previous research regarding mathematical literacy by evaluating the extent to which the various curricula of mathematics have not been successful in addressing students' difficulties with mathematics. Moreover, this study will draw out benefits and challenges of a pedagogy that mainly concentrates on mathematical literacy and discuss the relationship between mathematical literacy and student attitude.

To achieve its objective, this chapter will focus mainly on the role of community colleges, perceived challenges within the current mathematics educational system, define mathematical literacy as a curriculum reform, and describe theories in mathematics education applied to mathematical literacy. Lastly, this chapter will provide a description of previous studies that have implemented different mathematical literacy initiatives in community colleges.

Community Colleges' Role

Community colleges are an essential part of United States higher education and, in the fall of 2015, served nearly 7 million out of 17 million of the undergraduate learners in two-year colleges (Ginder, Kelly-Reid, & Mann, 2017). According to Maricopa Community Colleges (2017), the enrollment in community college is projected to reach nearly 9 million by the year 2026. Because of their flexibility, affordability, and accessibility, community colleges provide higher education options to "under-served, and dis-advantaged students, working adults, and students with family or employment responsibilities, enabling them to achieve their educational goals" (p. 4). Besides providing certificates and degrees of quality, community colleges also prepare learners for their pathway to success or transfer to a four-year college. According to Ginder et al. (2017), 39.6% of all students who started at four-year colleges in fall 2008 transferred to four-year or two-year institutions within six years.

In 2015, 24% of Hispanic learners, 14% of Black/Non-Hispanic learners, 45% of White/Non-Hispanic learners, 7% of Native/Pacific learners, and 10 % of others who were in higher education attended a two-year community college (American Association of Community Colleges, 2017).

Many learners in the two-year community colleges have not been historically represented in STEM (Blair et al., 2013; National Student Clearinghouse, 2017) and are more likely to face many barriers for success. The American Mathematical Association of America (2016) indicated that 57% of students in two-year community colleges in America were women, 36% were the first generation in the family to attend college, 17% were students with disabilities, and 12% were single parents. In addition, many learners in community colleges work and study at the same time: 63% of students (full-time and part-time) work full-time, while 72% of leaners (part-time and full time) work part-time.

Community college faculty represent a significant proportion of the overall faculty in higher education. A report from the NCES (2015b) indicated that faculty who taught at community colleges in 2013 represented 24% of all higher education, of which 20% were full-time in two-year public community colleges. Of all higher education faculty, 37% were part-time faculty, and about 70% of those were community college faculty. Approximately, 67% of full-time faculty in public two-year community colleges have a master`s degree, while 33% have a doctoral degree.

Challenges with the Mathematics Education System

In his article regarding developmental mathematics courses, “Why our Kids Hate Math,” Welsh (2012) stated that it is the fault of the school and parents that children do not like mathematics as a school subject. The author asserted this is because they push the children to advanced stages of mathematics when still at a very young age. Algebra serves as a gatekeeper in United States that ends up locking out a majority of the students and thus reducing the potential workforce (Martin, Gholson, & Leonard, 2011; Rech & Harrington, 2000; Usiskin, 2004). Usiskin (2004) argues that without a knowledge in algebra, one cannot attend any college that has any selectivity, do many jobs, or even enter many jobs training programs. According to Bryk and Treisman (2010), rather than a gatekeeper, mathematics should be a gateway in order for college education to be successful. Learners must see mathematics as a fundamental element of their daily lives, regardless of their major. Additionally, Garfunkel and Mumford (2011) reported that the current abstract curriculum is not ideal since “different sets of mathematical skills are vital for different careers, and our mathematics curriculum should be changed to reflect this fact” (p. 27). Because most people do not understand the concepts of algebra, calculus, and geometry in their day to day lives, it is the recommendation of the authors that more concentration should be put on the relevant problems but with a more contextual approach. All these authors are concerned about the effectiveness as well as the relevance of mathematics curricula.

To better understand this notion, it would be helpful to acknowledge the societal role played by mathematics education in the past. Cohen (2001) has argued that current mathematics courses are very similar to the curriculum that was developed in the 1820s. Over the past two centuries, the demands for active participation in society have changed significantly, and over the past two decades much information has become available at just the click of a mouse. Therefore, the largely static curriculum is a major challenge. It is essential that students make use of quantitative reasoning to understand various issues such as business decisions, finances, environmental monitoring, and even politics (Steen, 2001a). If there is no meaningful change in the mathematics curriculum, the "increasing sophistication of numerical argument" may continue holding the students back from "full participation in this modern style of thinking" (Cohen, 2001, p. 24). We are living in a world where politicians, businesses, and newspapers regularly utilize numerical arguments, and thus mathematics curricula must evolve to make sure that students have the skills they need to think quantitatively. In a world that is increasingly quantitative, mathematics education has a very important role to play. However, if it cannot adapt, then many students will be lacking the vital skills they need to actively contribute to society.

Traditional teaching can slow down the ability of the student to be knowledgeable in mathematics (Curtis, 2006; Hughes-Hallett, 2003). In this regard, poor teaching habits encourage and train students to use algorithms rather than construct deeper meaning. This results in the students memorizing common types of mathematics problems, which is not beneficial in the long run. Textbooks used in the classroom exacerbate this issue since they have worked-out solutions for all types of problems, and thus students rarely encounter a novel situation. The dependency on bad word problems is actually dangerous (Allen, 2011), because they are presented as real-life situations while they are just meaningless (Schoenfeld, 2001; Usiskin, 2001). Since students may see algebra in only "sanitized template exercises" (Madison & Steen, 2009, p. 5), they may not exercise their good judgment when faced with real-world problems.

Alsina (2002) referred to research conducted by Lieven Verscheffel, who discovered that students are faced with "suspension of sense making during mathematics modeling as well as during problem solving" (p. 4). In brief, students lose their ability to employ common sense in the process of solving real-life problems in the classroom. Unambiguous template problems leave little room for interpretation or reflection and therefore are unable to give the student the necessary preparation to reason in the real-world (Madison, 2006).

Schoenfeld (1990) deplored such practice because learning to solve such problems may teach students that mathematics problems are unrealistic (p. 324). Additionally, he stated that there is a lot of "non-reasoning" in school mathematics because reasoning in school differs from that in real situations (p. 324). These shortcomings are very disturbing, especially when it comes to their potential impact on the attitude and achievement of students.

Consequences of Curricular Shortcomings

Studies mainly focus on three key effects of the shortcomings in mathematics education: poor overall performance and skills, poor habits and attitudes, and inability to transfer knowledge to new situations.

National data from sources such as the Program for International Students Assessment (PISA) and the Trend in International Mathematics and Sciences Study (TIMSS) provide important feedback to understand and evaluate the performance of students in United States compared those in other countries. The report from the National Center for Education Statistics (2015) indicated that the United States performs slightly above the international average, but lower than most developed countries (492 in 1995, 508 in 2011, and 518 in 2015). According to Hanushek, Peterson, and Woessmann (2010),

> No less than 30 of the 56 other countries that participated in the Program for International Student Assessment (PISA) mathematics tests had a larger percentage of students who scored at the international equivalent of the advanced level on our National Assessment of Education Progress (NAEP) tests. (p. 4)

Such a message indicates that students in United States still lag behind in mathematical performing. The system, rather than focusing on the depth of mathematical knowledge, focuses on procedural knowledge. Compared to the mathematical education system in Taiwan, Hong Kong, Korea, and 12 other countries that have double the rate of highly proficient mathematics students, the mathematical education system in the United States does not produce highly proficient mathematics learners (Hanushek et al., 2010). "In short, the percentages of high-achieving mathematics students in the U.S.—and most of its individual states—are shockingly below those of many of the world's leading industrialized nations" (p. 4).

The mathematics education system is characterized by teaching students a procedure, practicing with them a couple of times, giving them a few problems to practice on their own, and finally giving them a well-behaving problem with everything clear for them to follow the same procedure. Cavanagh (2005) declared,

> To some education experts, though the U.S. performance on the two international exams reinforced their belief that American students suffer from an inability to perform complex reasoning and mathematical assignments—the kind they are likely to encounter in college and the workforce. (p. 1)

The Common Core State Standards Initiative (2010) called for better education that prepares students for colleges and workplace and expressed concerns about the current mathematics education system:

> Research studies of mathematics education in high-performing countries have pointed to the conclusion that the mathematics curriculum in the United States must become substantially more focused and coherent in order to improve mathematics achievement in this country. (p. 3)

Other explanations have been given by various authors (for instance the inability of students to work out fractions) (Packer, 2003). According to Packer, this shortcoming should be squarely laid on the school teachers. He argued that these instructors teach student fractions in a manner not related to real-life applications. Additionally, high school students barely retain whatever they are taught in class once they are out (Madison, 2003; Steen, 2012). It is Steen's argument that the only thing the student can remember is a "pale shadow" of what was taught and what the curriculum actually states (p. 3).

In addition, Steen (2012) compared today's students with students in the 1980s, when half left high school without knowing mathematics because they were not required to take mathematics courses. The unsetting difference, though, is that in today's school, students take the courses, but they retain "little or nothing of the mathematics they have been taught" (p. 6).

In addition to shortcomings in performance and skills, learners can develop poor habits and attitudes about mathematics. For some, it is socially okay to dislike mathematics, and this societal standard has a significant impact on students (Dewdney, 1993). This discrepancy between the mathematics taught in class and real-life applications influences students' perceptions about mathematics, as they tend to see mathematics and life as entirely separate. Madison (2006) stated that "some of the habits learned and attitudes formed in mathematics classes are actually obstacles to achieving the [numerate] habit of mind" (p. 23), and a minority group of students can even have beliefs about mathematics that hinder their mathematical literacy growth (Hughes-Hallett, 2003). This detachment of mathematics from the real world negatively affects the utility of the material, and it influences the ability of students to apply information in new circumstances.

Lack of ability to transfer knowledge is another devastating result of the current educational curriculum that isolates mathematics from real-life circumstances (Hughes-Hallett, 2003). In the case where students cannot transfer information into new situations, the knowledge and skills they get will not assist them in life after school. This is especially alarming when one considers all quantitative information that people experience in the 21st century. To understand such information and reason through it in a knowledgeable way, students require transferable prior knowledge, instead of general abilities (Steen, 2012). While examining the prior knowledge of business students, Albers

(2002) found that the mathematics that is taught to students is “either insufficient or difficult to apply to the situation they face in professional settings” (p. 14). Students are not learning the skills they require, forgetting the ones they once knew, or learning things they cannot utilize in their lives after graduation. How, at that point, would we address this issue? Is there any way for the mathematics curriculum to change along with current teaching methods to ensure that citizens are well prepared for the quantitative demands of daily life?

The PISA 2015 Framework and Mathematical Literacy

The main purpose of the 2015 Program for International Student Assessment (PISA) framework regarding mathematical literacy is to develop trends indicating the effectiveness of countries preparing their learners “to use mathematics in each aspect of their personal, civic and professional lives as well as their constructive, engaged and reflective citizens” (OECD, 2012). Mathematical literacy is defined as follows:

> *Mathematical Literacy* is an individual’s capacity to formulate, employ, and interpret mathematics in a variety of context. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgement and decisions needed by constructive, engaged and reflective citizens. (OECD, 2017, p. 51)

The PISA 2015 framework for mathematical literacy in practice is presented in Figure 1. The PISA 2015 framework identifies seven fundamental mathematical capabilities positively correlated with individuals’ level of mathematical literacy. As the individual’s level of mathematical literacy goes up, that his or her fundamental mathematical capabilities increase (Turner & Adams, 2012). The seven fundamental mathematical capabilities and the ways they interact with the three mathematical processes are described in Table 1.

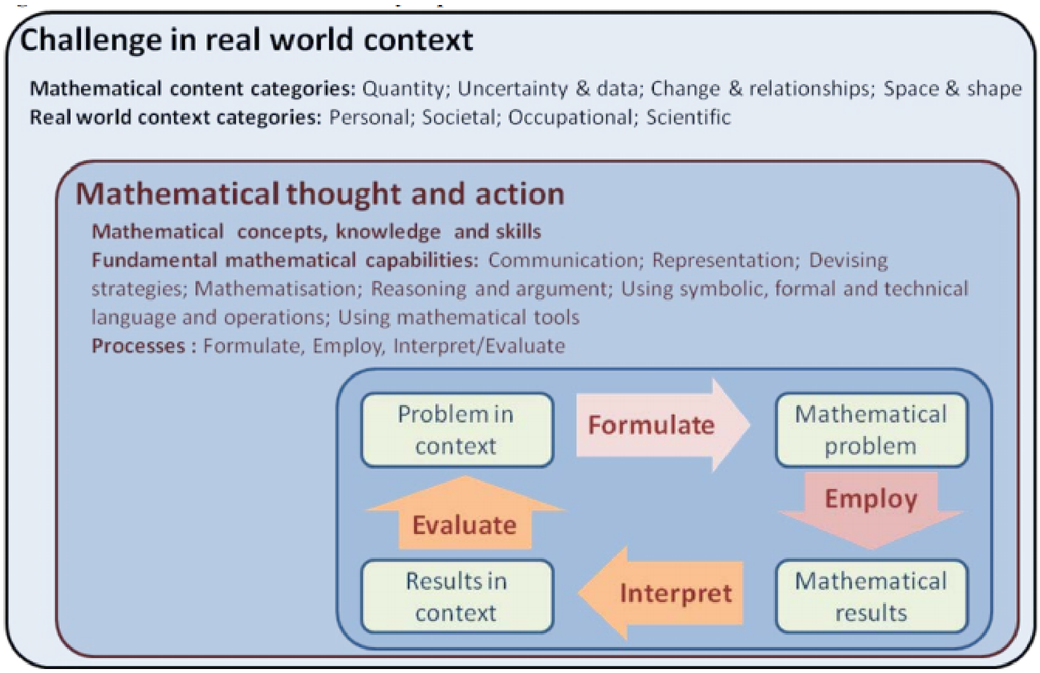


Figure 1. A model of mathematical literacy in practice (OECD, 2017; PISA, 2015)

Table 1: Relationships Between Fundamental Mathematical Capabilities and Mathematical Processes

	Formulating situations mathematically	**Employing mathematical concepts, facts, procedures, and reasoning**	**Interpreting, applying and evaluating mathematical outcomes**
Communicating	Read, decode, and make sense of statements, questions, tasks, objects or images, in order to form a mental model of the situation.	Articulate a solution, show the work involved in reaching a solution and/or summaries and present intermediate mathematical results.	Construct and communicate explanations and arguments in the context of the problem.
Mathematising	Identify the underlying mathematical variables and structures in the real-world problem, and make assumptions so that they can be used.	Use an understanding of the context to guide or expedite the mathematical solving process, e.g., working to a context appropriate level of accuracy.	Understand the extent and limits of a mathematical solution that are a consequence of the mathematical model employed.
Representation	Create a mathematical representation of real-world information.	Make sense of, relate and use a variety of representations when interacting with a problem.	Interpret mathematical outcomes in a variety or formats in relation to a situation or use; compare or evaluate two or more representations in relation to a situation.

Table 1 (continued)

	Formulating situations mathematically	Employing mathematical concepts, facts, procedures, and reasoning	Interpreting, applying and evaluating mathematical outcomes
Reasoning and argument	Explain, defend or provide a justification for the identified or devised representation of a real-world situation.	Explain, defend or provide a justification for the processes and procedures used to determine a mathematical result or solution. Connect pieces of information to arrive at a mathematical solution, make generalizations or create a multi-step argument.	Reflect on mathematical solutions and create explanations and arguments that support, refute or qualify a mathematical solution to a contextualized problem.
Devising strategies for solving problems	Select or devise a plan or strategy to mathematically reframe contextualized problems.	Activate effective and sustained control mechanisms across a multi-step procedure leading to a mathematical solution, conclusion, or generalization.	Devise and implement strategy in order to interpret, evaluate and validate a mathematical solution to a contextualized problem.
Using symbolic, formal and technical language and operations	Use appropriate variables, symbols, diagrams and standard models in order to represent a real-world problem using symbolic/ formal language .	Understand and utilize formal constructs based on definitions, rules and formal systems as well as employing algorithms.	Understand the relationship between the context of the problem and representation of the mathematical solution. Use this understanding to help interpret the solution in context and gauge the feasibility and possible limitations of the solution.
Using mathematical tools	Use mathematical tools in order to recognize mathematical structures or to portray mathematical relationships.	Know about and be able to make appropriate use of various tools that may assist in implementing processes and procedures for determining mathematical solutions.	Use mathematical tools to ascertain the reasonableness of a mathematical solution and any limits and constraints on that solution, given the context of the problem.

Source: Retrieved from http://www.oecd.org/pisa/pisaproducts/pdf

The NCED Seminal Work and Mathematical Literacy

The National Council on Education and Disciplines (NCED), during their seminal work, encouraged a group of teachers, professors, and leaders in mathematics education to inquire into the meaning of numeracy in the 21st century (Orrill, 2001). The mathematical literacy team expressed concern that in a world awash in numbers, a majority of students were still not quantitatively literate (p. 1). Mathematical literacy is an essential component of the general literacy of an individual. This point has been emphasized by the NCED, subdividing literacy into mathematics literacy, prose literacy, and document literacy. Mathematical literacy is regarded as essential for “active participation in the contemporary society” (p. 9). Unfortunately, most students are not mathematically literate. Although this issue often applies to learners who do poorly in mathematics, students with advanced mathematical backgrounds are often “unable to comprehend (much less to articulate) the nuances of quantitative inferences” (p. 2). This is, however, understandable because mathematical literacy emphasizes context, while mathematics tends to emphasize abstraction.

Several essential elements of mathematical literacy were highlighted: “confidence about mathematics, ability to interpret data, reasoning and critical thinking, quantitative decision making, mathematics in context, practical skills, background knowledge, number and symbol sense” (Steen, 2001a, p. 18). Though such elements overlap with elements of the traditional curriculum, they particularly emphasize reasoning and context.

The mathematically literate student must develop skills such as data analysis, knowledge of computers, modeling, quantitative reasoning, and knowledge of statistics. These skills must be taught and learned in context, and not in unrelated classroom situations. Some of these contexts are commonplace, such as splitting a restaurant bill three ways or understanding the interest rate of a loan, but there are many other valuable expressions of mathematical literacy, such as voting, sampling, analyzing economic and demographic data, personal finance, personal health, and management. The contrast between mathematics literacy and the traditional mathematics curriculum is that mathematical literacy "is driven by issues that are vital to individuals in their lives and work, not by future needs of the few who may make professional use of mathematics or statistics" (Steen, 2001a, p. 18). The Mathematical Literacy Team contended that teaching for mathematical literacy is like other student-centered pedagogy. It requires a different method of approaching education in terms of content, pedagogy, context, culture, and interdisciplinary work. The case for mathematical literacy as one potential solution to the problem of illiteracy is a provocative one, and to better understand what a mathematical literacy curriculum looks like, it may be helpful to go more in depth into some of its primary characteristics.

