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THE ANALYSIS OF SELF-EFFICACY FOR STUDENTS ENROLLED IN A CALCULUS I COURSE AT A COMMUNITY COLLEGE

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THE ANALYSIS OF SELF-EFFICACY FOR STUDENTS ENROLLED IN A CALCULUS I COURSE AT A COMMUNITY COLLEGE

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This book is dedicated to my father, who unfortunately did not live to see my journey come to the end, but whose support, unconditional love and absolute belief that I will succeed has inspired me.

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”The will to win, the desire to succeed, the urge to reach your full potential…these are the keys that unlock the door to personal excellence” (Confucius). It summarizes everything the PhD program meant for me starting with a career change from my engineering background to completing my doctorate in mathematics education.

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ABSTRACT

It is generally accepted that learning implies a multitude of factors meant to prepare the children for life and its challenges. Some of these factors are directly related to the level of knowledge of subject matter, but others are based on individual feelings, relationships, or capabilities of developing a sense of belonging and personal worth, confidence, or attitude toward a certain content area. All these elements together form the foundation of student's future success. On many occasions, certain factors such as the teaching approaches, encouragement from family members and school personnel, or past experiences in learning mathematics are important in creating a positive view of mathematics. From basic arithmetic to the more advanced calculus courses in first years of college, students build knowledge and shape continuously their views on mathematics. These factors and experiences can help form the foundations of a positive attitude toward mathematics and may influence students' self-efficacy with respect to the mathematics.

While literature provides examples where students' self-efficacy was a determining factor in pursuing and solving mathematics problems, the influence of college mathematics courses on developing higher or lower levels of self-efficacy was a scarcely explored area. The purpose of the current study was to identify the impact of a Calculus and Analytic Geometry I course on college freshman students' mathematics self-efficacy, and suggest ways of using the results for future teaching and learning. The study used an explanatory sequential mixed methods research design, where the quantitative portion of the study helped determine participants for qualitative portion of the study.

The results revealed that the Calculus and Analytic Geometry I course improved general students' self-efficacy in some areas of mathematics related to daily mathematical tasks. Also, it was determined that students' background in previous mathematics courses had a strong impact in maintaining a high level of self-efficacy, and class interaction had a particular role in increasing most students' self-efficacy. The majority of students reported that interactivity in mathematics classes in high school was less evident than the interactivity observed in these college mathematics classes. Not surprisingly, some students reported a preference to follow algorithms and step-by-step methods when solving mathematics problems rather than rely on deeper understanding.

Although the results of the study cannot be generalized, it was suggested that instructors should insist on constructing a strong mathematical background of students early in students' mathematics classes. While peer work and collaboration should be encouraged, the instructor should also identify those students who prefer different approaches in studying mathematics. The same observation about teaching and learning approaches is valid in the case of using algorithms and step-by-step problem solving methods.

Keywords: self-efficacy, interactivity, mathematical background, algorithm

CHAPTER 1: INTRODUCTION

The purpose of education is to help students develop the necessary skills for making informed decisions and eventually to become better citizens of an interdependent world governed by cultural diversity and democracy. While simplistic teaching and learning based on rote memorization was the basis of traditional school education in the past, nowadays, due to the labor requirements of a globalized economy new approaches have been promoted. These approaches support a fast-paced, technologically-driven society with an emphasis on problem solving and modern teaching and learning strategies being the new focus in education (Berns, Erickson, 2001). Developing new ways of thinking will help students turn pieces of information into useful knowledge, allowing this information to be interpreted within a relevant context rather than being used solely for the purpose of passing a test. It is easy to notice in a classroom that students develop skills or habits of mind, such as flexibility of thinking or applying past knowledge to new situations, through a variety of processes, such as modeling or personal experiences. Similarly, the perspective from which people interpret a phenomenon may differ from one subject to another, so there is not necessarily one right or wrong answer to a certain question; the answers will differ based on the perspective, conditions, or personal particularities of the student. Developing new ways of thinking and viewing surrounding phenomena and situations from different perspectives helped teaching and learning and made conceptual understanding more effective.

The diversity of possible answers begins by gathering data through all human senses. This is a natural process, and it continues throughout our entire life.