Characteristics of a Mathematical Literacy Curriculum

Teaching for mathematical literacy requires a pedagogical approach that focuses on real-world applications, understanding rather than memorization, and mostly depth more than breadth (Brown & Schäfer, 2006; Cuban, 2001). According to Burkhardt (2008), teachers must embrace the world beyond mathematics and should also motivate students by giving key directions and supplementary inquiries with the objective of giving students responsibility over their work. Additionally, technology must be a fundamental part of the instruction of mathematical literacy (Catalano, 2010; Edwards, 2008; Madison, 2006; Steen, 2003), and it should be used organically throughout the curriculum. Although these attributes can be found in many mathematics curricula, authors have stated that they are nonnegotiable in a mathematical literacy curriculum. Moreover, the literature emphasizes applications and interdisciplinary work as additional components of pedagogy essential to developing mathematical literacy skills.

Application and modeling are important for effective mathematical literacy instruction (Alsina, 2002), and their impacts should also be taken into consideration (Davis, 1993). This real application requires both accuracy and practice, as all problem solving is contextual in nature (Pollak, 1997). It is a strength that mathematical literacy depends on context (Brown & Schäfer, 2006; Madison & Steen, 2009; Steen, 2001c), because context itself promotes motivation and learning (Steen, 2004; Venkat, 2007). Teaching for mathematical literacy differs from traditional pedagogy in the sense that teaching shifts from complicated real-life situations to generalizable abstractions and not the other way around (Dewdney, 1993).

According to De Lange (2003), "applications can and should be used as a context within which the learning of mathematics concepts takes place" (p. 87). Therefore, mathematics must be used as a tool since instructors and learners primarily focus on solving real-world problems.

Since learners in the mathematical literacy classroom must have the skills to capture numerical aspects of contexts, the instruction of mathematical literacy must be interdisciplinary (Cohen, 2001; Madison, 2004; Orrill, 2001; Steen, 2001b). Steen (1999) contended that literacy serves the whole mathematics curriculum, and in the words of Malcom (1997), "mathematics needs to make explicit connection with other subject areas, and with people's everyday lives" (p. 73).

Authors from various disciplines have argued as to why mathematical literacy should be a vital part of their curriculum. Crowe (2010) in social studies argued that traditional mathematics courses do not help students "make reasonable judgement of inferences from information presented to them in the media, by the government, or by other citizens" (p. 105). To correct this situation, Crowe suggested interdisciplinary work where students in history learn to evaluate raw numerical information, getting an understanding of percentages and charts of averages. Miller (2010) made a convincing case for the relationship between mathematical literacy and English, because while learners need to "read, understand, solve and write about word problems," they are also required to write the answer "in prose in ways that put it back in its original substantive context, therefore bring[ing] the word problems full circle" (p. 336). Lutsky (2008) stated that mathematical literacy should be modelled after the writing across the curriculum initiative as well as "intertwined with teaching writing" (p. 60). Lutsky also said,

> We need to show others that numbers can add to precision in our thinking, as well as facilitate the public discussion and evaluation of claims, help us understand the attitudes of large and complicated phenomena, organise vast domains of information, and assist us discover pattern of relationships not easily accessible to the human perceptions. (p. 61)

Authors have also put forth the intersection of mathematical literacy with business (Albers, 2002), economics (Schuhmann, McGoldrock, & Burrus, 2005), and sociology (Atkinson, Czaja, & Brewster, 2006). Many disciplines understand and value the need for improvement in mathematical literacy despite its being a relatively new movement in the field of mathematics education.

Mathematical Literacy Pedagogical Technique

One of the most frequent recommendations to teach mathematical literacy is to engage students in small collaborative groups. In the mathematical literacy classroom, learners spend approximately one-half to two-thirds of the class period engaged in small group work. To make such groups real "connected-knowing groups," specific instructions must be followed.

First, as noted by Belenky, Clinchy, Goldberger, and Tarule (1986), "members of connected-knowing groups engage in collaborative exploration" (p. 119), which takes the form of planned group activities, not just mathematics problems that group members are required to work on in the group. These group activities are normally built on exploring real-world data, where students are not only responding to quantitative questions, but are also creating hypotheses before starting the activities and developing their explanations.

Second, “connected-knowing works best when members of the group meet over a longer period of time and get to know each other well” (p. 119); therefore, students stay in the same group during the entire semester. Groups are randomly assigned by the teacher at the beginning of the semester. And third, groups must be carefully monitored by teachers. Jacobs (1994) focused on the importance of activities done “cooperatively rather than competitively or in isolation from others” (p. 444). Thus, the teacher needs to manage the groups carefully, intervening when necessary. For instance, teachers often encourage groups to change the recorder’s role in their group, so that different students would have the opportunity to experience a leadership role. Finally, the group activities are structured to build on previous results in order to develop true collaborative work, so it is almost impossible for students to divide up the work and complete it individually. In addition, the teacher makes verbal reminders of the importance of communication and collaboration along the way. The objective is to ensure that students “generate their own knowledge and connect with the knowledge of other students” and that possibly these connected groups would form “a classroom which is a community of learners” (p. 443).

A second feature of the mathematical literacy course is the need for practical information. Jacobs (1994) stated that “an instructor can design learning activities that enable students to use their experiences, either real or classroom-based, to enable them to learn” (p. 444). Practicality is an important point of the mathematical literacy course. Students work with real data from different fields, such as economics, health, sciences, and personal finances. Mathematics content includes absolute and relative changes, including percent change, dimensional analysis, making and analyzing graphs including misleading graphs, and the fluctuation of currency, as well as personal finance, such as investment and loans, and some elementary statistics. Besides studying practical topics using real data, students also learn technical skills during the semester.

A third strategy used in the mathematical literacy course is based on the instructor’s role. The teacher’s role in this mathematical literacy class is to decrease the power differential between teachers and students; but Jacobs (1994) highlighted that total equality is unachievable, because “faculties select the curriculum, evaluate the students, and are paid for providing a service, teaching” (p. 443). Jacobs further noted that “the instructor must balance his role as question or problem poser and sources of answers, creating a more egalitarian environment than the more usual mathematics classroom” (p. 443).

Thus, in the mathematical literacy course, the instructor spends approximately one-third of class time leading classroom demonstrations of the mathematics materials. But even during this more directive role, the learners are typically engaged. The teacher then moves to a more facilitating role as the learners engage in their collaborative group activities. During that time, he supports students in their collaborative exploration.

Connecting-knowing groups, practicality of information, a balanced role of the instructor, and use of writing in mathematics are the mathematical literacy pedagogical strategies implemented in a mathematical literacy classroom. These techniques are used to create a classroom culture that, ideally, is a community of learners.

One of the primary reasons why mathematical literacy remains attractive is because it makes use of some key theories developed in mathematics education over the past century.

Education Theory and Mathematical Literacy

Over the past century, theories of how learners approach mathematics have changed dramatically. The conventional belief was that the teacher had all the knowledge and that learning occurred when the teacher filled the students’ heads with knowledge. Over the past hundred years, this belief has been challenged by Piaget, Vygotsky, Lave, and many others. In the theory of radical constructivism, Piaget stated that a child builds knowledge for himself, and thus learning can only happen when a child meets something new in his/her own preexisting knowledge structure (Von Glasersfeld, 1995). Vygotsky argued with Piaget but also stated that the social environment around the child is very important in the child's construction of his /her own knowledge (Van Oers, 1996). Lave (1991) went beyond the work of Vygotsky to analyze the phenomenon of situated learning, where learning can only be understood within a particular milieu or context. Each of these theories has an important ramification for mathematical literacy, and, in a way, mathematical literacy can be seen as a practical application of these fundamental theories.

Piaget's theory of radical constructivism rotates around the idea that "knowledge arises from the active subject's activity, either physical or mental, and that it is goal-directed activity that gives knowledge its organization" (Von Glasersfeld, 1995, p. 56). According to Piaget, knowledge was not just putting together information or facts, but it was something consciously created and recreated by everybody. Radical constructivism changed the way teachers thought about education. For the first time, teachers had to see the individuals themselves, since learning only occurred if a person could incorporate the new results into a preexisting knowledge structure.

New theories of how children learn would not end with Piaget. While Piaget did pioneering work by focusing the discussion on an individual, Vygotsky enriched the discourse by emphasizing the significance of society and culture:

> Constructivism often seems to stick to the view that children build and develop their own mental structures though interaction with the social environment. Cognitive apprenticeship from a Vygotskian perspective, on the other hand, implies that the quality of mental development is derived from the distinctive proprieties of the sociocultural organization of the activity. (Van Oers, 1996, pp. 107-108)

Vygotsky incorporates the way in which culture affects how a person constructs his own knowledge. Piaget and Vygotsky agree that learning occurs when students develop their potential through personal activity (Van Oers, 1996). According to the cultural historical theory of Vygotsky, the development of human personality "has a specifically historical character, content, and form" (Davydov, 1995, p. 15). But unlike Piaget, Vygotsky contended that "education was … basically, a process of enculturation," where community members come together with students to assist them to "re-invent valuable cultural elements in a meaningful way" and "grow into the intellectual life of those around them" (Van Oers, 1996, p. 93). Participating in a socio-cultural activity with the assistance of an adult lies at the heart of Vygotskian theory ("Zone of Proximal Development [ZPD]"). The ZPD "is constructed between the child and the adult on the basis of what the child wants and the actions the child actually can carry out, as well as the help the child gets from the adults" (Van Oers, 1996, p. 97). The construction of knowledge is based on Piaget's theory, but the help from the adult is distinctly at the heart of Vygotskian theory. A learning model built on the ZPD depends on the activities and interests of a child as well as the expertise and the guidance given by the adult. Lave (1997) extended the model of Vygotsky and explained that "learning, thinking and knowing are relations among people engaged in activity *in, with, and arising from the socially and culturally structured world*" (p. 67). Situated cognition is defined by Greeno (1989) as follows: "Thinking is situated in physical and social contexts. Cognition including thinking, knowing and learning can be considered as a relation involving an agent in a situation, rather than an activity in an individual's mind" (p. 135). As an illustration, Greeno cited Scribner's (1984) studies of unskilled" milk-processing plant workers. Scribner observed and monitored the behavior of workers who were asked to fill containers of different sizes in a dairy farm. Her analysis revealed that in more than 90 percent of the cases, workers chose highly specialized methods for mental computation more efficient than the general-purpose algorithms taught in school. Interestingly the workers' skills were not even based on what they had acquired in school; rather the ability developed during their daily experience. Lave (1991) explained groups' performance as "communities of practice, where common, shared, knowledgeable skills get organized" (p. 71). Focusing on the importance of context and culture, the theory of situated learning of Lave is an expansion of Vygotsky' s work. However, Lave pointed out that "genuine, participation, membership and legitimate access to ongoing practice" are not common in schools (pp. 78-79). A way of putting into practice the principles of situated learning, as well as incorporating Piaget's and Vygotsky's work, would be to let the mathematics curriculum focus on teaching mathematical literacy.

Mathematical literacy is based on Piaget's work, as students have a chance to learn about what they are interested in. Mathematical literacy activities are also based on learners' background knowledge, and, ideally, they create opportunities that improve and deepen student understanding. Mathematical literacy also puts into account Vygotsky's zone of proximal development as adults assist students to build new understanding. An effective mathematical literacy pedagogy uses instructional strategies that help students expand their own knowledge to new and much more complicated situations. And finally, teaching mathematical literacy is practically applying the situated learning theory of Lave, as it makes an attempt to stimulate authentic experience in a mathematical literacy classroom. Overall, teaching for mathematical literacy tries to implement the theories of Piaget, Vygotsky, and Lave, since it affords students an opportunity to extend their own knowledge to understand complicated real-life phenomena.

The literature discusses many reasons for teaching mathematical literacy, such as mathematical literacy needed for democracy, mathematical literacy as a requirement for a democratic mathematics classroom, mathematical literacy as a force for equity, and mathematical literacy as a stimulus for higher achievement.

Mathematical Literacy and Democracy

At the end of the 1980s, the National Research Council (1989) made a declaration that "mathematical illiteracy is both a personal loss and a national debt" (p. 18). As did Paulos's (1988) work, the National Research Council alerted everyone that innumeracy is both a personal and a national concern. Quantitative reasoning is so necessary for American citizens (Madison & Steen, 2009) that mathematical literacy has become vital for the preparation of future citizens and the well-being of our democracy (Alsina, 2002; Cuban, 2001). According to Steen (2003), “Numeracy lies at the intersection of statistics, mathematics and democracy” (p. 62). “Just as verbal literacy gives students the tool to think for themselves, to question experts, and to make civics decisions, mathematical literacy does exactly the same in a world increasingly drenched in charts, graphs, and data” (Cuban, 2001, p. 87). Mathematically literate individuals have a greater potential to impact the world and thus are more likely to improve their own position and the position of others (Wiest, Higgins, & Hart Frost, 2007). If students can learn how to plan, challenge, reflect, and measure their own work in the classroom, they will be able to live a better civic life. If they can learn to make use of the analytical tools of mathematics to examine inequalities and study problems in a society (Ball et al., 2005), then they also can improve the positions of others.

Mathematical Literacy and the Democratic Mathematics Classroom

Teaching for mathematical literacy satisfies the principles of a democratic mathematics classroom. According to Ellis and Malloy (2007), a democratic mathematics class must possess criteria such as a student problem solving, inclusivity, as well as rights and equal participation in classroom decision-making that influence students’ lives, in addition to equal encouragement for success. Most designed mathematical literacy curricula satisfy the problem-solving criteria and some techniques that are linked to teaching mathematical literacy. For example, a mathematical literacy curriculum satisfies Ellis and Malloy’s problem solving requirement, since it gives students a chance to “draw on their accumulated knowledge to solve problems important to their lives and society” (p. 161). These kinds of problems in mathematical literacy class are common because even the definition of mathematical literacy points out the skills “that people need in order to engage effectively in quantitative situations arising in life and work” (Alsina, 2002, pp. 2-3). According to Pollak (1997), “problem solving is also at the heart of quantitative literacy—the use of mathematics in everyday life, on the job, and as an intelligent citizen” (p. 91). Moreover, teaching for mathematical literacy can help promote inclusivity by “affirming the worth of diverse experiences” (Ellis & Malloy, 2007, p. 161) and by allowing equal participation in classroom decision-making, since students design their own experiences (Allen, 2011), and equal encouragement for success by providing students with “access to materials that engage them actively in the learning of mathematics” (Ellis & Malloy, 2007, p. 161).

Mathematical Literacy and Equity in the Classroom

The advantages of mathematical literacy for democracy spill over to equity as well. The role of mathematics education as a gatekeeper has traditionally acted like a filter instead of an equalizer. According to Madison (2003), the role of mathematics as a filter “misused mathematics and abused students”; even worse, “many mathematics faculties accept the long tradition of their discipline as a filter and expect a large number of students to fail” (p. 160). Given the misuse of mathematics, America is in the danger of being divided “both economically and racially by knowledge of mathematics” because poor mathematics preparation has a disproportionate impact on minorities (NRC, 1989, p. 13). On the other hand, mathematical literacy is about “the democratization of mathematics” instead of the all-to-frequent mathematics traditional task of separation (Steen, 2002). Mathematical literacy curricula give the opportunity for a more equitable society because they provide learners with the skills they need to participate in civic life (Wiest et al., 2007). A mathematical literacy curriculum could decrease the perception that some learners are better at mathematics than others, since more learners become engaged and ultimately successful in mathematics (Stith, 2001).

By encouraging our students to reason quantitatively, mathematics could be "accessible to all students" but also provide students with tools necessary to make them successful and participatory citizens (Ellis & Malloy, 2007 p. 161). That is, mathematical literacy could change mathematics education from a sorting mechanism to a mechanism able to uplift and empower students.

In the words of Moses and Cobb (2001), "mathematical literacy and economic access are how we are going to give hope to the young generation" of African Americans in the United States (p. 13). These authors describe algebra as a gatekeeper for advanced mathematics as well as a barrier for citizenship. Thus, Moses and Cobb advocate for the successful completion of algebra as a civil right (Ellis & Malloy, 2007). Practically, the algebra may include physical trips as well as modelling, intuitive language, structured language, and symbolic representation. As does mathematical literacy, the algebra focuses on students' interests and experiences to involve learners in extensive ideas and complex problems. Thus, Moses and Cobb (2001) hope to provide African American students with a chance to develop skills and credentials to access better employment opportunities.

Rivera-Batiz (1992) argued that mathematical literacy has an independent effect on the chance of an individual being employed. Carnevale and Desrochers (2003) stated that persons with quantitative skills get better salaries than those without such skills. More precisely, they found Algebra 2 to be the "threshold mathematics course taken by people who eventually get good jobs in the top half of the earnings distributions" (p. 26).

Mathematical literacy can provide students with the skills needed to uplift their own positions in life, but Gutstein (2006) claimed that students can also develop skills that would assist them to tackle injustices. According to Gutstein, most aspects of mathematical literacy could empower students and challenge inequalities. Gutstein advocated for a mathematical curriculum that used “real and potentially controversial issues” where mathematics becomes a tool to look into and act on social issues (p. 3). He further claimed that equity in mathematics education is not just for what is learned in the classroom but also what can be accomplished with the mathematics learned. Gutstein distinguished between a functional literacy that represents the social purposes of schooling and a critical literacy that represents the critical and sceptical abilities. The traditional mathematics curriculum aims at functional literacy, as “schooling was meant to reproduce dominant social relations” (p. 7). Gutstein emphasized critical literacy in the sense that he used many practices that help endorse mathematical literacy. Gutstein explained how he devoted 15% to 20% of the class time to real-life projects that helped empower students to read and write word problems. Gutstein’s pedagogy utilizes mathematics in context and is the kind of approach that makes mathematical literacy a very powerful tool for a more equitable system in mathematics education.

Mathematics Literacy and Achievement in Mathematics

Mathematical literacy provides students with the skills to combat inequality and give them better economic opportunities. It can also play a role in improving learners’ achievement. Fewer students would fail (Stith, 2001) in a mathematics classroom using a mathematical literacy approach with relevant and functional contexts (Steen, 2001c) that students are interested in (Allen, 2001; Malcom, 1997). Many studies illustrate this. For instance, Schiefele and Csikszentmihalyi (1995) revealed a positive correlation between interest and achievement. Ma (1997) showed a reciprocal correlation between attitudes toward mathematics (specifically enjoyment) and achievement. Koller, Baumert, & Schnabel (2001) revealed a relationship between interest and achievement at the secondary level. These examples emphasize students’ interest, which, along with self-efficacy and motivation, is one of the primary advantages of teaching mathematical literacy.

Studies have revealed that teachers can support the interest of students by helping them develop positive attitudes in the mathematics classroom. According to Hidi and Renninger (2006), positive attitudes can be promoted in the following way:

> Giving choices in the tasks, creating a sense of autonomy, innovative, support for developing the knowledge that is needed for successful task completion … building a sense of competence … project-based learning that includes students' work with peers or other social situations, computer environments that are attractive and word problems or passages that have contexts specifically addressing students' individual interests. (p. 122)

These features are generally present in a mathematical literacy classroom, especially one that provides students with the time and resources necessary for developing their interest. Flexibility to respond to the students in this way is fundamental in teaching for mathematical literacy. Additionally, by supporting the growth of upcoming or already developed individual interests, teachers can hope to move the students to a greater level of achievement.

Not only can mathematics classrooms encourage student interests, but they also have the potential to promote self-efficacy: "a belief in ones' capabilities to organize and execute the courses of actions required to produce given attainments" (Carmichael, Callingham, Hay, & Watson, 2010, p. 85). Authors showed that self-efficacy for students for statistical literacy is directly related to their interests, meaning that if a mathematical literacy classroom develops greater potential to pique students' interest, then it has the potential to promote students' self-efficacy as well.

Maybe teaching for mathematical literacy creates the right balance between giving students the chance to do mathematics as well as challenging them with complex and sophisticated problems that have unobvious answers. By selecting activities that are in a student's zone of proximal development, mathematical literacy can address self-efficacy as well as increase their interest and even achievement in mathematics.

Besides developing students' interest and self-efficiency, mathematical literacy also can promote student motivation, defined as "the reason individuals have for behaving in a given manner in a given situation" (Middleton & Spanias, 1999, p. 66). The authors distinguish between intrinsic and extrinsic motivation. They argue that "providing opportunities for students to develop intrinsic motivation in mathematics is generally superior to providing extrinsic incentive for achievement" (p. 81). The authors explained a model of how intrinsic motivations grows in a classroom:

> When students first come across an academic activity, they will tend to evaluate the challenge and curiosity fantasy it provides and the personal control (free choice, not too difficult) the activity affords. If students' arousal and control requirements are met constantly, they may choose to include the activity among their interest. (p. 75)

This shows the potential power of mathematical literacy in the classroom: if students regularly engage with mathematics that is relevant, interesting, and accessible, then they may start to develop intrinsic motivation for the subject. Teaching for mathematical literacy may be the "radical and consistent change" (p. 75) that is required to overcome the lack of motivation in students, as it focuses on skills that learners need so as to understand the quantitative situations in their day-to-day lives.

General Concerns about Teaching for Mathematical Literacy

Teaching mathematical literacy has numerous potentials benefits. However, it encounters considerable difficulties related to the choice of context, theoretical arguments, and teaching practices.

Challenges in the Choice of Context

Incorporating authentic situations in a mathematical literacy classroom is one of the challenges faced by instructors. Jurdak (2006) differentiated between a real-world problem and a situated problem in school:

> The situated problem solving in the school context is an activity within the school community, which results in a written solution using mostly mathematical tools and constrained by school rules, norms, and expectation; whereas, decision-making in real life is a complex activity that occurs within the larger social context and which results in a decision constrained by the acceptable social and personal rules and using all available mathematical and non-mathematical tools. (p. 296)

Similarly, Beswick (2011) noted that authentic situations must be filtered by the context of the classroom as well as by students' background knowledge and experiences. The outcome is a "nested pair of contexts, both of which include subjective aspects—the context evoked by the problem sitting within the context in which the problem is encountered" (pp. 383-384). Pollak (1997) stated that "real-world problem solving must meet the standards both of mathematics and of the external situation to which mathematics is being applied" (p. 104). Though creating truly authentic situations might be impossible, empowering real-life situations in the classroom is very beneficial. It makes mathematics more meaningful and relevant to students and also "may provide an opportunity for appreciating the power and limitations of using mathematics in real-world" (Jurdak, 2006, p. 298).

Mathematics instructors must be aware that if students learn any concept irrelevant to their lives, they will sooner or later dismiss it. In order to keep a mathematical concept alive and useable, instructors must link topics to real life by using authentic problems. This encourages students to be active and engaged in their learning. Instructors must provide learners with the opportunities to solve real-world applications connected to learners' future careers (Bottge & Cho, 2013; Valenzuela, 2012, 2014). These authors believe in real-life applications as fundamental to student learning and understandings. According to Pollak (1997),

> A student's mathematics education is simply not complete if that student has not experienced the usefulness of mathematics in the larger world. This experience comes through real-world problem solving. Thus, success in mathematics cannot be measured through assessment in mathematics courses alone, or in terms of preparation for the next level of courses. We must also

> consider the ability to examine in a mathematics way situations in everyday life, on the job, and as citizens. (p. 105)

Research has shown that learners often struggle solving problems based only on formulaic computations, without real-world applications (Puri, Cornick, & Guy, 2014). To keep students focused and engaged in the mathematics class, they need to understand the value of the mathematics concepts learned, which occurs only if related to their lives (Chang, 2010). Rather than spending time defining concepts, it is important to have learners solve authentic problems. In a study conducted by DeBay (2013) to observe the effect of real-world mathematical tasks, 62 participants were exposed to an Urban Planning Project involving graphical representation. The findings revealed a significant increase in students' understanding. DeBay stated, "This indicated that as a result of students' involvement in the Urban Planning Project, an overall understanding of using graphs in real-world problems has given students an increased understanding of solving questions that involve graphical representations" (p. 86).

Similarly, to observe and evaluate the effects of using problem solving to teach exponential and logarithm functions on learners' understanding and achievement, Donachy (2012) conducted a study using two high school classes. While one class used problem solving to teach the unit, the other used a more traditional method of teaching. The findings revealed that "the experimental group proved to be more engaged and enthusiastic in the learning of the unit. The application problems promoted more discussion and team work from the students as well" (p. 38). Donachy concluded that:

> Mathematics courses need to be made as relevant as possible to students' lives. If students can't relate to the material, and find some meaning in it, they will turn out and turn off during class time. When students can infer meaning behind a concept, they will apply that concept leading to a better and longer retention of the information. (p. 38)

Theoretical Concerns

Madison (2004) offered a few theoretical arguments against instruction for mathematical literacy: mathematical literacy is too challenging, mathematical literacy cannot be taught, major curriculum adjustments are implausible, and any emphasis on mathematical literacy will hurt mathematics. Madison discussed these concerns one by one. First, he argued that mathematical literacy includes modern applications and confusing wording, yet he asserted that the context itself is simply basic mathematics. Second, Madison claimed that problem solving and critical thinking are involved in school, and mathematical literacy couldn't be harder to develop than any other habit of mind. (However, to be reasonable, it is difficult to develop either problem-solving skills or critical thinking abilities.) Third, major curricular changes might be uncommon, yet they are possible, with "writing across the curriculum" programs as a recent case. And finally, Madison believed that underscoring mathematical literacy may require sacrifices that harm traditional programs, yet he confessed that mathematical literacy is so important that the curriculum should change to accommodate it.

Practical Challenges

In addition to some theoretical challenges, research points out certain practical concerns in teaching for mathematical literacy. Hughes-Hallett (2003) stated that instructors lack experience teaching effectively for mathematical literacy. Therefore, they would need extensive professional development (Usiskin, 2001). Indeed, some research does demonstrate that professional development positively influences teaching for mathematical literacy (Edwards, 2008). Despite well-trained and qualified instructors, there are some significant obstacles to promoting students' mathematical literacy. Madison and Dingman (2010) experienced these challenges when they created and implemented a new mathematical literacy course. They discovered that fluency in mathematics or statistics does not necessarily imply higher mathematical literacy. They also found that students struggled to transfer knowledge to new situations and were not confident about their ability in mathematics. Additionally, Madison and Dingman showed that learners doubted the reasonableness of their answers, were unable to understand the difference between magnitude and relative change, and tended to think that greater numbers were always better (even the percentage of deaths per 1,000 patients in hospitals). Finally, learners had significant issues with elementary algebra and barely understood its value as a problem-solving tool. These practical concerns, along with pedagogical and political challenges, made instructing for mathematical literacy much more complicated. And this explains why the traditional curriculum in mathematics education has prevailed.

Findings on Mathematical Literacy at the Undergraduate Level

Much research has investigated the viability of teaching mathematical literacy in college. While many studies have concentrated on how colleges address mathematical literacy in a comprehensive way, others have examined the efficiency of classes designed to promote mathematical literacy.

Colleges and Mathematical Literacy

In 1996, the Mathematics Association of America (MAA) explained how colleges should address quantitative reasoning. The authors expressed four important conclusions:

> First, colleges and universities should consider mathematical literacy as a thoroughly and legitimate and even necessary goal for the baccalaureate degree; secondly, colleges and universities should expect every college graduate to be able to apply simple mathematical methods to the solution of real-world problems; thirdly, colleges and universities should devise and establish mathematical literacy programs each consisting of a foundation experience and a continuation experience, and mathematics departments should provide leadership in the development of each program. And finally, colleges and universities should accept responsibilities for overseeing their mathematical literacy programs through regular assessments. (Sons et al., 1996, pp. 16-17)

Based on research, numerous schools and colleges have taken up this charge. Brakke and Carothers (2004) depicted how James Madison University uses various strategies to promote quantitative reasoning abilities. Diefenderfer, Doan, and Saloway (2004) portrayed the quantitative reasoning program at Hollins University, where learners need to satisfy minimum requirements, such as a weekly computer laboratory, and the completion of at least two projects using quantitative reasoning in real-world problems. As is the case at James Madison, Hollins University emphasizes professional development, which is reasonable given the non-traditional pedagogy required for mathematical literacy. The authors found that students improved on a post-test after completing their mathematical literacy courses, especially with respect to their applied skills. They also revealed a significant improvement in self-assessment. Richardson and McCallum (2003) described Wellesley College's mathematical literacy requirements: learners take a course that focuses on literacy authenticity, relevance, comprehension, and common sense. The Wellesley College elements are very similar to the characteristics of mathematical literacy described earlier. Apparently, the majority of colleges are aware of the importance of mathematical literacy to liberal arts education.

Some research has gauged the efficacy of mathematical literacy programs at the college level. Steel and Kilic-Bahi (2010) described the growth of mathematical literacy along with an insignificant development in basic skills for students at Colby-Sawyer College. At the same time, Jordan and Haines (2003) described the growth of mathematical literacy at Lawrence University, where students developed a higher level of appreciation for the utility of statistics. Many colleges have responded to the call for implementing and improving programs in mathematical literacy. While the research just cited addressed school-wide initiatives, the following described the efficacy of specific college-level classes.

Mathematical Literacy Course Design

Briggs et al. (2004) designed a mathematical literacy course at the University of Colorado Denver. The goal of this course was to strengthen and broaden mathematical literacy skills, reinstall confidence in students, and prove the relevance of mathematics. To promote attitudes and increase student engagement, classes involved activities where students were required to bring in articles that included a quantitative element. Teachers always presented real-world applications first, and they focused on group problem-solving processes rather than solution, discussion, and effort. The objectives of this course were to develop critical thinking, number sense, and statistical reasoning by looking at financial problems, probability, and exponential growth, as well as voting, apportionment, mathematics and the arts, graph theory, and energy and environmental problems. From pre- and post-course questionnaires, students revealed a decrease in anxiety, an increase in confidence, and an increase in comfort because of working groups. Briggs et al. also found that unmotivated students reported higher levels of motivation; and student performance was highly correlated with diligence and study.

Madison (2006) described a course that sought to analyze and criticize newspaper articles using mathematical and statistical reasoning. He pointed out several important features of the course, such as the requirements for the materials to be fresh and authentic. Madison found that students did not dispute the fact that they should understand them, even if they were not interested. Madison expected students to engage more than they would in a traditional mathematics or statistics course, so the course awarded extra credit if students brought in an interesting article with a quantitative component. Madison's course had nine lessons that addressed numbers, percent, linear and exponential functions, indices, graphs, counting, probability, weights, and maps. Instructors tried to situate the mathematics in context. The mathematics itself was often elementary in nature, but the contexts and reasoning were rather "sophisticated" (p. 23). Additionally, technology was an integral part of the classroom, and interdisciplinary endeavors often arose unpredictably. To evaluate the efficacy of this course three years later, Dingman and Madison (2010) used pre- and post-course tests, attitude surveys, and think-aloud sessions. The authors found a slight change in student reports about the usefulness of mathematics. Compared to a group using a more traditional text, students' attitude scores increased slightly, and their confidence with quantitative reasoning also increased. Student retention and grades were also better in this course, but the authors admitted that this result may have been due in part to the grading scale. The authors also looked at several challenges of their course, such as managing unpleasant habits that students had developed in previous mathematics courses, determining scope of content, finding authentic tasks for assessments, and struggling with various pedagogical deficiencies.

Catalano (2010) described a college algebra course with a contextual focus. He found that traditional college algebra courses leave pre-service elementary instructors with negative attitudes about the utility of mathematics, so his goal was to improve their perceptions of mathematics and to increase their mathematical literacy. Catalano argued that college algebra used to serve as a bridge to calculus, but since it has transformed into a terminal mathematics course for many students, educators must rethink its purpose. The author reorganized the typical college algebra content, and he inserted topics in probability and statistics while removing polynomials, rational and radical functions, as well as systems of equations. The course emphasized modeling, and it utilized pertinent social issues such as income inequality, the 2008 election, homelessness, and life expectancy. Catalano utilized the Student Assessment of Learning Gains (SALG) survey, along with interviews, student data, and a final examination, to evaluate the course. Results suggest that the course was more effective, and students reported an increase in levels of confidence. Furthermore, despite a slight degradation in skills, fewer students withdrew, and student success rates were much better.

Van Peursem, Keller, Pietrzak, Wagner, and Bennett (2012) attempted to compare a college algebra course and a mathematical literacy course by means of an examination modeled after the Collegiate Assessment of Academic Proficiency (CAAP) examination. They found no significant differences in scores on the examination, even though students with weak backgrounds self-selected into mathematical literacy. For example, 57.8% met the college readiness benchmark in college algebra, while 26.9% met the benchmark in mathematical literacy. Meanwhile, students in mathematical literacy reported higher gains in attitudes toward mathematics and felt that mathematics had more value and utility for their lives. Mathematical literacy students felt that they could better apply knowledge, and they scored higher on the application problems. A further analysis of the students who did not meet the college readiness benchmark showed that this subset of students performed much better in mathematical literacy than they did in college algebra.

Finally, Boersma and Kylve (2013) described a course that taught mathematical literacy through media articles, using the casebook from Madison, Boersma, Diefenderfer, and Dingman (2010). They wondered whether students needed a basic set of skills to learn mathematical literacy and noticed that students who lacked “basic mathematics skills, and possibly basic critical reading and study skills as well, may not be able to overcome these deficiencies in a fast-paced demanding course without some form of supplemental instruction or remedial reinforcements” (Boersma & Kylve, 2013, p. 9). They suggested that teachers dedicate more time to study habits and basic skills if they wanted students to succeed in acquiring mathematical literacy in authentic and contextual situations.

In sum, research on mathematical literacy has focused primarily on students at the undergraduate level. Some researchers described school-wide initiatives, while others evaluated specific courses. Research on school-wide initiative took a broader approach as authors described the efficacy of programs at James Madison University. The research on specific courses went into detail on curriculum changes, and on the assessment techniques that revealed that students had basic skills deficiencies that were preventing them from fully developing their mathematical literacy. Each of these studies adds to the research on mathematical literacy in a unique way, but they all focus on undergraduate students and programs, and they mostly use quantitative methods to perform their analysis.

Many studies have focused on innumeracy and the issues of the educational system to promote quantitatively literate citizens. The PISA framework (OECD, 2012; PISA, 2015) and the NCED (Steen, 2001a) advocated for the importance of mathematical literacy, and several researchers looked at the characteristics of mathematical literacy, with a particular focus on democracy and equity, as well as the many concerns about teaching for mathematical literacy. Mathematical literacy as a mathematical practice grew out of the work of Piaget, Vygotsky, and Lave, and it has already begun to take hold at the college level. In fact, several authors studied mathematical literacy at the undergraduate level, both in terms of college-wide initiatives and specific mathematical literacy courses.

This literature review suggested a need for research, and particularly for quantitative and qualitative research, on mathematical literacy at the community college level, and there is a need for research on student attitudes at all levels. Therefore, a quantitative and qualitative study on how mathematical literacy can impact community college students would benefit community college educators who understand that students need to develop a basic level of mathematical literacy to be thoughtful, well educated, active citizens in a complex, quantitative world.

Chapter III

METHODS

This chapter describes the methodology used in this research. In an attempt to understand the phenomena being studied, this chapter begins with an overview of the pedagogy of the algebra and mathematical literacy courses followed by the study design, setting, the survey, the data collection and analysis, and the validity of the methodology.

The intent of this study is to observe and evaluate learners' attitudes regarding mathematics in a community college mathematical literacy course. The research questions for this study are the following:

1. How are attitude toward self-confidence and ability of doing mathematics, as well as the value and usefulness of mathematics, affected by taking a mathematical literacy course?
2. What are the views of students concerning their experiences in a community college mathematical literacy course?

The study uses a mixed-methods approach. Data were collected during the fall semester of 2017 and were obtained from the use of surveys (Likert-type questions and open-ended questions). There were three sections of a mathematical literacy course with three different teachers, and three sections of an elementary algebra course with three different teachers as well. However, one instructor taught one section of elementary algebra and one section of mathematical literacy.

Overview of the Courses

Students are placed into developmental mathematics and/or college-level mathematics courses based on Assessment Test Scores. Students may be exempt depending on different sources such as the New York Regents Exam Scores, the Scholastic Aptitude Test or Scholastic Assessment Test (SAT), and the American College Testing (ACT). With the new City University New York placement exam grading system, students first take the COMPASS Mathematics 2 (Algebra) exam. If they pass, they are exempt from remedial mathematics. If they fail, then they take the COMPASS Mathematics 1 (Arithmetic) exam in order to determine the remedial mathematics placement level. Based on their intended major, students who require algebra for their degree are placed in the elementary algebra course if they pass the COMPASS Mathematics 1 placement exam. If students' fields do not require calculus, then students are placed in mathematical literacy QuantWay.