Unfortunately, for centuries the traditional education system has discouraged a process of student-teacher interaction. In traditional classrooms students were not encouraged to ask questions, but instead were supposed to listen and respond with expected answers. The result was that historically, mathematical aptitude was difficult to be discovered or addressed in the classrooms, and many students had fewer opportunities to analyze their attitude or confidence with respect to mathematics. Conversely, it is widely accepted, as mentioned in the literature (Edwards, Harper, Cox et al., 2014; Nebesniak, Burgoa, 2015) that in mathematics at least, asking students to memorize facts is not the best approach to education, and given technological advancements much of this information can be easily accessed. This supports the idea that students should be engaged not in memorizing information but in inquiry, for asking questions, while problem solving allows them to learn what to do with the information they can access.

Recent literature (Blanchard et al., 2010; Sesen & Tarhan, 2011; Smart, Witt, & Scott, 2012) demonstrates that traditional teaching methods have proven to be less effective than a learner-centered approach. On the one hand, one of the most important differences between the two with respect to teaching and educators' behavior is the attitude and actions of the teacher, who is expected to become a facilitator of learning rather than an information provider. Students, on the other hand, will learn to cooperate in teams and self-construct knowledge rather than being passive receivers of information and working alone. While many countries still prefer the traditional approach to education, understanding the behavior of teachers and students in the classroom should represent an important step toward conceiving the curriculum as "an interrelated set of plans and experiences that a student undertakes under the guidance of school" (Marsh, 2007, p. 15).

Teaching style represents only one aspect that may influence student success in areas involving mathematics. Achievement depends on a variety of factors, including but not limited to gender, ethnicity, environment and cultural background. As society changes, teaching and learning approaches shift, and what is defined as achievement shifts as well. Learners must adapt and should feel comfortable with every new system implemented in school or at work. Being comfortable with a particular educator's way of teaching or feeling comfortable with the learning process is possible only if there is a positive attitude towards subject areas, such as mathematics, and is more easily achieved when the student has high levels of academic self-confidence. Neither positive attitude towards mathematics nor high levels of academic self-confidence is a characteristic that students typically possess. Many students harbor negative feelings about mathematics, and this can lead to mathematics anxiety and subsequent poor performance in or avoidance of mathematics classes (Taylor & Brooks, 1986).

Research with respect to academic self-confidence related to mathematics, or, in the case of the present dissertation, self-efficacy with respect to mathematics is important. While decades ago gender disproportion in technical fields was a common occurrence, today this gap is narrowing, and in some areas is disappearing, and yet, students are still not entering the field (Fennema, 1977). Prior experiences that discouraged students from becoming mathematics majors in their future are difficult to overcome. However, there is still hope about finding the appropriate teaching methods and strategies that will engage learners from an early age, and will help them feel connected with this field. Such approaches would supposedly have a great impact on mathematics anxiety, which in turn would impact both self-confidence and attitudes towards mathematics. Understanding why the majority of students struggle in mathematics or are not interested in mathematics, is as important today as it was decades ago.

Conceptual Outlines of the Study

Self-efficacy is "the belief in one's capabilities to organize and execute the courses of action required to manage prospective situations" (Bandura, 1994, p. 71). In the past, many researchers investigated "the importance of self-efficacy (often referred as confidence) to educational and career development with respect to career-related behaviors" (Paulsen, 2004, p. 354). For the purposes of this study self-efficacy is not viewed as a judgment related to the individual's previous or present performance within the field of mathematics, but rather represents individuals' judgments about how well they think they can perform in mathematics. While some studies have focused on certain types of self-confidence, such as leadership confidence or career decision-making confidence, others have highlighted the mathematics self-efficacy or one's confidence in the ability to perform well in mathematics (Lopez, Lent, Brown, & Gore, 1997). Drawing on Bandura's (1986) findings, Pajares and Miller (1994) stated that:

> Social cognitive theorists contend that self-efficacy beliefs, or 'people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances' (Bandura, 1986, p. 391), strongly influence the choices people make, the effort they expend, the strength

> of their perseverance in the face of adversity, and the degree of anxiety they experience (p. 193).