Elementary Algebra Course

The highest level of remedial mathematics classes offered by the college has traditionally been a remedial "Elementary Algebra" course (MAT 51) taught for 4 hours a week and that offers no college credit. Placement in this class depends on students' initial COMPASS scores. Students who take the ACT's COMPASS placement exam and have a score lower than 40 on the elementary algebra part and a score greater than 45 on the arithmetic part are placed in the elementary algebra courses. A score lower than 45 would place students in the arithmetic class. Students who successfully complete arithmetic courses are placed in the elementary algebra courses. This course prepares learners Freshman Skills Assessment test required for advanced college mathematics courses and for transfer to the upper division of Colleges. To pass this course, students must take and pass a computerized final exam (CEAFE) with a minimum of 35% and have at least 70% on overall course average before taking the college-level mathematics required for their associated degree. Students either pass with a grade of "S" or repeat the class with a grade of "R". The rate of students who successfully completed this course in 2014 was 38.9%. This first remedial course covers contents such as "signed numbers, algebraic representation, factoring, operations with polynomials, the coordinate system, the solutions of simultaneous linear equations of two variables and graphing" (see Table 2).

Table 2. Outline of Topics

Week 1	Chapter 1 The Basics 1.1 Variables, Notation, and Symbols 1.2 Real Numbers 1.3 Addition and Subtraction of Real Numbers 1.4 Multiplication of Real Numbers 1.5 Division of Real Numbers		Week 8	Chapter 5 Exponents and Polynomials 5.1 Multiplication with Exponents 5.2 Division with Exponents (scientific notation) 5.3 Operations with Monomials 5.4 Addition and Subtraction of Polynomials
Week 2	1.6 Properties of Real Numbers 1.7 Subsets of Real Numbers 1.8 Addition and Subtraction of Fractions with Variables Chapter 2 Linear Equations and Inequalities 2.1 Simplifying Expressions 2.2 Addition Property of Equality		Week 9	5.5 Multiplication with Polynomials 5.6 Binomial Squares and Other Special Products 5.7 Dividing a Polynomial by a Monomial Chapter 6 Factoring 6.1 The GCF and Factoring by Grouping
Week 3	2.3 Multiplication Property of Equality 2.4 Solving Linear Equations (including rational equations from supplemental material) **(Supplemental Material on WebAssign)** 2.5 Formulas 2.6 Applications Proportions and Percents**(Supplemental material on WebAssign)**		Week 10	6.2 Factoring Trinomials 6.3 More Trinomials to Factor 6.4 The Difference of Two Squares
Week 4	2.7 More Applications 2.8 Linear Inequalities Chapter 3 Linear Equations and Inequalities in Two Variables 3.1 Paired Data and Graphing Ordered Pairs 3.2 Solutions to Linear Equations in Two Variables		Week 11	6.6 Factoring: A General Review 6.7 Solving Equations by Factoring 7.1 Simplifying Rational Expressions Chapter 8 Square Roots 8.1 Definitions and Common Roots
Week 5	3.3 Graphing Linear Equations in Two Variables 3.4 More on Graphing: Intercepts 3.5 The Slope of a Line 3.6 Finding the Equation of a Line		Week 12	8.2 Properties of Radicals 8.3, 8.4 Operations with Radicals **Pythagorean Theorem (Supplemental Material on WebAssign)**
Week 6	Chapter 4 Systems of Linear Equations 4.1 Solving Linear Equations by Graphing 4.2 The Elimination Method 4.3 The Substitution Method 4.4 Applications		Week 13	Review for Final Exam **Department Final Exam**(13th or 14th week)
Week 7	Review for Midterm Exam **Departmental Midterm Exam:** Signed Numbers, Algebraic Expressions and Exponents, Solving and Graphing Linear Equations/Inequalities, Systems of Linear Equations		Week 14	**Department Final Exam** Review for the **CUNY-Wide Math EXAM (CEAFE)**
			Week 15	**MATH CUNY-Wide EXAM (CEAFE)**

The elementary algebra course is generally taught in a standard lecture format. Although some teachers of the algebra sections may have adopted the use of small groups or an individual basis occasionally, regular group work is not a customary part of the elementary algebra class. Although other elements of the pedagogy used in the mathematical literacy course, such as writing and the extensive use of real data, may have been implemented by individual teachers, these elements are not customary components of the traditionally taught version of the course. The elementary algebra student learning outcome is illustrated in Table 3.

Table 3. Elementary Algebra Student Learning Outcomes

<u>Variables and Expressions</u> a. Translate a quantitative verbal phrase into an algebraic expression. b. Add and subtract monomials and polynomials. c. Evaluate algebraic expressions by substitution. d. Multiplication of a monomial and binomial by any degree polynomial. e. Divide a polynomial by a monomial. f. Factoring i. Identify and factor the greatest common factor from an algebraic expression. ii. Identify and factor the difference of two perfect squares. iii. Factor all trinomials of a single variable, including a leading coefficient other than 1. iv. Factor algebraic expressions by grouping with up to 4 terms. v. Factor algebraic expressions completely where factorization requires more than one step.
<u>Equations and Inequalities</u> a. Translate sentences into mathematical expressions or equations. b. Solve linear equations in one variable. c. Systems of Linear Equations (2x2) i. Solve systems of two linear equations in two variables algebraically. ii. Solve systems of two linear equations in two variables graphically. d. Solve literal equations for a given variable. e. Quadratic Equations i. Understand and apply the zero-factor property to solve quadratic equations with integer coefficients. ii. Solve quadratic equations. iii. Determine the measure of a third side of a right triangle using the Pythagorean Theorem, given the lengths of any two sides. f. Linear inequalities in a single variable: Solve linear inequalities in one variable and represent the solution on a number line.

Table 3 (continued)

Coordinate Geometry a. Slope and equations of a line i. Determine the slope of a line, given the coordinates of two points on the line. ii. Determine the slope of a line, given the line’s graph. iii. Write the equation of a line, given its slope and the coordinates of a point on the line. iv. Write the equation of a line, given the coordinates of two points on the line. v. Write the equation of vertical or horizontal lines. vi. Determine the slope of a line, given its equation in any form. vii. Find the slope of any line parallel or perpendicular to a given line. viii. Write and transform equations of lines in the following forms: Point-Slope form, Slope intercept form, Ax + By = C form. b. Draw and recognize graphs of lines.
Proportions and Percent a. Solve simple verbal problem with two quantities that are proportional. b. Solve simple verbal problem involving a single percent including increase/decrease.

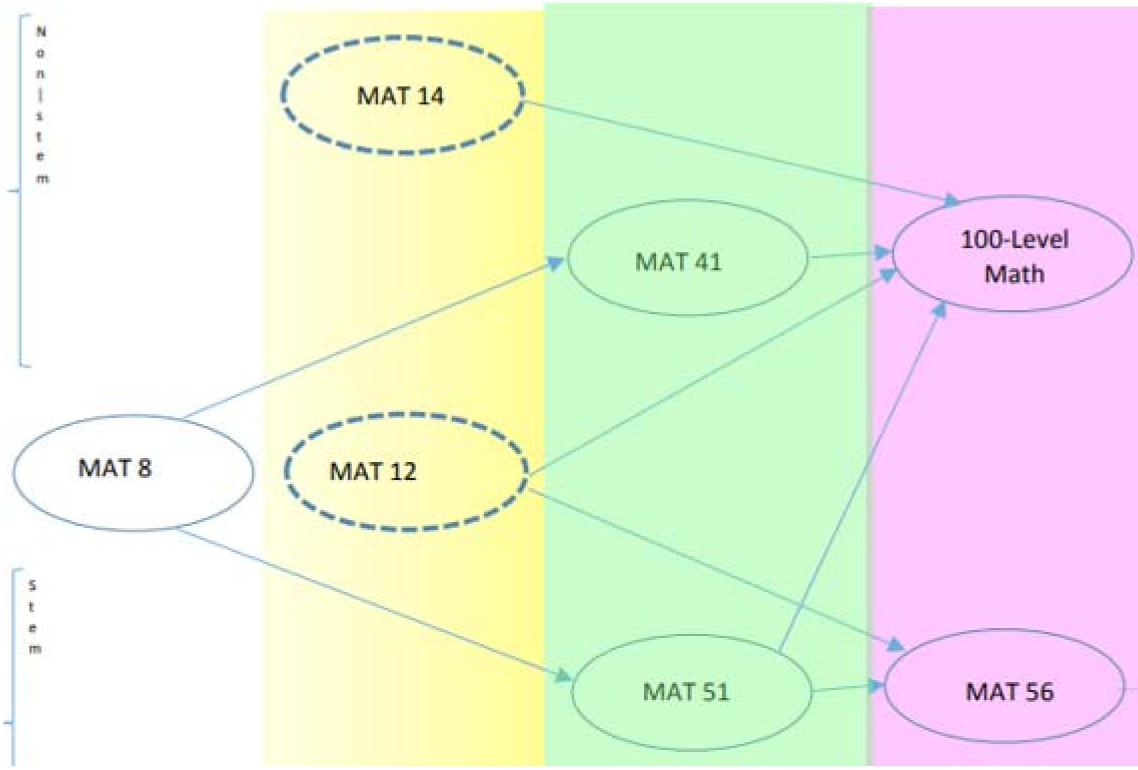
Sources: Retrieved from the College` Mathematics Department website

Mathematical Literacy Course

The mathematics literacy course involved in this study is MAT 41, “an innovative remedial mathematics course designed to prepare and move students to college-level work more quickly” (Carnegie Foundation, n.d.). (The course has been developed in collaboration with the Carnegie Foundation.) MAT 41 is a non-credit developmental course taught for 4 hours a week using a “student-based pedagogy that encourages learners to struggle with real-world problems that need mathematics rather than memorizing procedures for solving algebraic equations” (Carnegie Foundation, n.d.). Similar to the elementary algebra courses, students who take the ACT COMPASS and obtain a score greater than 45 on the arithmetic and less than 40 on the elementary algebra portions are placed in the mathematical literacy QuantWay courses if their fields do not require calculus. Also, students who pass the basic mathematics or are exempt by their score on the college placement test are placed in this class. Students pass with a “S” or fail with a “R.” A cumulative score of at least 70% and a minimum score of 60% on the comprehensive final examination are required in order to pass the class. Students who fail the course cannot move on to college-level courses. Their GPA is not affected if they don't succeed; they simply need to retake the course. The rate of students who successfully completed this course in 2014 was 53%. This course is "an alternative and accelerated pathway to the college level liberal arts mathematics courses." The required textbook and readings are *Mathematical Literacy*, College Edition. MAT 41 focuses on applications of arithmetic, proportional reasoning, and algebra using three themes:

- Citizenship: students study how to understand quantitative information about societies, government, and the world that is important in many decisions they make.
- Health: students learn how to understand quantitative information about health issues and medical treatments.
- Personal finance: students learn how to understand and use quantitative information to make decisions in their lives. (Appendix D)

The course cannot be taken as a prerequisite for any Science, Technology, Engineering, or Mathematics (STEM) courses. The mathematical literacy and the elementary algebra courses differ in their pedagogy. Figure 2 shows the sequence of mathematics courses offered by the college.



Source: *Retrieved* from the College's Mathematics Department Website

MAT 8: Basic Mathematics
MAT 12: Basic Arithmetic and Algebra
MAT 14: Mathematical Literacy with Computational Support
MAT 41: Mathematical Literacy QuantWay 1
MAT 51: Elementary Algebra
MAT 56: Intermediate Algebra and Trigonometry
MAT 100 Levels: College level mathematics

Figure 2. Remedial Mathematics Sequences

MAT 41 is created to fulfill a general education requirement (see Tables 4 and 5).

Table 4. Mathematical Literacy Outcomes

1. Students will demonstrate quantitative reasoning to analyze problems, critique arguments, and draw and justify conclusions using the following skills and concepts.
Q.1 Performing arithmetic operations
Q.2 Using proportional reasoning, geometric concepts of area and volume, statistical and probabilistic reasoning
Q.3 Understanding how quantities change including, but not limited to, multiplicative vs. additive and relative vs. absolute
Q.4 Estimating both in terms of mathematical calculations, and in contexts where estimation of values is essential because exact measures are unknown
Q.5 Making comparisons based on relative magnitude
Q.6 Understanding the magnitude and representations of numbers
Q.7 Understanding and using concepts of measurement: units, precision, accuracy, error
Q.8 Creating and using models (tables, words, graphs, and equations) of real-world situations
Q.9 Checking answers and determining the reasonableness of results
Q.11 Reading and interpreting quantitative information from a variety of real-world situations
Q.12 Knowing where to find relevant data and how to evaluate its appropriateness for purpose and validity of source
Q.13 Organizing and translating between and among various representations of quantitative information
Q.14 Analyzing and using quantitative information to support an argument
Q.15 Recognizing, making and evaluating quantitative assumptions

2. Students will communicate quantitative results in writing and orally using appropriate language, symbolism, data, and graphs.

3. Students will use technology appropriately as a tool, including using computers and the internet to gather, research, and analyze quantitative information, using spreadsheets, data simulations and other appropriate technology, and knowing when and how to use calculators appropriately.

4. Students will exhibit confidence in quantitative reasoning through perseverance and ability to transfer prior knowledge in unfamiliar context.

Source: *Retrieved* from the College's Mathematics Department Website

Table 5. Mathematical Learning Outcomes

1. Numeracy: Students will develop and apply the concepts of numeracy to investigate and describe quantitative of and competency in using magnitude in the context of place values, fractions, and numbers written in scientific notation.
N.3 Use estimation skills, knowing how and when to estimate results and to what precision, to solve problems, detect errors, and check accuracy relationships and solve problems in a variety of contexts. Therefore, students will be able to:
N.1 Demonstrate operation sense and communicate verbally and symbolically the effects of common operations on numbers.
N.2 Demonstrate an understanding.
N.4 Apply quantitative reasoning to perform calculations in applications involving quantities or rates.
N.5 Demonstrate measurement sense.
N.6 Demonstrate an understanding of the mathematical properties and uses of different types of mathematical summaries of data (e.g., measures of central tendency) and mathematical models.
N.7 Read, interpret, and make decisions based on data from graphical displays (e.g., line graphs, bar graphs, scatterplots, histograms).

2. Proportional Reasoning: Students will represent proportional relationships and solve problems that require an understanding of ratios rates, proportions, and scaling. Therefore, students will be able to:
P.1 Recognize proportional relationships represented in different ways.
P.2 Compare proportional relationships represented in different ways.
P.3 Apply quantitative reasoning strategies to solve real-world problems with proportional relationships based on an understanding that derived quantities can be described with whole numbers, fractions, or decimals, or in a combination of these, and that to fully explain these relationships, units must be used to investigate, represent, and solve problems. Therefore, students will be able to:
A.1 Understand various uses of variables to represent quantities or attributes.
A.2 Describe the effect that a change in the value of one variable has on the value(s) of other variables in the algebraic relationship.
A.3 Construct and use equations or inequalities to represent relationships involving one or more unknown or variable quantities to solve problems.

3. Functions: Students will represent relationships between quantities in multiple ways and solve problems that require an understanding of functions. Therefore, students will be able to:
F.1 Translate problems from a variety of contexts into a mathematical representation and vice versa.
F.2 Describe the behavior of common types of functions using words, algebraic symbols, graphs, and tables.
F.3 Identify when a linear model or trend is reasonable for given data; when a linear model does not appear to be reasonable, know how to explore the applicability of other models.
F.4 Identify important characteristics of functions in various representations.
F.5 Use appropriate terms and units to describe rate of change.
F.6 Understand that abstract mathematical models used to characterize real-world scenarios or physical relationships are not always exact and may be subject to error from many sources, including variability.

Source: *Retrieved* from the College's Mathematics Department Website

To make sense of the world, the mathematical literacy course focused on applications of quantitative reasoning, involving topics from arithmetic, proportion, and basic algebra (Table 6).

Table 6. Mathematical Literacy Outline of Topics

Weeks	Topics Covered	Lesson #
Week 1	Introduction to Quantitative Reasoning What is Percent?	1.1 1.2
Week 2	Affordable Care Act Whose Footprint is Bigger?	1.3 1.4
Week 3	Interpreting Statements About Percentages Module 1 Review	1.5
Week 4	Module 1 Assessment How Crowded Are We?	**Exam 1** 2.1
Week 5	Counting Our Votes Measuring Population Change	2.2 2.3
Week 6	Picturing Data with Graphics What is Average?	2.4 2.5
Week 7	What is the Chances? Module 2 Review	2.6
Week 8	Module 2 Assessment What is the Correct Dose?	**Exam 2** 3.1
Week 9	The Facts on the Ground The Fixer Upper	3.2 3.3
Week 10	Balancing Blood Alcohol A Return to Proportional Reasoning	3.4 3.5
Week 11	Module 3 Review Module 3 Assessment	**Exam 3**
Week 12	Modeling Money More Liner Modeling	4.1 4.2
Week 13	Compounding Interest Makes Cents Compounding Makes More Cents	4.3 4.4
Week 14	The Rising Seas Module 4 Review	4.5
Week 15	Module 4 Assessment Final Assessment Review	**Exam 4**
Week 15	Final Exam	**Final**

Source: *Retrieved* from the College's Mathematics Department Website

Study Design

The underlying philosophy guiding this research is pragmatism, which "opens the door to many approaches for collecting and analyzing data rather than subscribing to only one way" (Creswell, 2018, p. 10). Pragmatism supports mixed-methods studies in order to provide the best understanding of the research problems and questions by using all available approaches (Figure 3).

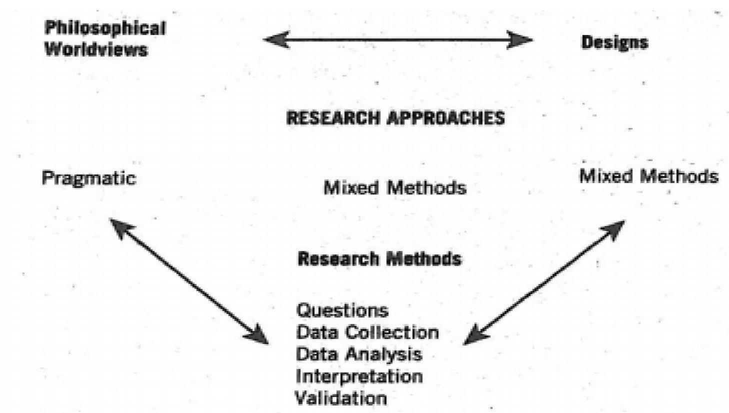


Figure 3. Framework Guiding the Research Methods

A mixed-methods study was utilized to answer the research questions of this study. A *mixed-methods* study is defined as "an approach to inquiry involving the collection of both qualitative (open-ended) and quantitative (closed-ended) data in response to research questions, integrating the two forms of data and using distinct designs that may involve philosophical assumptions or theoretical frameworks" (Creswell, 2018, p. 4). In the words of Caruth (2013), "mixed method research has become a valid alternative to quantitative or qualitative research designs. It offers richer insights into the phenomenon being studied and allows the capture of information that might be missed by utilizing only one research design" (p. 112).

The drive of this study is to examine and evaluate the effects of a mathematical literacy course on students' attitudes regarding mathematics. Quantitative data alone won't provide a full picture of such effects. Creswell (2018) declared, "In a sense, more insight into a problem is to be gained from mixing or integration of the quantitative and qualitative data. This mixing or integrating of data, it can be argued, provides a stronger understanding of the problem or question than either by itself" (p. 213). Caruth (2013) indicated an advantage of utilizing a mixed method design: "words, photos, and narratives can be used to add meaning to numbers while numbers can add precisions to words, photos, and narrative" (p. 115). Quantitative data give numerical differences, while qualitative data explain in detail the data. The use of mixed method design has the power to take advantages of both. According to Creswell (2018),

> At a general level, mixed method design is chosen because of its strength of drawing on both qualitative and quantitative research and minimizing the limitations of both approaches. At a practical level, mixed methods provide a sophisticated, complex approach to research that appeals to those on the forefront of new research procedures. It also can be an ideal approach if the researcher has access to both quantitative and qualitative data. At a procedural level, it is a useful strategy to have a more complete understanding of research problems and questions. (p. 216)

To collect quantitative data, pre- and post-attitude surveys were administered to students. To collect qualitative data, an open-ended questionnaire was used during the last week of the semester.

The quantitative data were chosen as appropriate for evaluating the change in students' attitudes before and after taking courses and comparing the change in attitudes between the two groups of students. According to Bordens and Abbott (1999), "pretest and posttest designs are used to evaluate the effects of some change in the environment on subsequent performance" (p. 260); they added, "By using a pre-test and post-test designs, you compare the level of performance before the introduction of your change to levels of performance after the introduction of the change" (p. 260).

The qualitative data were chosen as appropriate for measuring the change in learners' attitudes as the result of taking the mathematical literacy course. Participants were provided with an open-ended question about their opinions and feelings on the new courses.

A convergent mixed-methods design was utilized to add depth and precision to this study (Figure 4).

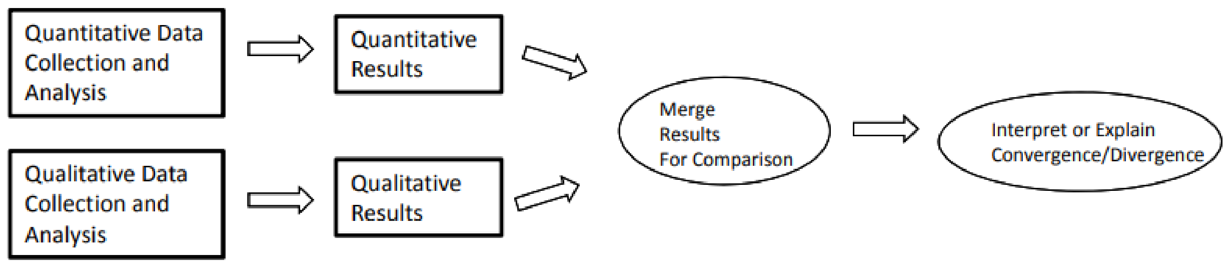


Figure 4. Convergent Mixed-Methods Design

Source: J. W. Creswell (2018). *Research design: Qualitative, quantitative and mixed methods approaches*.

A convergent mixed approach design was used because of the need to "converge or merge quantitative and qualitative data in order to provide a more comprehensive analysis of the research problems" (Creswell, 2018, p. 15). Further, Creswell described convergent mixed methods as follows:

> The convergent mixed methods design is probably the most familiar of the core and complex mixed methods approaches. In this single-phase approach, a researcher collects both quantitative and qualitative data, analyzes them separately, and then compares the results to see if the findings confirm or disconfirm each other. The key assumption of this approach is that both quantitative and qualitative data provide different types of information—often detailed views of participants qualitatively and scores on instruments quantitatively—and together they yield results that should be the same. (p. 217)

Setting and Participants

The research was conducted in an accredited two-year public college in the greater New York City area. During fall 2017, 26,748 students enrolled in credit programs at the college (6,580 first-time freshmen, 1,511 transfers, 1,723 readmits, 15,734 continuing students, 520 special admits, 680 nondegree), of which 15,317 were females and 11,431 were males. The major ethnicities were categorized as follows: 41.9% Hispanic, 31.4% Black, 14.3% Asian, 11.9% White, and 0.4% American Indian. In terms of gender, 56.7% of students were females and 43.7% were male. About 76.4% of students were under the age of 25 (CUNY, Office of Institutional Research and Assessment, 2016). The college has 1,496 faculties (952 part-time, 544 full-time) and awards three degrees: the Associate in Arts (AA), the Associate in Science (AS), and the Associate in Applied Science (AAS). The Mathematics Department remains the largest department with 63 full-time instructors and 172 adjuncts. Learners entering the school are assessed through placement examinations and reviews of their performance records from high schools to determine their competence in basic skills. The results from such exams are used to place students in the developmental mathematics courses they need to master before taking credit-bearing mathematics coursework. In fall 2016, over 5,000 of new freshmen students (72%) failed the ACT COMPASS Mathematics 2 exam and were placed in remedial mathematics.

To evaluate the effects of a mathematical literacy course on students' attitudes, two groups of students who were in need of basic skills in mathematics at the level of remediation were surveyed, one group taking mathematical literacy courses and another group taking algebra courses. A total of 79 students responded to the pre-survey, and 68 responded to the post-survey.

Theoretical Framework and Instrument

The collection and analysis of any data should be based on a theoretical framework whether it is a quantitative, qualitative or mixed methods approach. Consequently, in order to examine and evaluate these issues, two frameworks were utilized to collect and analyze data. Although many prominent quantitative instruments exist, for the intent of this study, the focus is on those validated instruments that measure students' attitudes at the college levels. Tapia`s Attitudes Towards Mathematics Inventory (Tapia, 1996) was used to collect and analyze quantitative pre- and post-survey data about learners` attitudes regarding mathematics. The full length of Tapia`s Attitudes Towards Mathematics Inventory consists of four instruments (self-confidence, value, enjoyment, and motivation) with a total of 40 items. Items from such frameworks that measure attitudinal variables of self-confidence (confidence and self-concept of performance), value and usefulness of mathematics (beliefs of students about usefulness and relevance of math in their lives) were selected (Figure 5).

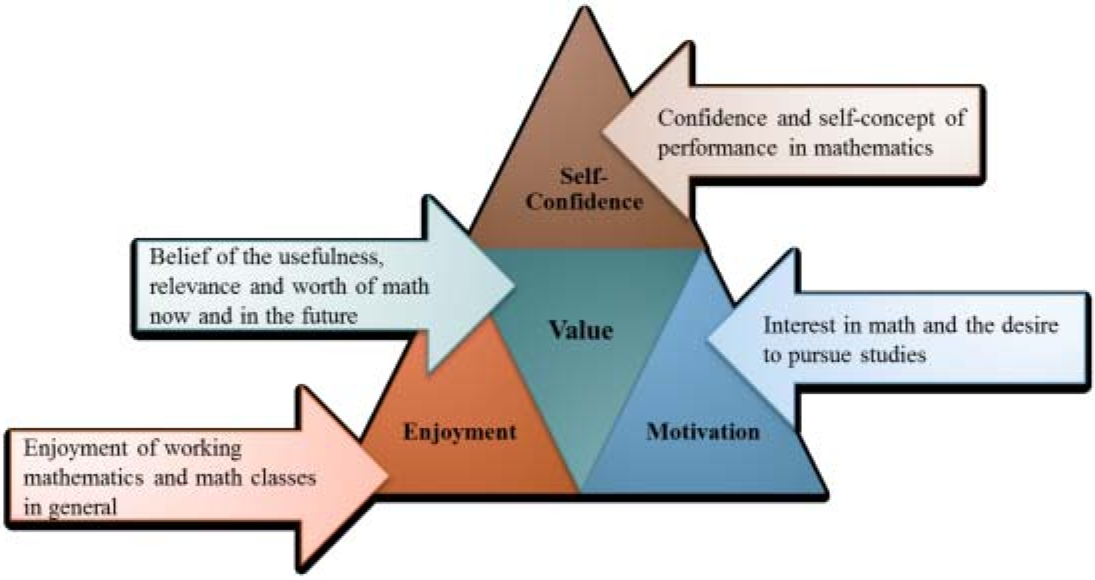


Figure 5. Attitude Towards Mathematics Instrument factor descriptions. Retrieved from "An Instrument to Measure Mathematics Attitudes," by M. Tapia and G. Marsh, III, 2004, *Academic Exchange Quarterly, 8*(2), p. 17.

Additionally, these frameworks guided the analysis of the qualitative data gathered through open-ended questionnaires, particularly how learners' views concerning their experiences support or challenge the quantitative findings.

During the first and last week of the 2017 fall semester, a survey of 14 questions (Appendix A) was administered to students in the mathematical literacy and elementary algebra courses. One of the purposes of the survey was to gain some insight into the changes of student attitudes regarding mathematics. The surveys involved questions that help measure learners' attitudes regarding mathematics and its relevance to their daily lives. Participants answered such questionnaires before and after taking both courses. Items 1, 2, 3, 4, and 5 measured the value and usefulness of mathematics, while items 6, 7, 8, 9, and 10 measured mathematics self-confidence. Items 11, 12, 13 and 14 on the mathematics-attitude survey were questions of particular importance to the mathematical literacy courses and were added to measure student attitudes toward enjoying real-life world problems, group work, using computers, and finally, a willingness to take further mathematics courses. All these items were taken from Tapia`s "Attitude Towards

Mathematics Inventory" (shown in Appendix B). In addition, an open-ended survey of five questions (shown in Appendix C) was given to students after completing the mathematical literacy course.

Data Collection and Analysis

Student Attitudes Toward Mathematics

To evaluate and measure any changes in attitudes, the mathematics attitude surveys were distributed by instructors in class during the first week and again during the last week of class.

To answer question 1, the pre- and post-surveys were given to students to examine if any relationship existed between the mathematical courses and student growth in mathematics self-confidence and to determine if any correlation existed between the mathematical courses and student growth in perceived value and usefulness of mathematics. Both the value and usefulness of mathematics and mathematics self-confidence subscale included five items each. They were measured using a Likert Scale Questionnaire 1-5, coded as: "Strongly agree = 5, Agree = 4, Neutral = 3, Disagree = 2 and Strongly disagree = 1." Items 5 and 7 were reverse coded. A composite score was calculated as the total of the five items and could range from 5 to 25, with larger scores meaning a more positive attitude.

All subsequent analysis about the mathematics attitudes surveys were conducted using a descriptive statistic, SSPS, and independent t-tests (Creswell, 2018). An independent t-test is more appropriate to compare two groups in terms of outcomes (Creswell, 2018, p. 159). To measure the change in students' attitudes between the two groups, an independent t-test was utilized. A total of 14 questions were used to evaluate changes in student attitude toward mathematics after taking the mathematical literacy course or the elementary algebra course. Such questions evaluated student attitudes prior to the class, and their attitudes after completing the course. The net gain was determined by taking the difference in value for the responses.

Students' Views of Their Experiences

To answer question 2, qualitative data were gathered with open-ended questionnaires administered to participants in the mathematical literacy sections during the last week of the semester to offer richer insights into the findings from the attitude survey.

The qualitative data were analyzed following the steps advised by Creswell (2018): "Organize and prepare the data for analysis; read or look at all the data and start coding all the data. Coding is the process of organizing the data" (p. 193).

After collecting and organizing data, responses were coded as *useful, not useful*, or *neutral* for usefulness of working in groups, as *yes*, *no*, or *blank* for students' attitudes toward the mathematical literacy course, and were coded as indicative of a *positive change*, a *negative change*, or *no real change* for students' attitudes toward mathematics. These questions provided students with opportunities to share what they liked or disliked about the course and offer richer insights into the results of the aforementioned surveys.

Validity

Creswell (2018) defined validity as "one of the strengths of qualitative research … based on determining whether the findings are accurate from the standpoint of the researcher, the participant, or the readers of an account" (p. 199). This author indicated procedures that researchers must use to measure validity: "Procedures for validity include those strategies used by researcher to establish the credibility of their study" (p. 125). By following the recommendations of Creswell, *multiple validity procedures* were utilized to "enhance the ability to assess the accuracy of findings as well as convince reader of that accuracy" (p. 200). Creswell indicated eight primary strategies to check for validity: "Triangulate different data sources, use member checking, use a rich, thick description, clarify the bias the researcher brings, present negative or discrepant information, spend prolonged time in the field, use peer debriefing, and use an external auditor" (pp. 200-201). In this study, expert panels, spending time in the field, and triangulation were used to ensure validity of the findings. The issues of validity were addressed by having a team of critical colleagues review the research instruments and the data, either collaboratively or independently. Based on their comments and feedback, questions that were unclear or obscure were revised and reworded. Also, by "spending prolonged time in the field, the researcher develops an in-depth understanding of the phenomenon under study. The more experience the researcher has in the field, the more accurate or valid will be the findings" (p. 201). The researcher has taught many sections of mathematical literacy and elementary algebra within the same site of the study. In addition, "validity using the convergent approach should be based on establishing both quantitative validity and qualitative validity" (Creswell, 2018, p. 221). To strength the validity of the data analysis and findings, triangulation was utilized to gain quantitative and qualitative data in order to corroborate the findings (p. 4). In the words of Creswell, "triangulating data sources is a means for seeking convergence across qualitative and quantitative methods" (p. 14). Quantitative data were gathered through Likert-type questions, and qualitative data were collected through open-ended questions. Opinions that learners have about the mathematics attitude surveys were cross-validated with their responses from the open-ended questions.

Creswell (2018) declared that reliability of data and findings indicate that the "researcher's approach is consistent across different researchers and different projects" (p. 199). Further, Nunan (1999) stated that reliability addresses the dependability and replicability, as well as the consistency of the "results obtained from a piece of research" (p. 14). The dependability of the findings can be guaranteed by using methods such as triangulation and the researcher position (Lincoln & Guba, 1985; Merriam, 1998). To strengthen the reliability of this study, the different steps of the procedures were clearly explained. Additionally, the design and rationale of the study, as well as the subjects, were described in detail. Various procedures such as open-ended questions and Likert-type questions were used to collect data, and information was obtained from different learners in six courses' sections. Consequently, this strategy adds reliability to the data and the findings in this study. Additionally, in this study, quantitative data were gathered using Tapia`s Attitudes Towards Mathematics Inventory which has greater internal reliability and was validated for students in the college level mathematics (Tapia & Marsh, 2005).

Ethical Considerations

To ensure that the requirements for ethical research were met, an IRB application was requested from the Office of Research Compliance, and approval was ultimately granted. Issues inside the IRB application involved possible sensitivities of the study regarding the activity, the procedure and design, as well as voluntary participation, confidentiality, anonymity, risk, and informed consent. Participants in the research were informed of the objective of the study and their roles. They were not forced to participate in the study and could stop at any moment. Participants need to sign a letter of informed consent (Appendix E), which described the objective of the research, the methodology, the eventual benefits, and information about anonymity, confidentiality, as well as eventual risks involved in participating. White (2005) stated that anonymity occurs when the researcher is unable to identify given responses with given respondents. According to Cohen et al, (2001), confidentiality means that "although researchers know who has provided the information or are able to identify participants from the information given, the boundaries surrounding the shared secret will be protected" (p. 62). Participants were not expected to disclose their names. Completion of mathematics-attitude surveys was a choice and was not an obligation. Though a line was given for students to fill in their college name as on the mathematics attitude surveys, this information was not necessary. Therefore, in order to obtain more responses, teachers informed students that they could complete the survey anonymously. Completion of the open-ended questions provided during the last week of the semester in the mathematical literacy course was optional as well.

Chapter IV

FINDINGS

The findings of the research will be organized and discussed in the order in which the study questions were presented in the first chapter. For each study question addressed, the sample and analysis are described.

Student Attitudes About Mathematics

The first research question evaluated any change in participants' growth in self-confidence and in perceived value and usefulness of mathematics after completing the mathematical literacy course and elementary algebra course: How are attitude toward self-confidence and ability of doing mathematics, as well as the value and usefulness of mathematics, affected by taking a mathematical literacy course?

Student Attitudes Toward Mathematical Self-Confidence

Mathematics self-confidence was evaluated using the response to questions 6, 7, 8, 9, and 10. Scores on this self-confidence scale could range from 5 to 25, with larger scores meaning a greater positive mathematics self-confidence.

Learners indicated positive changes in their self-confidence and capability of doing mathematics. Specifically, the mean self-confidence and ability of doing mathematics slightly increased from 14.75 to 14.78 for the elementary algebra sections, and from 14.46 to 14.52 for the mathematical literacy sections. Students in mathematical literacy reported a gain of 0.06 points while their counterparts in elementary algebra reported a gain of 0.03. So essentially, neither the change in self-confidence for MAT 41 students (pre-post) nor MAT 51 students was statistically significant. Further, there was no statistically significant difference between the post-course self-confidence scores of the two groups (t = 0.150, p = 0.8809) (see Table 7).

Table 7. Pre- vs. Post-survey Self-confidence

	Mean(SD)				95%			
	n	pre	post	net	lower	upper	t-test	p
MAT 41	28	14.46(3.19)	14.52(3.20)	.06(.85)	-1.65	1.77	0.07	.94^{NS}
MAT 51	40	14.75(3.47)	14.78(3.48)	.03(.78)	-1.52	1.58	.04	.97^{NS}

Difference	0.030	t-statistics	0.150
Standard error	0.199	DF	66
95% CI	-0.3682 to 0.4282	Significance level	P = 0.8809

Scores could range from 5 to 25.

Note: ^{NS} = Not Significant

Student Attitudes Toward the Value and Usefulness of Mathematics

The score could range from 5 to 25, with a larger score reflecting a greater positive attitude regarding the perceived value and usefulness of mathematics. Overall, participants reported positive changes in the value and usefulness of mathematics. The reported mean score value and usefulness for the elementary algebra courses increased from 16.28 to 17.35 and from 17.46 to 19.79 for the mathematical literacy courses. Students in the mathematical literacy reported a gain of 2.33 points, while students in elementary algebra reported a gain of 1.08. Results of this analysis revealed a difference between the post-test scores of the two groups that was statistically significant (t = 2.712, p = 0.0085). The mathematical literacy group seems to have increased in attitude regarding the perceived value and usefulness of mathematics (Table 8).