While methods used in K-12 schools encourage new, interactive approaches that promote students' growth, including student-centered learning, college courses in general, and mathematics courses in particular, are designed mostly as lectures, giving students significantly less opportunity to interact with their peers or with the lecturer during classes. Student-centered learning describes a multitude of approaches to teaching and learning that are used in general in K-12 education and preponderantly in mathematics and science, addressing students' needs, aspirations, and backgrounds by employing a variety of instructional methods. One typical example is inquiry-based learning, supposedly largely used at the high school level, which is in essence a student-centered method of teaching mathematics. This instructional method was developed in order to improve traditional methods of instruction, based on memorization of instructional material (Abdi, 2014). In essence, according to Haury (1993):

> Inquiry-oriented teaching engages students in investigations to satisfy curiosities, with curiosities being satisfied when individuals have constructed mental frameworks that adequately explain their experiences. One implication is that inquiry-oriented teaching begins or at least involves stimulating curiosity or provoking wonder. There is no authentic investigation or meaningful learning if there is no inquiring mind seeking an answer, solution, explanation, or decision. (p. 3)

The importance of this student-centered approach in high school versus college will be discussed in more detail a little later in this dissertation. Unfortunately, it seems that due to many students’ lack of confidence related to mathematics, all teaching approaches provide their own challenges.

From basic arithmetic to the more advanced calculus courses in the first years of college, students develop and attain knowledge and academic achievements, forming their views on mathematics. These views form the foundations of more or less positive attitude toward mathematics as well as self-confidence with respect to the mathematical field and with their ability to perform at a higher or lower level in the future. Different aspects of the learning and teaching as experienced by students will have an impact on their self-efficacy and consequently on their future experiences. In conclusion, teaching and learning may influence students’ feelings toward their own capability in general and mathematics in particular, and may also influence students’ performance and achievement in the mathematical field (Cech, Rubineau, Silbery, & Seron, 2011).

Although freshman and sophomore college students may have different qualifications, such as ACT or SAT scores, and different expectations about mathematics, there are cases in which students with higher confidence and a positive attitude toward mathematics, despite conceivably lower qualifications, perform better than many of their counterparts with perceived better qualifications. While some of the factors that may influence attitude toward mathematics in general and student confidence in particular were extensively discussed in literature (Astin, 1993; Bandura, 1994; Cech, Rubineau, Silbey, & Seron, 2011; Karp, Hughes, & O’Gara, 2010; Tinto, 1987), this paper will focus on a more narrow set of data that examines the impact of a college level mathematics course, “Calculus and Analytic Geometry I” on freshman students’ self-efficacy in the field of mathematics.

Teaching at K-12 or college levels mathematics has more than one purpose. Beyond engaging students in the process of thinking mathematically and problem solving, educators must help learners to overcome or even better, prevent feelings that would deter them from learning effectively, such as mathematics anxiety, which can greatly influence students' attitudes toward mathematics. Most of the time mathematics anxiety occurs as a result of previous unpleasant experiences related to mathematics (Pyzdrowski et al., 2013). On the one hand, it may be incapacitating with respect to future academic performance in the field of mathematics, and students will avoid careers involving mathematics. On the other hand, by doing this, they may miss a whole spectrum of opportunities in a society where technical skills or mathematical skills are desired and valued. Their future success may depend on the first experiences in the classroom when learning the basics, or even later, in high school, when learning more advanced mathematical concepts. If some of students' early mathematical experiences caused anxiety or low self-confidence with respect to mathematics, their future decisions with respect to mathematics in general or with mathematics-related careers may be negatively influenced.

The central aspect around which this study revolves and which will be discussed in most detail is students' academic confidence about their capability to perform well in mathematics. Confidence plays an important role in the future success of the students. There are many beliefs that can influence in one way or another students' confidence. The idea that there is "one best way" of solving a certain problem is something that occurs many times in learners' minds, and is usually the one that most often leads to lower degrees of success in the end. Some students, predominantly among those considered low-achieving, have a tendency of considering their capability of solving problems to be limited, and interviews showed that such students usually avoid any real challenges, such as trying to solve difficult problems (Signer, Beasley, & Bauer, 1996).

As previously mentioned, higher scores in prior tests, such as ACT or SAT, and the skills supposedly associated with those purport to suggest how qualified a student should be with respect to mathematics; also, higher scores in such tests, as well as higher levels of confidence in mathematics were shown to be associated with better academic grades. The findings suggest that lecturers could seek to boost student confidence in their ability in mathematics as further means to improve academic performance (Parsons, Croft, & Harrison, 2009). Unfortunately, many research studies revealed that a high percentage of freshman and sophomore college students either lack confidence or have negative attitudes toward mathematics, or both. In either case, the self-efficacy was affected in a negative way (Astin, 1993; Lerch, 2004; Pascarella & Terenzini, 1991; Tinto, 1975). Studies also reveal that a variety of factors, such as gender, diversity, or previous vs. current teaching methods will influence confidence and attitude toward math (Boaler, 1998; Cech et al., 2011; Chalice, 1995; Petrides, Middleton-Detzner, Jimes, Hedgspeth, & Rubio, 2011).