Table 8. Pre- vs. Post-survey Value and Usefulness of Mathematics Using t-Test

	Mean(SD)				95%			
	n	pre	post	net	lower	upper	t-test	P
MAT 41	28	17.46(3.45)	19.79(3.95)	2.33(.99)	.34	4.32	2.31	.0222**
MAT 51	40	16.28(3.86)	17.25(5.58)	1.08(2.29)	-.94	3.09	1.08	$.28^{NS}$

Difference	1.250	t-statistics	2.712
Standard error	0.461	DF	66
95% CI	0.3297 to 2.1703	Significance level	P = 0.0085

Scores could range from 5 to 25.

Note: **= $p < 0.05$; ^{NS} = Not Significant

Student Attitudes About Real-World Problems

This study also explored whether students preferred solving real-world problems after their mathematics class experiences. This item of the mathematics attitude survey was not specifically part of either of the aforementioned scales. The responses for this item, “I like solving real-world problems in mathematics,” were used to investigate possible relationships between the mathematical literacy course and students’ attitudes toward real-world application problems. The score could range from 1 to 5, with a larger score meaning a greater positive preference regarding real-world applications. The findings showed that the mean score on preference regarding real-world problems for the mathematical literacy course increased significantly, while the mean of the elementary algebra sections decreased. Particularly, the average score on preference regarding real-world problems for the mathematical literacy courses increased from 2.78 to 4.77, while the mean of the elementary sections decreased from 3.29 to 3.25. Students in mathematical literacy sections reported a gain in attitude toward their preference in real-world problems of 1.99 points, while their counterparts in elementary in algebra reported a loss of 0.04. Results of this analysis revealed a difference between the post-test scores of the two groups that was statistically significant ($t = 7.967$, $P < 0.0001$). The mathematical literacy group seems to have increased in enjoyment in solving real-world problems (see Table 9).

Table 9. Pre- vs. Post-survey Attitudes about Real-world Problems Using t-Test

	Mean(SD)				95%			
	n	pre	post	net	lower	upper	t-test	p
MAT 41	28	2.78(3.34)	4.77(3.95)	1.99(.98)	-.03	3.95	2.04	.04**
MAT 51	40	3.29(3.86)	3.25(5.58)	-.04(1.07)	-2.18	2.10	-.04	$.97^{NS}$

Difference	2.030	t-statistics	7.967
Standard error	0.255	DF	66
95% CI	1.5213 to 2.5387	Significance level	P < 0.0001

Scores could range from 1 to 5.

Note: **= $p < 0.05$; ^{NS} = Not Significant

Student Attitudes About Working in Small Groups

The study also investigated whether participants enjoyed working as a group after completing the courses. Results for the item "I enjoy working in small groups when solving problems" were used to examine the relationship between the mathematical literacy course and students' attitudes toward working in groups in a mathematical classroom. The score could range from 1 to 5, with a larger score meaning a more positive attitude regarding working in groups.

Findings of this analysis showed that the mean scores on attitudes regarding working in small groups increased for both courses. The average score reported on students' responses significantly increased from 3.11 to 4.08 for the mathematical literacy courses, and slightly increased from 3.45 to 3.55 for the elementary algebra courses. Students in mathematical literacy reported a gain in their attitudes about working in groups that was 0.97, while students in elementary algebra reported only a gain of 0.10. Findings of this analysis revealed a difference between the pre-post test scores of the two groups that was statistically significant (t = 2.445, p = 0.0172). The mathematical literacy group seems to have increased in enjoyment in working with small groups (see Table 10).

Table 10. Pre- vs. Post-survey Attitudes About Group Work Using t-Test

	Mean(SD)				95%			
	n	pre	post	net	lower	upper	t-test	P
MAT 41	28	3.11(1.17)	4.08 (1.25)	.97(.32)	0.32	1.62	3.00	.004^{NS}
MAT 51	40	3.45(1.11)	3.55(1.1)	.10(1.86)	-.50	.70	.34	.74^{NS}

Table 10 (continued)

Difference	0.870	t-statistics	2.445
Standard error	0.356	DF	66
95% CI	0.1594 to 1.5806	Significance level	P = 0.0172

Scores could range from 1 to 5

Note: **= $p < 0.05$; ^{NS} = Not Significant

Student Attitudes Regarding Using Computers

To investigate any possible relationship between taking the mathematical literacy course and student attitudes toward using computers in mathematics, responses to "Using computers helps me learn mathematics" were examined. The score could vary from 1 to 5, with a larger score reflecting a greater positive attitude regarding working with computers.

Findings of the analysis showed that the reported mean scores on attitudes regarding using computers increased for both courses. Particularly, the mean scores on this item increased slightly from 3.13 to 3.28 for the elementary algebra sections and significantly from 2.71 to 3.89 for the mathematical literacy sections. Students in mathematical literacy sections reported a gain in their attitude toward using computers of 1.18, while students in elementary algebra reported only a gain of 0.15. Findings of this analysis revealed a difference between the post-test scores of the two groups that was statistically significant ($t = 2.628$, $p = 0.0107$). The mathematical literacy group seems to have increased in attitude toward using computers when solving mathematics problems (see Table 11).

Table 11. Pre- vs. Post-survey Attitudes Regarding Using Computers

	Mean(SD)				95%			
	n	pre	post	net	lower	upper	t-test	p
MAT 41	28	2.71(1.36)	3.89(1.17)	.1.18(.34)	.50	1.86	3.48	.001**
MAT 51	40	3.13(1.34)	3.28(1.36)	.15(2.05)	-.50	.80	-.46	$.64^{NS}$

Difference	1.030	t-statistics	2.628
Standard error	0.392	DF	66
95% CI	0.2474 to 1.8126	Significance level	P = 0.0107

Scores could range from 1 to 5.

Note: **= $p < 0.05$; ^{NS} = Not Significant

Attitudes Toward Taking Another Mathematics Class

The last item was "After taking this course, I would consider taking another mathematics class." As with the previous three items, higher scores reflect greater willingness to take another mathematics course. The item explored how student attitude toward taking additional mathematics changes because of completing the mathematical literacy course or the elementary algebra course. The score could range from 1 to 5, with a larger score reflecting a greater willingness to take additional mathematics courses.

Overall, participants in both courses reported a positive change in their willingness to take additional mathematics courses. The mean slightly increased from 3.39 to 3.57 for the mathematical literacy section and from 3.15 to 3.43 for the elementary algebra section. Students in the mathematical literacy course reported a gain of 0.18 points, while students in the elementary algebra course reported a gain of 0.28 points. So essentially, neither the change in willingness to take additional mathematics courses for MAT 41 students (pre-post) nor MAT 51 students was statistically significant. Further, there was no statistically significant difference between the post-course willingness to take additional mathematics scores of the two groups (t = -0.251, p = 0.8029) (see Table 12).

Table 12. Pre- vs. Post-survey Attitudes Toward Taking Another Mathematics Class

	Mean(SD)				95%			
	n	pre	post	net	lower	upper	t-test	p
MAT 41	28	3.39(1.17)	3.57(1.25)	.18(.32)	-.47	.83	-.56	.58^{NS}
MAT 51	40	3.15(1.27)	3.43(1.38)	.28(2.09)	-.39	.94	.83	.41^{NS}

Difference	-0.100	t-statistics	-0.251
Standard error	0.399	DF	66
95% CI	-0.8968 to 0.6968	Significance level	P = 0.8029

Scores could range from 1 to 5.

Note: ^{NS} = Not Significant

Students' Views of Their Experiences

The second and final research question was: What are the views of students concerning their experiences in a community college mathematical literacy course? An open-ended questionnaire (Appendix D) was distributed during the last week of the semester in the mathematical literacy courses. Participation in this survey was optional, and a total of 28 surveys were collected. In place of their names, a pseudonym was used to protect participants' confidentiality.

For all items except those that simply asked for any additional comments, students' responses were coded using some variation of positive, negative, or neutral responses.

The following analysis will include results as well as specific excerpts from students' surveys that highlight emergent themes.

Usefulness of Working in Groups

The use of small collaborative group work was a vital part of the pedagogy of the mathematical literacy course; therefore, questions were included not only on the mathematics-attitude surveys, but also on the open-ended survey. On this survey, students were asked if they thought working in groups was useful. Responses were coded as *useful, not useful*, or *neutral*. Three students stated that they did not generally find the group work useful, and one other student's response was neutral in nature. Adrian wrote, "Not in the group I was in." Marie stated, "Not really." Amber declared, "No, most of the group members didn't come, and when they did come, some still did not get what they needed or knew what they were doing." All other students' responses indicated that they found the groups useful.

Most of students indicated that working with others helped their understanding. Awa stated, "Yes, because it helps me a lot to express more my idea and my classmate helps me if I don't get it, and vice-versa." Daniela concurred, stating, "Yes, because it helped me to have a better understanding of a topic in class." Wong stated, "Yes, interaction helps us learn more from each other." Janet stated, "Yes, it was useful because when one person did not understand the work, the other did." Raymond declared, "Yes, I learned a lot of equations better when I have the luxury of communicating with others." Sarah wrote, "Yes, because we came up with great answers much quicker." Mariama stated, "I found working in small groups useful because everyone has his own way of solving problems. From listening, it helps you find which one works well or is more understanding to you." Sherma stated, "I like working in groups because I can share my opinions and thoughts into the problems and bounce back with each other's idea." Brianna wrote, "Yes, because I was able to see how other people think when solving questions and help each other." Diamond stated, "Yes, because if you miss a day or don't understand something, there are people in your group who may understand and help you. So, it works out well."

The final open-ended questions were included to allow students the opportunity to elaborate on their overall experiences in the course. The pre- and post-mathematics attitude survey data indicated that the students reported positive changes in the value and usefulness of mathematics. The result from the final questions of the open-ended surveys provided evidence in support of that finding.

Students' Attitudes About the Mathematical Literacy Course

Participants were asked about the usefulness of this specific course compared to the previous courses. Their responses were coded as *yes*, *no*, or *blank*. With the exception of two students who indicated *no* and four students who left this question blank, all other students' responses revealed that *yes*, the mathematical literacy course was more useful compared to their previous mathematics courses.

Many of the students' comments reflected ideas and themes previously discussed, such as the enjoyment of the group work; however, the most common theme was students' valuing of the usefulness of the material, sometimes even highlighting a difference between the practicality of this material and the lack thereof in prior mathematics courses. Johanna stated, "I found it useful, because I have taken a mathematics course before; I have not learnt nothing from my old mathematics class, but [in] this class I learnt a lot." Raymond similarly pronounced, "I found this course [more] rewarding than the previous mathematics course, because of the amount of helps and after class help I received." Juan likewise affirmed, "I found this course useful. We used everyday real-world situations. We used mathematics equations to solve problems such as budgets, insurance eligibility, things we encounter in real life." Kadijah concurred, saying, "More useful. I feel like I may use this in real-life." Mariama stated, "Yes, because our class had a personal tutor that was available to us all week. He was very thorough and helpful." Jose stated, "I found this course useful in comparison to my last course because I was able to understand the work much better." Similarly, David stated, "I found this course pretty useful because I learnt a lot more than before." Richard said, "Yes, I find it useful because it improved my mathematics skills." Lala stated, "Yes, because this course offered a more practical form of mathematics useful in everyday life." Likewise, Gomis stated, "The professor was very patient with the class. It was also very beneficial for the class to have an assistant as well." Patricia declared, "It was very useful, because I had a good professor." Gabriela stated, "It was more useful, because the professor took time out to explain stuff I did not know." Tyler revealed that in previous mathematics classes, "I felt that the teachers in those classes were not supportive. However, in this class, it was not the same scenario. The teacher was here to help us, not to intimidate us."

Students' Attitudes Toward Mathematics

Participants were asked whether the course led to changes in any of their attitudes or opinions regarding mathematics. Responses were coded as indicative of a *positive change*, a *negative change*, or *no real change*. With the exception of three students who indicated a n*egative response* and four students who left the questions blank, students generally indicated a *positive change.* Lishaune stated, "Not particularly." Marie wrote, "Not really." Similarly, Jessica stated, "No."

Generally, the students' comments were overwhelmingly positive about their own perceived attitudinal changes toward mathematics. Some indicated feeling more mathematically confident. For example, Johanna wrote, "Yes, it has changed my opinion on mathematics. It made me feel more confidence. I can solve a problem." Similarly, Tyler stated, "Yes, I have gained more confidence in mathematics." Likewise, Nysha stated, "Yes, this course made me actually want to continue with mathematics. I was not confident or sure at first, but now I am." Briah wrote, "Yes, it made me approach mathematics problems more confidently."

Other students, such as Awa, revealed seeing the usefulness of the subject: "Yes, it makes me know more about the importance of mathematics." Likewise, Kim wrote, "Yes, I can apply it in my life." Brianna stated, "Yes, it made me more aware of what is going on with real-life situations." Specific comments were made by other students. For example, Mariama pronounced, "Yes, it made me understand mathematics more and see different ways to do a mathematics problem. Juan stated, "Yes, I feel mathematics is a little more entertaining, and I like the feeling I get when I solve a problem." Daniella wrote, "Yes, I have a better understanding in what I am doing." Lala pronounced, "This class has been different, and enjoyable. We have learnt real-life skills, which is something most of my previous mathematics classes do not offer." And finally, Andrea revealed a growth from a lower initial starting point, "Maybe a little, before I had a closed mind, saying that I am not good in mathematics. The problem was that I never had a good mathematics teacher. But this time I learnt a lot."

Summary

In the quantitative analysis, statistically significant effects were found in the areas of attitudes toward the value and usefulness of mathematics, and in the attitudes toward real-world applications, working in groups, and using computers to learn mathematics.

The qualitative analysis revealed that students generally described their experiences working in groups positively, and over all felt that the course helped improve their attitudes regarding mathematics.

Chapter V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The main objective of conducting this research was to examine learner attitudes regarding mathematics in a community college mathematical literacy course.

The study took place in an accredited two-year public college in the greater New York City area. During fall 2017, 26,748 students enrolled in credit programs at the college (6,580 first-time freshmen, 1,511 transfers, 1,723 readmits, 15,734 continuing students, 520 special admits, 680 nondegree), of which 15,317 were females and 11,431 were males. The major ethnicities were categorized as follows: 41.9% Hispanic, 31.4% Black, 14.3% Asian, 11.9% White, and 0.4% American Indian. In terms of gender, 56.7% of students were females, and 43.7% were male. About 76.4% of students were under the age of 25 (CUNY, Office of Institutional Research and Assessment, 2016). The college has 1,496 faculty members (952 part-time, 544 full-time) and awards three degrees: the Associate in Arts (AA), the Associate in Science (AS), and the Associate in Applied Science (AAS). The Mathematics Department remains the largest department with 63 full-time instructors and 172 adjuncts. The mathematics course involved in this study was MAT 41, “an innovative remedial mathematics course designed to prepare and move students to college-level work more quickly” (Carnegie Foundation, n.d.). MAT 41 is a non-credit developmental course. Students who fail the course cannot move on to college-level courses.

Students in need of basic skills in mathematics at the level of remediation, and who registered for MAT 41 (Mathematical Literacy) and MAT 51 (Elementary Algebra) represented the samples for this research. This study was conducted using three sections of the mathematical literacy course with three different teachers, and three sections of the elementary algebra course with three different teachers as well. The mathematical literacy sections of the study started with 33 participants, and the elementary algebra course sections started with 46 participants. An anonymous mathematics attitudes survey was administered (n= 79 participants for the pre-survey and n= 68 participants for the post survey). A total of 14 questions from a mathematics attitude survey were used to evaluate changes in the students' attitude toward mathematics because of taking a mathematical literacy course or an elementary algebra course. Such questions evaluated students' attitudes prior to the class and their attitudes after completing the course. In addition, an open-ended question was distributed during the last week of the semester in the mathematical literacy courses, and a total of 28 surveys were collected.

Conclusions

Statistically significant effects were discovered regarding perceived value and usefulness of mathematics, and in the attitudes regarding real-world problems, working in groups, and using computers in mathematics courses for participants in the mathematical literacy sections compared to their counterparts in the elementary algebra sections. There were no significant effects for mathematics self-confidence and students' willingness to take future mathematics courses.

The qualitative data indicated participants' positive views on working in groups, the usefulness of the mathematical literacy course, and feeling that the course helped improve their attitudes regarding mathematics.

Student Attitudes About Mathematics

The first question of this research was: How are attitude toward self-confidence and ability of doing mathematics, as well as the value and usefulness of mathematics, affected by taking a mathematical literacy course?

Student attitudes toward mathematical self-confidence. Results from the quantitative data indicated a slight increase in students' self-confidence and reported capability of doing mathematics for both courses. However, findings of this analysis revealed a difference between the post-test scores of the two groups that was not statistically significant.

In contrast, the qualitative data indicated that many students reported growth in self-confidence. Though questions particularly addressing perception of students' mathematics self-confidence were not on the open-ended survey, comments about that item did emerge. Participants were asked whether the mathematical literacy course caused changes in any of their attitudes or opinions regarding mathematics, and the usefulness of the specific course in comparison to their previous courses. Many participants indicated feeling more mathematically confident. For example, Johanna commented, "Yes, this course has changed my opinion on mathematics. It makes me feel more confident. I can solve a problem." Tyler stated, "Yes, I have gained more confidence in mathematics." Likewise, Briah wrote, "Yes, this course made me approach mathematics problems more confidently."

For this research question, the qualitative results seemed not to support the quantitative findings. Responses to the mathematics attitudes surveys showed no statistically significant changes in students' self-confidence. In contrast, the open-ended survey indicated many unprompted comments revealing an increase in confidence. Comments from two particular students raised questions about such discrepancy: Nysha stated, "This course made me actually wants to continue with mathematics. I was not confident or sure before, but now I am." Also, Andrea wrote, "Maybe a little, before I had a closed mind, saying that I am not good in mathematics. The problem was that I never had a good teacher. But this time I am confident, and I learn[ed] a lot." These comments from Nysha and Andrea raise the possibility that some participants gained confidence given the particular content in this mathematical literacy course but may have been responding to the mathematics attitudes survey from a general perspective of their overall mathematical self-confidence beyond the singular experience in this mathematical literacy course. Consequently, there may be two kinds of mathematics self-confidence here: mathematics self-confidence specifically within the mathematical literacy course and the broader kind of mathematics confidence that would go beyond this course and maybe into other courses and life experiences.

Student attitudes toward the value and usefulness of mathematics. Findings based on both the qualitative and the quantitative data revealed that students enrolled in the mathematical literacy sections perceived increased value and usefulness of mathematics.

The quantitative data indicated that the mean scores for perceived value and usefulness of mathematics increased for both courses, but students in the mathematical literacy sections had a greater mean increase than students in the elementary algebra sections. Results of this analysis revealed a difference between the post-test scores of the two groups that was statistically significant. The mathematical literacy group seems to have increased in attitude regarding the perceived value and usefulness of mathematics.

The qualitative data were aligned with the quantitative findings. Students were asked whether the mathematical literacy course made changes in any of their attitudes or opinions regarding mathematics, and the usefulness of this specific course in comparison to their previous courses. Their comments were positive and indicated a growth perceived value and importance of studying mathematics. Students compared their actual mathematical literacy course's experiences with their previous mathematics courses. For example, Awa stated, "Yes, this course makes [me] know more about the importance of mathematics." Kim wrote, "Yes, I can apply mathematics in my life." Similarly, Bryanna declared, "Yes, this course made me understand mathematics more and see different ways to do a mathematics problem."

In addition to students' attitudes toward mathematical self-confidence and their attitudes toward the value and usefulness of mathematics, four more items in the mathematics attitude survey are relevant here.

The first item addressed the preference of students regarding real-world problems. It may be possible that many learners regard real-world problems in mathematics as identical to what they are used to seeing as word problems in mathematics textbooks. Such problems often include situations that have little meaning in students' lives. Many of the word problems, rather than intending to emulate real-life situations, involve real-life objects only to support learners' thinking regarding concepts and models. Therefore, this item was included on the mathematics attitude survey. The findings showed that the mean score on preference regarding real-world problems for the mathematical literacy course increased, while the mean of the elementary algebra sections slightly decreased. Results of this analysis revealed a difference between the post-test scores of the two groups that was statistically significant ($P < 0.0001$). The mathematical literacy group seems to have increased in enjoyment in solving real-world problems. Although items on preferences about real-world problems were not included on the open-ended survey, comments about such items emerged and supported the findings from the quantitative data. For example, Davin stated, "I found this course useful. We used everyday real-world situations and mathematics equations to solve problems such as budgets, insurance, things we encounter in real-life."

The second item addressed students' preferences about working in small groups. Quantitative and qualitative data both revealed that learners enrolled in the mathematical literacy sections reported a greater affinity for working in small groups. On average, the findings from the quantitative data showed that students in mathematical literacy reported a gain in their attitudes about working in groups that was higher than the gain for students in elementary algebra. Findings of this analysis revealed a difference between the post-test scores of the two groups that was statistically significant ($p = 0.0172$). The mathematical literacy group seems to have increased in enjoyment in working with small groups.

In interviews, participants were asked whether they believed that working in groups was helpful. Their responses to this question were extremely positive. Students declared that working in small groups helped them learn the material better, and they stated that their peers possessed various strengths that allowed them to assist one to another. For example, Awa stated, “Yes, because working in small groups helps me a lot to express more my idea, and my classmate helps me if I don’t get it, and vice-versa.” Likewise, Mariama wrote, “I found working in small groups useful because everyone has his own way of solving problems. From listening, it helps you find which one works well or is more understanding to you.”

Overall, most students found working in small groups to be useful. However, they failed to justify why they found such groups to be worthwhile. Students typically declared that groupmates were able to help explain the material to one another. But in reality, this potential is often found in nearly every group in every mathematics class. In these particular mathematical literacy classrooms, even participants who acknowledged not typically enjoying working in groups, found the group experience valuable. An emergent question is: Why were these group experiences perceived differently in comparison to those in other mathematics courses?

The third item addressed students’ preferences regarding using computers in learning mathematics. The results revealed that the mean scores reported increased in both courses, and the net mean score reported from students in the mathematical literacy sections was greater compared to the net mean score from students in the elementary algebra sections. Findings of this analysis revealed a difference between the post-test scores of the two groups that was statistically significant (p = 0.0107). The mathematical literacy group seems to have increased in attitudes toward using computers when solving mathematics problems.

Finally, the fourth item addressed students' attitudes toward taking further mathematics courses. Findings revealed that participants in both courses reported a slight increase in their willingness to take additional mathematics courses. The net mean scores reported from students in the mathematical literacy sections were slightly higher than the net mean score from students in the mathematical literacy sections. Results of this analysis revealed a difference between the post-test scores of the two groups that was not statistically significant (p = 0.8029).

Students' Views of Their Experiences

The second and final research question was: What are the views of students concerning their experiences in a community college mathematical literacy course? To obtain detailed responses from participants in the mathematical literacy course, a survey with open-ended questions was used. Some of the responses regarding overall attitudes about mathematics and this particular mathematical literacy course have already been discussed in the preceding sections.

Usefulness of working in groups. Working in small groups was a vital part of the pedagogy of the mathematical literacy course. Therefore, questions about the usefulness of working in groups were included not only on the mathematics attitudes surveys, but also on the open-ended questionnaires surveys. On this survey, students were asked if they thought working in groups was useful. Except for three students who didn't generally find the group work useful and another student whose response was neutral in nature, all other students' responses indicated that they found the groups useful. Most of the students declared that working with others helped their understanding when they were unclear on concepts. These findings supported the results from the mathematics attitudes surveys, where students reported a growth on their attitudes toward working in small groups.

Students' attitudes about the mathematical literacy course. Participants were asked about the usefulness of this specific course compared to previous courses. Almost all responses suggested that the mathematical literacy course was more useful and rewarding than previous courses; however, the most common theme was students' valuing the usefulness of the material, sometimes even highlighting a difference between the practicality of this material and the lack thereof in prior mathematics courses. Johanna stated, "I found it useful, because I took mathematics course before, I did not learn nothing from my old mathematics class, but this class I learnt a lot." Similarly, Raymond pronounced, "I found this course more rewarding than the previous mathematics course, because of the amount of supports and after class help I received." Jose stated, "I found this course useful in comparison to my last course because I was able to understand the material much better." Juan likewise affirmed, "I found this course useful. We used everyday real-world situations. We used mathematics equations to solve problems such as budgets, insurance eligibility, things we encounter in real life." Kadijah concurred, saying, "More useful. I feel like I may use this in real life."

Though questions particularly addressing students' views on the role of the instructor and supplemental instruction were not on the open-ended survey, comments related to such themes emerged. Many participants indicated that instructors and tutors were very supportive and had a positive influence on their perceived success. For example, Mariama stated, "Yes, because our class had a personal tutor that was available to us all week. He was very thorough and helpful." Likewise, Gomis stated, "The professor was very patient with the class. It was also very beneficial for the class to have an assistant as well." Patricia declared, "It was very useful, because I had a good professor." Gabriela stated, "It was more useful, because the professor took time out to explain stuff I did not know."

Students' attitudes toward mathematics. Learners were asked whether the course led to changes in any of their attitudes or opinions regarding mathematics. With the exception of three students who reported a negative response and four students who left the question blank, all other students indicated a positive change. Generally, the learners' comments were overwhelmingly positive about their own perceived attitudinal changes regarding mathematics. Some felt more mathematically confident.

Additional Concluding Observations

This final area of discussion is related to themes that emerged from data. Comments related to pedagogical approaches for teaching mathematics and teachers' instructional practices arose in different parts of the open-ended questionnaires. Tyler revealed that in previous mathematics classes, "I felt that the teachers in those classes were not supportive. However, in this class, it was not the same scenario. The teacher was here to help us, not to intimidate us." Gabriella stated, "The mathematical literacy was useful, because the professor took time out to explain stuff I didn't know." Patricia pronounced, "The mathematical literacy course was useful, because I had a good professor." The negative comments by Tyler regarding his prior experiences are supported by Skovsmose (2000), who agrees that intimidation is seen as a barrier in mathematics. The formal rules and procedures associated with mathematics classes discourage many learners from taking mathematics.

The overwhelming positive comments regarding teachers' instructional practice and the affirmative influence on their experiences are consistent with the literature. For instance, Bansilal, Mkhwanazl, and Mahlaboratoryela (2010) revealed a positive correlation between continuous support and feedback tutors provided to learners and the learners' performances during the semester. The authors saw this growing interaction as offering positive learning opportunities to learners. In a study conducted by Graven and Venkat (2009), the authors reported that the students who participated in the study were positive overall about mathematical literacy. Venkat and Graven (2007) attributed this change to the instructors who significantly improved their pedagogic practices.

> This differs from the elementary algebra teaching in that the nature of task in mathematical literacy (engagement with a scenario rather than application of mathematics in 'word problems') and the nature of interaction in mathematical literacy (much slower pace, more discussion and group work). (p. 2)

If a mathematical literacy course is to address individual learners and engage them in ways the elementary algebra classroom cannot, then a critical aspect of teaching for mathematical literacy has to be instructors' ability to teach any topic with an acceptable level of quantitative context.

Students' comments about the role of instructors and the effect of their experiences in the mathematics course are also supported by Brown and Schäfer (2006) and Venkat (2007). These authors stated that teaching successfully mathematical literacy relies significantly on the skills of the instructors to use meaningful teaching strategies, such as more discussions and problem solving. According to Venkat, students became positive regarding mathematical literacy, enjoyed the subject, and found it practical, useful, and challenging when instructors improved the nature of tasks and interactions used in the mathematical literacy class. "Both these shifts provided opening for learning to communicate and participate in classroom activities, in addition to gaining understandings and make sense of the mathematics being used" (p. 30). Mathematical literacy is based on learners' interests, experiences, goals, and objectives. Consequently, the role of teachers as "knowledgeable adult" was to assist them in getting where they wanted to go and not directing where they should go.

Several participants reported that mathematical literacy provided "a more practical form of mathematics that could be useful for their lives" and that mathematics was "not all difficult equations to solve." When reflecting on their experience, Juan affirmed, "I found this course useful. We used everyday real-world situations. We used mathematics equations to solve problems such as budgets, insurance eligibility, things we encounter in real life." Such statements helped to see that the objective of a mathematical literacy course is to assist learners in reasoning quantitatively regarding topics like financial institutions and, more generally, in understanding the importance of using quantitative approaches, tools, and arguments in daily life. This is consistent with much of the literature on mathematical literacy. For example, the Department of Education (DoE, 2011) suggests that mathematical literacy teaching must focus on the inclusion of content and skills in real-life applications. "Teachers should provide learners with the opportunities to analyze problems and devise to work mathematically in solving them, develop and practice decision-making and communication skills" (pp. 9-10). Brown and Schäfer (2006) declared that the mathematical literacy curriculum must focus on contextualized mathematics. By being realistic and having real-life authenticity, such contexts should provide students with opportunities to apply and utilize mathematics to make sense of the world around them, rather than having students perform more mathematical contents (Bansilal et al., 2010). The DoE (2011) stated, "These problems should relate to a learner's daily life, the workplace and the wider social, political and global environment" (p. 12). Venkat (2007) argued that "if learners are engaged in problem situated in real-life situations, they will develop valuable skills such as mathematical reasoning, sense making, applying different procedures and decision-making" (p. 2).

Positive comments about working in groups are also reflected in the literature. For example, Lambert (2004) pronounced that "the practice of teaching is not only about the actions of the teachers but the evolution of relationships between the teacher and learners and among learners themselves around mathematics and engaging together in constructing mathematical meaning" (p. 2). Students must collaborate with each other to support, strengthen, and challenge each other's ideas (Artzt, Armour-Thomas, & Curcio, 2008). Unfortunately, many elementary algebra classes do not offer enough opportunities for learners to develop mathematical knowledge (Franke, Kazemi, & Battey, 2007). The authors agree that "learners must have the opportunity to become encouraged and curious and talk about and with mathematical expertise" (p. 229). National studies focus on the importance of learner-centered pedagogies where students are taking part in the lesson, in discussions and small group work (Brown & Schäfer, 2006; Venkat, 2007; Venkat & Graven, 2007).

One of the requirements of a mathematical literacy classroom is that the curriculum must be "driven by issues that are important to people in their lives, and work," but students in the elementary algebra class were not aware about the relevance of mathematics in their everyday lives (Quantitative Literacy Design Team, 2001, p. 18). Without knowledge of mathematics content and its relevance to their everyday lives, learners are at a disadvantage. Unlike elementary algebra courses, where instructors must follow the assigned curriculum, teaching for mathematical literacy provides opportunities to learn any contexts where mathematics is utilized. This works especially for underachieved learners, since it offers instructors the flexibility to teach content that might engage any learners.

Findings and Existing Research Studies

This study contributed to the mathematical literacy literature by being one of just a few to use a mixed-methods approach to examine a mathematical literacy course.

The findings of this study supported many of the literature's curricular recommendations regarding community college: for instance, the suggestion to include real-world applications based on everyday situations (Alsina, 2002; Catalano, 2010; De Lang 2003; Dewdney, 1993; Edwards, 2008; Ellis & Malloy, 2007; Madison, 2006; Pollak, 1997; Steen, 2003), to organize instruction around different students' interests, which helps develop positive attitudes (Hidi & Renninger, 2006) and moves students to a greater level of achievement (Carmichael et al., 2010), and to implement collaborative work among students (Briggs et al., 2004).

The findings of this study are in line with the results of Jordan and Haines (2003), who described the growth of mathematical literacy at Lawrence University where students were found to have a higher level of appreciation for the utility of mathematics. Findings in this study revealed that students enrolled in the mathematical literacy sections perceived an increased value and usefulness of mathematics.

Also, the results of this dissertation support the findings of Dingman and Madison (2010), who found a positive change in student reports about the usefulness of mathematics as a result of taking a mathematical literacy course.

The findings of this dissertation study support the finding of Van Peursem et al. (2012), who found that students in mathematical literacy reported high gains in attitudes toward mathematics and felt that mathematics had more value and utility for their lives.

In contrast, the results of this dissertation do not strongly support the findings of Catalano (2010) and Briggs et al., (2004). While these authors found in their study that students reported an increase in the level of confidence, the t-test of this study revealed that there wasn't a statistically significant difference in student confidence. This finding does agree with the results of Madison and Dingman (2010), who found that students struggled to transfer knowledge to new situations and were not confident about their ability in mathematics.

Comments on the open-ended questions reflected the importance students placed on the elements of practicality in the course, which was a specific element of the implemented pedagogy. Finally, this study responds to one of challenges in teaching for mathematical literacy. Learning the importance and value of mathematics is among the main benefits of teaching for mathematical literacy; however, according to Ma (1997), "successful efforts in bringing students to better awareness of the importance of mathematics may not automatically improve other attitudinal aspects" (p. 228). Findings of this study support Ma's statement, since participants' beliefs in the value and usefulness of mathematical did not necessarily correspond to their feelings about taking further mathematics courses. In fact, the mathematics attitude survey indicated no statistically significant effect in learners' attitudes toward taking another mathematics class.

Limitations

This study has four limitations related to the students and the instructions.

The first limitation of this research was related to the size of the sample. The number of students completing the post-mathematics attitude surveys was smaller than the number of students completing the pre-survey because of learners being absent the day the post-survey was administered or dropping the course. Finally, 40 pairs of mathematics attitude surveys were obtained from the elementary algebra sections. Similarly, 28 pairs of surveys were gathered from the mathematical literacy sections of the course in the fall 2017 semester. All the conclusions based on qualitative data were formed from voluntary completion of the open-ended surveys. The survey required students to reflect on their experiences in the mathematical literacy course.

The second limitation was related to potential generalizations of this study. This research did not attempt to explore a cause-and-effect relationship. Rather, it sought to generate hypotheses about relationships between the pedagogy of the mathematical literacy sections and certain variables. However, without additional research, the study makes no attempt to generalize its results to a bigger population. Typically, the mathematical literacy course is not thought of as leading students toward a STEM field. This suggests another restriction in generalizing this study to any other type of mathematics course without additional studies.

The third limitation was how students may interpret problem solving between the two courses. Since mathematical literacy and elementary algebra have different curricula, the two groups of students may interpret differently the meaning of "problem solving." Learners from the mathematical literacy course utilized real-world problems in which they had to try different approaches to find the solutions of a given problem with a real-world context. Problem solving may be interpreted differently by each group based on their experiences. Learners in the algebra sections reported a decline in attitudes about their preferences involving real-world problems, but their course contained problems that differed from those in the mathematical literacy sections. Many learners in the algebra sections may regard real-world problems in mathematics as identical to what they are used to seeing as word problems in mathematics textbooks. Such problems often include situations that have little meaning in students' lives, involve real-life objects only to support learners' thinking regarding concepts and models, rather than intending to emulate real-life situations.

Finally, the fourth limitation was that the two courses in this study were taught by different instructors, and only the mathematical literacy courses had tutors in the classroom during the period. This suggest additional research where courses are taught with the same instructors with the supplement of tutors.

Recommendations

Implications for Teachers and Researchers

The drive of this study was to observe and evaluate the effects of a mathematical literacy course on students' attitudes regarding mathematics. The quantitative and qualitative data revealed significant effects in the areas of attitudes regarding perceived value and usefulness of mathematics and attitudes regarding real-world problems, working in groups, and using computers in mathematics courses. This study adds evidence to the literature that teaching mathematical literacy improves students' attitudes.

The findings suggest an instructional practice that emphasizes teaching strategies such as working in small groups and discussions in class (as suggested by some of the literature). Instructors should stay away from traditional teaching methods by giving learners opportunities to discuss the problems in groups besides individual work and by helping guide students in constructing their own knowledge of concepts through solving real-world problems relevant to their lives.

An additional recommendation is to emphasize the practicality of content whenever possible. Instructors should include real-world problems in their lesson plans and curriculum, using real data from various fields of study, and incorporate current and appropriate technology to help students develop quantitative reasoning skills. Providing students with the necessary tools they need would increase and reinforce their interest and engagement.

The study also suggested balancing the role of the teacher in the classroom to create an environment where learners are not exclusively taking information from the instructor, but rather actively constructing knowledge. Instructors must acquire an adequate sense of procedural knowledge and conceptual understanding. By following these recommendations, it is hoped to see a classroom environment that is reflective of connecting teaching and learning, encouraging all learners.

For administrators and schools, this study showed the effects a curriculum can have on learners. It is fundamental they give students a curriculum capable to better prepare them for the future. Following a given procedure is not enough in this modern world that requires people to interact and collaborate with others to solve a given problem.

Suggestions for Future Research

Further study is needed to improve our understanding of the relationship between mathematical literacy pedagogical techniques and students' confidence in mathematics. While the pre- and-post-mathematics attitude survey revealed no significant changes in students' confidence in mathematics, many students reported a growth in confidence in the open-ended survey questions. Investigating students' self-confidence at one course level and comparing findings with those from other mathematics courses could raise questions about the existence of two different types of mathematics self-confidence. Maybe studying mathematics self-confidence within just an individual course is the initial phase in a larger procedure of studying the broader notion of mathematics self-confidence that expands to other courses and facets of life. Further study of self-confidence within areas other than mathematics could offer clarification into eventual steps in process of changing one's confidence.