At the college level, use of student-centered teaching practices for freshman and sophomore students has been shown to improve learning outcomes (Petrides et al., 2011). A qualitative research study conducted among eighteen colleges in California over a two year period used a mixed methodological approach, and researchers gathered data from interviews, observations, site visits, artifact analysis, surveys, concluding that implementation of student-centered teaching practices improved students' performance

(Petrides et al., 2011). It should be mentioned at this point that student-centered teaching practices are considered by many to be confined to PK-12 levels, although, given the era of high stakes testing, this is likely not common place. While the learner–centered education approach in mathematics teaching and learning may be more common for middle and high school, in college mathematics classes, there is supposedly a much stronger focus on traditional teaching methods, such as lecture. It was already discussed in the past whether or not learner-centered methods are vital in improving students' attitude towards mathematics as well as increasing knowledge, or not. One of the supporting factors for the benefits of using student-centered methods in college mathematics classes is a well-known inquiry-based learning method for college level, the Modified Moore Method. Described by Chalice (1995), it concludes that its use may be favorable from the standpoint of student knowledge view point. The author claims that the method was used on multiple occasions in college classes with average students as well as with exceptional students, and in both cases the gains were significant. For two decades the inquiry-based learning method was found to be "superior to simply lecturing" (Chalice, 1995).

The Necessity of the Study

Research about students' attitudes toward mathematics and academic self-confidence is obviously more important than it was during last century due to the continuous necessity for improvement of students' skills in science and mathematics. For example, while 50 years ago gender disproportion was common in technical fields, today the gender gap is narrowing, and in some areas is disappearing. While students' discouraging past experiences with mathematics cannot be eliminated, there must be ways to find appropriate approaches that will engage learners from an early age and will make them feel connected with this field. As was already mentioned, such an approach would supposedly have a great impact on mathematics anxiety, which is tied to both self-confidence and attitude toward mathematics (Jennison & Beswick, 2010). Such research studies can define elements that contribute to student achievement in the future and prevent the use of less effective teaching methods in the classroom. As Zan and Di Martino (2007) mentioned:

> After all, this way of seeing attitude towards mathematics – constructed as a grounded theory – may become a useful instrument for both teachers and researchers. The diagnosis of a 'negative' attitude becomes a starting point for the teacher to design an intervention aimed at modifying the component(s) identified as 'negative' for that pupil. As for researchers, this definition, as it has been constructed, provides a strong link with practice prevents from falling into circularity and, in the end, allows them to overcome some of the critical points of research on attitude (p. 167).

Real help can be achieved only by looking at the whole picture rather than only at a few aspects of the students' lives; analyzing the whole picture means paying close attention to a variety of elements, from content or subject area to private life issues, past experiences, cultural influences, communication, or emotional and psychological particularities.

Self-efficacy is not a characteristic assigned solely to students, children, or learners in general. It is a characteristic of everyone, regardless the domain of activity, the diversity factor, or the level of education. Self-efficacy represents, as Bandura

(1977) purported, one’s belief in his or her capabilities to achieve a certain goal. Just from reading the definition it seems obvious that people with higher levels of self-efficacy would have better chances of being more successful than people with lower levels. But is this always true? Does self-efficacy impact in any way knowledge, capability, or other traits that unequivocally influence performance? These questions were explored in the past in numerous research studies that revealed that relationships exist among certain variables, and determined that self-efficacy was related in many situations to success (Bandura, 1977; Demir, Kilic, & Unal, 2010; Petrides et al., 2011).

Teachers at all levels should be aware of these potential correlations. Student achievement levels are based on a multitude of factors, from socio-economic status (SES) conditions to teaching styles, teachers’ attitudes, or role models perceived from the media. The educator must be aware of all these elements and should be able to use that awareness and understanding to improve students’ attitudes toward learning. Looking back at the turning points in the history of mathematics education it is apparent that a variety of changes occurred through the years. Traditional ways of teaching were replaced by methods specific to Progressivism, after which teaching reflected a back-to-the-basics ideology, and so on. History describes a struggle to find a better and better ways of teaching students. Optimizing the outcome in this situation means engaging students in and with mathematics, in contexts that relate to their surrounding environments and real life situations, working to stimulate their growth and building a strong foundation for the future. Hayes & Greaves (2008) suggest that in the United States today traditional educational practices coexist with learner-centered approaches to learning.