In addition, further research could explore the relationship between particular elements of group work and students' attitudes toward the value of that group work. This research question is a consequence of the students who indicated they did appreciate the collaborative component of this course, without clearly explaining the reason for that change of opinion. Another eventual area for future research might be to investigate why the experience of working in groups is beneficial. For example, a study with learners in the form of interviews about what they have not found in group work in the past and what they did value about these group experiences would be helpful.

An additional possible area of research is the extent to which attitude differences are affected by the presence of supplemental tutors. Only the mathematical literacy courses had tutors in the classroom during the period.

That the two courses had different curricula raises another question. Students in the mathematical literacy courses were required to constantly work in groups when solving real-world problems while their counterparts were not. Did students in the mathematical literacy courses enhance their attitudes because of working in groups and solving real-world problems? If the elementary algebra courses supplemented their curriculum with real-word problems, how would learners' attitudes between the two courses differ?

The research could be extended in order to observe the effects of a mathematical literacy course on students' success (earning a grade of C or higher) and achievement. For example, investigating the achievement of students (in an instructional practice that is student-centered) from the mathematical literacy and elementary algebra courses on a common test and/or outcome of students in a credit-bearing college mathematics course. Also, it could be extended to perform analysis that explores possible differences in attitudes by gender/ethnicity.

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Appendix A

Pre- and Post-Mathematics Attitude Survey

STUDENT INFORMATION: These surveys will remain completely confidential. The student information asked below will only be used to help organize the information for data analysis.

Date: ________________________Course: ________________

____

This inventory consists of statements about your attitude toward mathematics. There are no correct or incorrect responses. Read each item carefully. Please think about how you feel about each item. Circle the response that most closely corresponds to how the statements best describes your feelings.

1	I study mathematics because I know how useful it is.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
2	Knowing mathematics will help me earn a living.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
3	Mathematics is a worthwhile, necessary subject.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
4	I'll need a good understanding of mathematics for my future work.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
5	Doing well in math is not important for my future.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
6	I am sure of myself when I do mathematics.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
7	When my answer to a mathematics problem doesn't match somebody else's, I usually assume my answer is wrong.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
8	I think I could handle more difficult mathematics.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
9	I can learn and get good grades in mathematics.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
10	Mathematics is something learned best when you work by yourself.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
11	I like solving real-world	Strongly	Disagree	Neutral	Agree	Strongly

	problems in mathematics.	disagreed				agree
12	I enjoy working in small groups when solving problems.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
13	Using computers helps me learn mathematics.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
14	After taking this course, I would consider taking another mathematics class.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree

Appendix B

Attitudes Toward Mathematics Inventory
(Tapia, 1996)

This inventory consists of statements about your attitude toward mathematics. There are no correct or incorrect responses. Read each item carefully. Please think about how you feel about each item. Circle the response that most closely corresponds to how the statements best describes your feelings.

1	Mathematics is a very worthwhile and necessary subject.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
2	I want to develop my mathematical skills.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
3	I get a great deal of satisfaction out of solving a mathematics problem.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
4	Mathematics helps develop the mind and teaches a person to think.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
5	Mathematics is important in everyday life.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
6	Mathematics is one of the most important subjects for people to study.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
7	College math courses would be very helpful no matter what I decide to study.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
8	I can think of many ways that I use math outside of school.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
9	Mathematics is one of my most dreaded subjects.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
10	My mind goes blank and I am unable to think clearly when working with mathematics.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
11	Studying mathematics makes me feel nervous.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
12	Mathematics makes me feel uncomfortable.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree

13	I am always under a terrible strain in a math class.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
14	When I hear the word mathematics, I have a feeling of dislike.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
15	It makes me nervous to even think about having to do a mathematics problem.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
16	Mathematics does not scare me at all.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
17	I have a lot of self-confidence when it comes to mathematics	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
18	I am able to solve mathematics problems without too much difficulty.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
19	I expect to do fairly well in any math class I take.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
20	I am always confused in my mathematics class. Strongly	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
21	I feel a sense of insecurity when attempting mathematics.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
22	I learn mathematics easily	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
23	I am confident that I could learn advanced mathematics.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
24	I have usually enjoyed studying mathematics in school.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
25	Mathematics is dull and boring.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
26	I like to solve new problems in mathematics.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
27	I would prefer to do an assignment in math than to write an essay.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
28	I would like to avoid using mathematics in college.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
29	I really like mathematics.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
30	I am happier in a math class than in any other class.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
31	Mathematics is a very interesting subject.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree

32	I am willing to take more than the required amount of mathematics.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
33	I plan to take as much mathematics as I can during my education.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
34	The challenge of math appeals to me.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
35	I think studying advanced mathematics is useful.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
36	I believe studying math helps me with problem solving in other areas.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
37	I am comfortable expressing my own ideas on how to look for solutions to a difficult problem in math.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
38	I am comfortable answering questions in math class.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
39	A strong math background could help me in my professional life.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree
40	I believe I am good at solving math problems.	Strongly disagreed	Disagree	Neutral	Agree	Strongly agree

Source: Retrieved from http://lib.uky.edu/ETD.pdf

Appendix C

Open-Ended Survey Questions

(Administered at the end of the Mathematical Literacy course)

STUDENT INFORMATION: These surveys will remain completely confidential. The student information asked below will only be used to help organize the information for data analysis.

Date: ________________________ MAT041_________________

____

I. Reflection on your Experiences in Working in Small Groups this Semester.

1. Did you find working in small groups useful? Why or why not?
2. Any other comments regarding the group work component of the course?

II. Reflection on your Experiences in this Mathematics Literacy Course Compared to Previous Mathematics Courses.

1. Did you generally find this mathematical literacy course more or less useful than previous mathematics courses? Why or why not?

III. Reflection on your Overall Experiences in this Course.

1. Do you feel this mathematical literacy course has changed any of your attitudes or opinions about the subject of mathematics? If so, in what ways?
2. Any other comments regarding this mathematical literacy course that you did not previously get to comment on? (i.e. other likes or dislikes)

Appendix D

Mathematical Literacy Outline of Topics

(Reference: Charles A. Dana Center at The University of Texas, 2011)

Topics Covered **Main Math topic**	**Specific Objectives**	**Lesson #**
Introduction to Quantitative Reasoning **Main Math Topic:** Defining quantitative Reasoning	**Students will understand that** • Quantitative reasoning is the ability to understand and use quantitative information. It is a powerful tool in making sense of the world. • Relatively simple math can help make sense of complex situations. • 1 billion = 1,000 x 1,000 x 1,000. • The representations 1 billion, 1,000,000,000, and 109 have the same meaning. **Students will be able to** • Identify quantitative information. • Convert units from feet to miles. • Round numbers (based on homework). • Name large numbers (based on homework). • Work in groups and participate in discussion using the group norms for the class.	1.1
What is Percent? **Main Math Topic:** Rounding and estimating	**Students will understand that** • Rounding numbers before calculating estimations makes for easy approximations. • There are many strategies for estimating. • Percentages are an important quantitative concept. **Students will be able to** • Round and estimate with difficult numbers. • Estimate 1% of a number. Use 1% as a benchmark estimate to find other percent values of a number. Calculate the percent of a number.	1.2

Affordable Care Act **Main Math Topic:** Mathematical operations, order of operations	**Students will understand that** • Flexibility with calculations is an important quantitative skill. • Different methods of calculation are often possible and helpful. **Students will be able to** • Write a calculation in at least two different ways based on equivalent forms of fractions/decimals/percentages, relation of multiplication and division, Commutative property [knowing when the order of numbers can be reversed, such as $3 + 4 = 4 + 3$, but $3 – 4 \neq 4 – 3$], and order of operations	1.3
Whose Footprint is Bigger? **Main Math Topic:** Large numbers, ratio	**Students will understand that** • The magnitude of large numbers is seen in place value and in scientific notation. • Proportions are one way to compare numbers of varying magnitudes. • Different comparisons may be needed to accurately compare two or more quantities. **Students will be able to** • Express numbers in scientific notation. • Estimate ratios of large numbers. • Calculate ratios of large numbers. • Use multiple computations to compare quantities. • Compare and rank numbers including those of different magnitudes (millions, billions).	1.4
Interpreting Statements About Percentages **Main Math Topic:** Percentages	**Students will understand that** • Percentages involve a numerator (comparison value) and a denominator (reference value). **Students will be able to** • Correctly identify the quantities involved in a verbal statement about percent. • Convert between ratios and percent. • Convert between the decimal representation of a number and a percent. • Read and use information presented in a two-way table.	1.5

How Crowded Are We? **Main Math Topic:** Ratios and proportional reasoning	**By the end of this lesson, you should understand that** • Population density is a ratio of the number of people per unit area. • Proportionality can be used to compare population densities. **By the end of this lesson, you should understand that** • Calculate population densities. • Determine if two population density ratios are proportional to each other. • Compare and contrast populations via their densities.	2.1
Counting Our Votes **Main Math Topic:** Ratios and proportional reasoning	**Students will understand that** • The concept of proportional representation in voting. • How representation in the U.S. Congress is allocated. **Students will be able to** • Calculate a unit rate. • Solve a proportion by first finding a unit rate and then multiplying appropriately.	**2.2**
Measuring Population Change **Main Math Topic:** Absolute and Relative Change	**By the end of this lesson, you should understand** • A relative change is different from an absolute change. • A relative measure is always a comparison of two numbers. **By the end of this lesson, you should be able to** • Calculate a relative change. • Explain the difference between relative change and absolute change.	2.3

Picturing Data with Graphics **Main Math Topic:** Graphical displays	**Students will understand that** • The scale on graphs can change perception of the information they represent. • To fully understand a pie graph, the reference value must be known. **Students will be able to** • Calculate relative change from a line graph. • Estimate the absolute size of the portions of a pie graph given its reference value. • Use data displayed on two graphs to estimate a third quantity.	2.4
What is Average? **Main Math Topic:** Measures of central Tendency	**Students will understand that** • Numerical data can be summarized using measures of central tendency. • The mean and median statistics for a set of data can provide different snapshots of the data. • Conclusions derived from statistical summaries are subject to error. • A spreadsheet can be used to organize data. **Students will be able to** • Calculate the mean and median for numerical data. • Create a data set that meets certain criteria for measures of central tendency.	2.5
What is the Chances? **Main Math Topic:** Introduction to Probability	**Students will understand that** • A probability is a likelihood of an event occurring. • There are different types of probability. **Students will be able to** • Determine a theoretical probability. • Compare theoretical probability to experimental probability.	2.6

What is the Correct Dose? **Main Math Topic:** Dimensional analysis	**Students will understand that** • The units found in a solution may be used as a guide to the operations required in the problem. • That is, factors are positioned so that the appropriate units cancel. • Units provide meaning to the numbers they get in calculations. **Students will be able to** • Write a rate as a fraction. • Use a unit factor to simplify a rate. • Use unit conversion to help determine the factors in a series of operations to obtain an equivalent measure.	3.1
The Facts on the Ground The Fixer Upper **Main Math Topic:** Two-dimensional geometric reasoning	**Students will understand that** • They can find formulas through the Internet and reference books. • A variable can be used to represent an unknown. • Using a formula requires knowing what each variable represents. • They must know the appropriate units for length, area, and volume. **Students will be able to** • Use formulas from geometry and perform calculations that involve rates and measures to support financial decisions. • Evaluate an expression.	3.2 3.3
Balancing Blood Alcohol **Main Math Topic:** Solving linear equations	**Students will understand that** • Addition/subtraction and multiplication/division are inverse operations. • Solving for a variable includes isolating it by "undoing" the actions to it. **Students will be able to** • Solve for a variable in a linear equation. • Explicitly write out order of operations to evaluation a given equation.	3.4
A Return to Proportional Reasoning **Main Math Topic:** Proportions	**Students will understand that** • Proportional relationships are based on a constant ratio. • Rules for solving equations can be applied in unfamiliar situations.	3.5

	Students will be able to • Set up a proportion based on a contextual situation. • Solve a proportion using algebraic methods.	
Modeling Money **Main Math Topic:** Linear equations	**Students will understand that** • Linear models are appropriate when the situation has a constant increase/decrease. • Slope is the rate of change. • The rate of change (slope) has units in context. • Different representations of a linear model can be used interchangeably. **Students will be able to** • Label units on variables used in a linear model. • Make a linear model when given data or information in context. • Make a graphical representation of a linear model. • Make a table of values based on a linear relationship. • Identify and interpret the vertical and horizontal intercepts in context.	4.1
More Liner Modeling **Main Math Topic:** Linear models and slope	**Students will understand that** • Linear models are appropriate when there is a situation with a constant increase/decrease. • Slope is the rate of change. • The rate of change (slope) has units in context. • Different representations of a linear model can be used interchangeably. **Students will be able to** • Label units on variables used in a linear model. • Make a linear model when given data or information in context. • Make a graphical representation of a linear model. • Make a table of values based on a linear relationship. • Identify and interpret the vertical and horizontal intercepts in context.	4.2

Compounding Interest Makes Cents **Main Math Topic:** Exponential models	**Students will understand that** • Compounding is repeated multiplication by a compounding factor. • Compounding is best expressed in terms of exponential growth, using exponential notation. • Exponential growth models the compounding of interest on an initial investment. • What are differences and similarities between exponential growth and decay? **Students will be able to** • Calculate the earnings on a principal investment with annual compound interest. • Write a formula for annual compound interest. • Compare and contrast linear and exponential models. • Write an exponential decay model.	4.3
Compounding Makes More Cents **Main Math Topic:** Exponential functions	**Students will understand** • The differences in amounts for different compounding periods **Students will be able to** • Use the compound interest formula for different compounding periods.	4.4
The Rising Seas **Main Math Topic:** Comparing linear and exponential models	**Students will understand that** • Both linear and exponential models for growth may be applied to the same set of data, but • Result in significantly different long-term projections. **Students will be able to** • Build both exponential and linear models. • Compare an exponential and linear model, and make a conclusion based on the comparison.	4.5

Source: "Charles A. Dana Center at the University of Texas at Austin under sponsorship of the Carnegie Foundation for the Advancement of Teaching". Retrieved from http://www.savingstudentsmoney.org/QW/QWinstr.pdf

Appendix E

Informed Consent

Teachers College, Columbia University

525 West 120th Street

New York NY 10027

212 678 3000

Teachers College, Columbia University
Institutional Review Board
Protocol Number: 17-305
Consent Form Approved Until: No Expiration Date

Protocol Title: The Effects of a Mathematical Literacy Course on Student Attitudes: A Community College Study

Principal Investigator: Serine Ndiaye, Teachers College

646-468-0974, sndiaye@bmcc.cuny.edu/sn2546@tc.columbia.edu

INTRODUCTION

You are being invited to take part in this study called "The Effects of a Mathematical Literacy Course on Student Attitudes: A Community College Study". if you are willing to participate in the study, you will be asked to sign an informed consent form and complete a participant information sheet. Approximately 60 participants will be in this study which will take 25 minutes of your time to complete.

WHY IS THIS STUDY BEING DONE?

The study aims to investigate how a mathematical literacy course affects learners' attitudes regarding mathematics. The study may inform community college developmental mathematics programs and instructors as to the value of incorporating mathematical literacy courses into instructional practices. In addition, it may benefit developmental mathematics program by reversing the high failure rate of community college remediation mathematics and improving the success rate of students.

WHAT WILL I BE ASKED TO DO IF I AGREE TO TAKE PART IN THIS STUDY?

If you agree to take part in this study, you will complete a presurvey questions at the beginning of the semester. The interview will about twenty five minutes long. You will be given a pseudonym or false name in order to keep your identity confidential.

Finally, you will be asked to complete a postsurvey and an open-ended survey questionnaire at the end of the semester. This will take about twenty-five minutes. All of these procedures will be done in your classroom during class period.

WHAT POSSIBLE RISKS OR DISCOMFORTS CAN I EXPECT FROM TAKING PART IN THIS STUDY?

The risks of taking part in this study are minimal. They are similar to the ones you would encounter in your normal daily activities. The probability of these risks is 9%.

WHAT POSSIBLE BENEFITS CAN I EXPECT FROM TAKING PART IN THIS STUDY?

There is no benefit for accepting to take part in this research. Participation may benefit developmental mathematics program to reverse the high failure rate of traditional remedial mathematics for community college students and promote a high level of success.

WILL I BE PAID FOR BEING IN THIS STUDY?

Participants will not be paid; however, taking part in this study will not cost you nothing.

WHEN IS THE STUDY OVER? CAN I LEAVE THE STUDY BEFORE IT ENDS?

The study is over after completing and filling out the questionnaire. But you can give up the study at any moment.

PROTECTION OF YOUR CONFIDENTIALITY

Efforts will be made to keep confidentiality of any information collected during this study that may identify you. Your confidentiality will be protected by using a pseudonym instead of your name and keeping all information on a password protected computer and locked in a file drawer. The data of this study will be kept private for at least three years before being destroyed.

HOW WILL THE RESULTS BE USED?

The results will be used in my dissertation and possibly published in journals.

WHO MAY VIEW MY PARTICIPATION IN THIS STUDY?

___I consent to allow written materials viewed at an educational setting or at a conference outside of Teachers College

____

Signature

___I **do not** consent to allow written materials viewed outside of Teachers College Columbia University

____

Signature

WHO CAN ANSWER MY QUESTIONS ABOUT THIS STUDY?

If you have any questions about taking part in this research study, you should contact me, Serine Ndiaye, at 6464680974 or at sndiaye@bmcc.cuny.edu/sn2546@tc.columbia.edu

If you have questions or concerns about your rights as a research subject, you should contact the Institutional Review Board (IRB) (the human research ethics committee) at 212-678-4105 or email IRB@tc.edu. Or you can write to the IRB at Teachers College, Columbia University, 525 W. 120th Street, New York, NY 1002. The IRB is the committee that oversees human research protection for Teachers College, Columbia University.

PARTICIPANT'S RIGHTS

- I have read and discussed the informed consent with the researcher. I have had ample opportunity to ask questions about the purposes, procedures, risks and benefits regarding this research study.
- I understand that my participation is voluntary. I may refuse to participate or withdraw participation at any time without penalty to future medical care; employment; student status or grades; services that I would otherwise receive.
- The researcher may withdraw me from the research at his or her professional discretion.
- If, during the course of the study, significant new information that has been developed becomes available which may relate to my willingness to continue my participation, the investigator will provide this information to me.
- Any information derived from the research study that personally identifies me will not be voluntarily released or disclosed without my separate consent, except as specifically required by law.
- I should receive a copy of the Informed Consent document.