Although mathematics education has evolved, like other fields of study, it was always strongly related to the specific conditions of the society. From this point of view, progress not only had a temporal character, but was also influenced by many factors, including economic, political, social, or geographical conditions. These factors have a direct impact on students' ability to complete majors in science, technology, engineering, and mathematics (Maltese & Tai, 2011). The result is that the field of mathematics education needs to continually evolve in the direction suggested by external conditions, and needs to be shaped continuously according to the reforms aimed at helping students attain mathematical understanding and confidence in mathematics.

On certain occasions mathematics itself and mathematics education are affected by each other's growth. While the field of mathematics becomes richer and richer with every new approach on yet unexplored issues (recent fractal theory is a representative example), mathematics educators must respond and decide how and which parts of these new concepts should be taught and at what level. As such, the continuous collaboration between the content area and pedagogy is based on the interactions and feedback among a significant set of ideas, beliefs, social data, or input from other interrelated fields beyond mathematics. Obviously, this struggle to improve mathematics teaching and learning should not bypass such areas of science as psychology. When Albert Bandura brought his contribution to this field through the social cognitive theory, conducted the Bobo-doll experiment, and later published the book *Self-Efficacy: The Exercise of Control* (1997), his results and conclusions could not go unnoticed. Self-efficacy shortly became an important element of research, and was correlated to many other factors in education and professions in general. Studies that included self-regulation, goal orientation, self-efficacy, worry, and mathematics achievement are available (Malpass, O'Neill, & Hocevar, 1996), and many other researchers have focused on self-efficacy since the 1980's when it became one of the central subjects of education.

Drawing on Bandura (1977, 1982), Randhawa, Beamer, and Lundberg (1993) examined self-efficacy as a mediating factor between attitude toward mathematics and achievement in mathematics, and found that:

> a person's self- efficacy expectation concerning the ability to successfully perform a given task is a reliable predictor of whether the person will attempt the task, how much effort he or she will spend, and how much the person will persevere in pursuing the task in the face of unforeseen difficulties (Randhawa et al., 1993, p. 41).

Although many studies have focused on self-efficacy as a reliable predictor of performance of specific tasks (Bandura, 1986; Campbell & Hackett, 1986; Hackett & Betz, 1989; Norwich, 1986; Relich, Debus, & Walker, 1986; Siegel, Galassi, & Ware, 1985), Randhawa et al.'s (1993) study demonstrated that self-efficacy was a mediator indeed between attitude and achievement. This study was also confirmed the findings of Hackett and Betz (1989), stating that:

> Hackett and Betz (1989) reported that (a) mathematics performance and achievement and (b) mathematics self-efficacy measures were significantly and positively correlated with attitude toward mathematics and mathematics related major. Also, results of Hackett and Betz's hierarchical regression analysis

showed that mathematics self-efficacy was a more robust predictor of the choice of a mathematics-related major than were mathematics achievement and performance variables (p. 41).

A sample of 225 high school students participated in Randhawa's study, all enrolled in an Algebra class. The instruments used were a "Mathematics Achievement Test" based on a 40-item questionnaire that measured students' algebra achievement, the modified "Mathematics self-efficacy scale" (MSES) similar to the one used also in this paper, a "Mathematics Attitude Inventory" (MAI) based on a 48-item questionnaire that measured participants' attitude towards mathematics, and a "Mathematics Attitude Survey" (MAS) that included a set of 23 statements with which participants noted if they agreed or not, on a 4-point Likert scale. The first model used by Randhawa aimed to determine if mathematics attitude was a mediator between mathematics self-efficacy and mathematics achievement. After analyzing the data, mathematics self-efficacy was shown to be a mediator between mathematics attitudes and mathematics achievement. It is interesting to mention a short comparison between the mathematics achievements of male versus female participants. Randhawa's (1991) longitudinal study over a span of eleven years showed better performances of boys as compared to girls in this area, which was consistent with other studies (Meece, Wigfield, and Eccles, 1990), especially for unfamiliar or standardized tests (Kimball, 1989). When the tests were made and assigned by the teacher, Kimball (1989) found that either no significant difference in achievement existed, or female participants scored better than males.

The importance of self-efficacy became obvious, and as a result a variety of research studies were conducted to discover how it impacted different cognitive areas related to learning. Confidence was described frequently as having extremely tight similarities to self-efficacy, despite being considered a different trait in many other studies. Using both terms interchangeably is not necessarily a mistake, but when doing so the description of the type of confidence should be mentioned accurately. An excellent example in this direction is offered by a research study conducted and published by Pajares and Miller (1995). This study involved almost 400 students, who provided three different types of mathematics self-efficacy judgments: confidence to solve mathematics problems, confidence to succeed in math-related courses, and confidence to perform math-related tasks. The authors hypothesized correctly that the most powerful predictor of performance in solving problems would be the first - confidence to solve mathematics problems. When looking for a good predictor with respect to the choice of mathematics-related majors, the confidence to succeed in math-related courses was the best predictor when compared to either confidence of solving problems or performing math-related tasks. These findings support Bandura's argument that "because judgments of self-efficacy are task specific, measures of self-efficacy should be tailored to the criterial task being assessed and the domain of functioning being analyzed to increase prediction" (Pajares & Miller, 1995, p. 190). Based on the examples above it becomes obvious that research should be focused on defining properly the variables in order to reach accurate results.

A similar study was conducted more recently, in 2011, in Germany. Schukajlow et al., (2012) formulated the following research questions:

> (1) Do students' enjoyment, value, interest and self-efficacy expectations differ depending on the type of task? (2) Does the treatment of modelling problems in

> classroom instruction influence these variables? (3) Are there any differential effects for different ways of teaching modelling problems, including a "directive", teacher-centered instruction and an "operative-strategic", more student centered instruction emphasizing group work and strategic scaffolding by the teacher? (p.215)

Although the results did not reveal any significant differences in students' enjoyment, interest, value and self-efficacy between the three types of tasks, "teaching oriented towards modeling problems had positive effects on some of the student variables, with the student-centered teaching method producing the most beneficial effects" (Schukajlow, et al., 2011, p. 215). The results indicate that some variables, including self-efficacy, did not differ among modeling problems, word problems and intra-mathematical problems. Schukajlow et al. (2011) mentioned the existence of two other studies (Frenzel, Jullien, & Pekrun, 2006; Pekrun et al., 2007) whose results revealed that intra-mathematical problems were more enjoyable than word problems. Schukajlow et al. (2011) noted the practical implication of all these findings:

> Students do not automatically show more interest if a modeling problem is presented instead of an intra-mathematical or a word problem. Task-specific affect of students may, however, change in different ways if different problem types are actually solved and discussed (p. 231).

If achievement is viewed as an important goal of teaching and learning, then researchers must study a variety of variables that may influence the outcome of teaching and learning. Such variables may include the teaching methods (learner-centered methods versus traditional teaching), confidence, attitude towards mathematics, or mathematics self-efficacy. As previously mentioned, Randhawa et al. (1993) found that one variable does not always lead directly to achievement. Most of the time, it is necessary to find a mediating factor, such as self-efficacy, which was demonstrated to mediate between attitude toward mathematics and achievement. It must be mentioned at this point that in this dissertation the words “variable” or factors” should not be always interpreted in the mathematical or statistical sense. Some aspects were simply discussed from qualitative perspectives, and the meaning of these words should be interpreted within context.

Career development of minorities and women as a result of their self-efficacy in respect to mathematics was a subject of careful study (Ayres, 1981; Betz & Hackett, 1981; Fox, Brody, & Tobin, 1980; Hackett, 1985; Hewitt & Goldman, 1975; Kerns, 1981; Richardson & Suinn, 1972; Sells, 1980; Sherman & Fennema, 1977; Taylor & Betz, 1983). These studies addressed two concerns: first, the necessity for better preparation in the field of mathematics due to integration of math in a broader range of careers; and second, gender difference, which was considered a “critical filter” in the process of professional choices for women and minorities (Sells, 1980). While some controversies existed in the past, and still exist today with respect to the gender-type of male-dominating world of mathematics, researchers found these correlations to have an indirect character, and would be better described using other factors, for example the attitude toward mathematics early in high school years (Sherman & Fennema, 1977) which may determine eventually higher levels of self-efficacy about mathematics, and will contribute essentially to a larger availability of careers for women.

Other studies found relationships between attitudes toward mathematics and achievement without focusing on mediating factors. Small positive correlations have been found in studies conducted by some researchers, among them Aiken (1976), Ma and Kishor (1997) and Crosswhite (1972). McLeod (1992) found that attitude toward mathematics and achievement do not depend on one another in any way, but their relationship is based on other complex variables in a way that the author described as "unpredictable." Some of these complex variables include those listed in the paragraph above, and as Randhawa (1993) demonstrated, an important mediating factor is mathematics self-efficacy in the case of students studying mathematics.

Since a variety of factors and pedagogical practices influence student learning and achievement, more research is needed to understand the relationships among these variables. Obviously, some of the variables represent important mediators between controllable variables such as teaching methods and possible goals of teaching, such as achievement. Since self-efficacy has been determined to be such a mediator, it is the purpose of this research to examine if mathematics self-efficacy is significantly influenced by the transition from high school to college, in the context of the course "Calculus and Analytic Geometry I," where conditions related to teaching and learning, environment, accountability and responsibility typically change.

Purpose of the Study

While a multitude of studies demonstrate that certain teaching methods, such as a learner-centered approach in general can have a positive influence on knowledge, performance, and achievement for high school students, studies of the influence of taking a calculus course on students' academic self-efficacy in the field of mathematics are scarce. It is expected that students' mathematics self-efficacy would change one way or another when studying a college level calculus course. Coming from high school settings and being familiar with a certain teaching and learning style, students may feel the impact of being on their own. Some of them may feel an extra burden, while others may be either untouched by the new environment, or challenged to work and perform in a higher gear. The importance of these relationships is obvious. If the findings of such a study show that taking the course does not influence in any way self-confidence or attitude toward mathematics, then researchers must look for methods to increase self-confidence and attitude toward math, since self-confidence and attitude are the driving forces of performance and achievement (Demir et al., 2010).

Overall, this study aimed at reaching a better understanding of how the transition from the high school's safety net to a different level of mathematics taught in college settings may influence the mathematics self-efficacy for college freshman and sophomores' mathematics students' academic self-efficacy in the field of mathematics. In general, a likely scenario suggests that teaching in high school is expected to involve the facilitator-type instructor, as opposed to the more formal authority professor typical in colleges and universities. While the latter might be more interested in providing content, the former may focus on activities, emphasizing the learner-centered environment, thereby stimulating student's growth and collaboration. In high school, assuming that the learner-centered environment is present, students should feel both nurtured and stimulated to become responsible for meeting the demands of a multitude of tasks assigned by the teacher. The interactions with the teacher and with other students are strong, creating the feeling of a safety net, offering students the belief that opportunities to succeed abound; exam re-takes, make-up assignments, or grades on homework upon completion are meant to help students develop self-confidence and a positive attitude towards mathematics. Problem solving and learning in collaboration with other students are conducted by teachers based on appropriately designed group activities. As opposed to this, in college, most of the time the lectures that are typical to a teacher-centered style replace the nurturing environment from high school. The students have to deal with the content, will be required to cover the material by independent study in most cases, and will have a more distant relationship with the instructor than they had in high school. Although academic relationships with other students are not discouraged, they will be less important than they used to be during the years before college. Overall, in college, students are exposed to an environment based on a formal authority teaching style, where lecture, content and responsibility with respect to independent study replace the nurturing environment, the interaction, and the cooperative work for activities typical to high school years.

Based on the fact that student-centered approaches might be more common in high school than in college settings, this study will try to determine if a drop in college freshman and sophomores' academic self-confidence may be the result of changing teaching and learning environment and approaches. Many studies note the significant drop in college freshman and sophomores' academic self-confidence. Although few focused solely on the teaching approaches used in high school compared to college, a study focusing on the relationship between decisions of college students enrolled in a college level algebra course and their system of beliefs found that many students did not pursue further attempts to solve a problem because of lack of self-confidence (Lerch, 2004).

Finally, this study aimed to identify the influences of a “Calculus and Analytic Geometry I” course on college freshman students’ mathematics self-efficacy, and to suggest ways of using the results for future teaching and learning. This work also extended beyond the American school system and considers a variety of factors that may have an impact mathematics self-efficacy, such as gender, age, or ethnic diversity.

Research Questions

This was an explanatory sequential mixed methods research that aimed at finding answers to questions of a quantitative and respectively qualitative nature. While the first question aimed at determining if, and how much, participants self-efficacy modified during a calculus course, the second question focused on feelings exhibited by students about objective and subjective factors present in high school and/or college that may have impacted the levels of their self-efficacy over the length of the calculus course.

The research questions for this study were:

1. Is there a significant change in students’ mathematics self-efficacy levels over the necessary time period for completing the Calculus and Analytic Geometry I course?

2. How do students view the transition from mathematics classes previously taken in high school or in developmental mathematics to college-type instruction in a Calculus and Analytic Geometry I course?

Summary

The concern for improving mathematics teaching and learning in mathematics preoccupied educators for decades. Research has identified relationships between factors that may or may not influence quantitatively or qualitatively the subject content and tried to develop more successful teaching strategies. Over the last century shifts could be noticed from one educational class climate to another, or, to be more specific, from traditional teaching to learner-centered style, and vice-versa, aiming for the same goals: better performance and more successful learners.

Many educators acknowledged that performance in mathematics is dependent on motivation, on mathematics confidence, on attitude toward mathematics, on mathematics self-efficacy, as well as on other aspects of education, that hardly can be studied simultaneously. Bandura introduced the term “self-efficacy” a few decades ago, which was defined as "the belief in one’s capabilities to organize and execute the courses of action required to manage prospective situations" (Bandura, 1994, p. 71). His social cognitive theory mentions that self-efficacy is the foundation of motivation, which in return leads to better performance through a variety of other mediators.

Since mathematics self-efficacy was not explored in depth in the past, the purpose of this dissertation is to discuss the influence of certain factors on students’ self-efficacy, narrowing the spectrum of factors of interest to those related to the teaching approach. These factors are related to the class climate, or to be more exact, the teaching strategies employed by educators in a mathematics class in two cases: a more learner-centered environment specific to high school classes, compared to a more traditional approach used most of the time at college level.

General Structure of the Dissertation

The present study comprises five chapters. Chapter 1 explains the purpose and the research questions used in the study, and the reasons behind the necessity of researching this particular field in mathematics education. Chapter 2 presents a review of the literature relevant to the dissertation. Chapter 3 focuses on the methodology employed to complete the study. Chapter 4 explains the data analysis and describes the findings. Finally, Chapter 5 discusses the implications of the findings and the importance of the study in general as related to the field of mathematics education.

CHAPTER 2: LITERATURE REVIEW

Conceptual Understanding of Self-Efficacy

Self-efficacy was first described as an important element in human learning and future success first by Bandura, and later by other researchers who analyzed different aspects of human behavior as related to self-efficacy. Starting from the general definition, as the belief of someone in his or her own capabilities to achieve a goal or an outcome, Margolis and McCabe (2006) determined that a strong sense of self-efficacy will positively influence students to accept challenges and pursue more difficult tasks. Moreover, such students will be more likely to increase their efforts for the purpose of reaching their targets. An important finding was that, when students were not successful, failure was in most cases attributed to factors that were dependent on students' direct intervention rather than being attributed to external factors. The authors concluded also that students with high levels of self-efficacy were able to recover faster and more efficiently from setbacks, showing eventually better probabilities to succeed. By contrast, low self-efficacy was associated with students' lower academic performances, reluctance in accepting the challenges of more difficult tasks, and with less effort for reaching the desirable outcome. Based on the findings of Henk and Melnick (1995) and Walker (2003), Bandura mentioned that these students' "belief in their ability to execute the requisite activities" (Bandura, 1997, p. 36) is low.

It would seem obvious that self-efficacy has an impact on a variety of areas. While motivation, achievement, and other school-related measures are the first to be noticed in a child, later, the student will develop aspirations and career trajectories based on his or her self-efficacy beliefs. This can happen in a direct way, when the subject perceives his or her own capability of reaching a goal in certain fields of activity, or indirectly, through the efficacy in different areas as perceived by the child's parents or guardians (Bandura, Barbaranelli, Caprara, & Pastorelli, 1996). The latter is commonly encountered when talking about socio-cognitive aspects that may impact students' career aspirations and directions in future professional life. The focus of the research work presented above started from the premises that many studies were focused in the past on children's academic development (Bussey & Bandura 1999; Eccles, 1989; Steinberg, 1996), but only few discussed in what ways children's career development was influenced by parents.

According to Bandura et al. (1996), there are several elements that define the process through which parents impact their children's choice of future career, such as: self-efficacy appraisals, educational aspirations, and scholastic achievement. Assessing parents for their self-efficacy was necessary for understanding their influence on their children's academic goals was necessary, because the authors have determined previously that perceived academic efficacy (or in other words academic self-efficacy) was one of the most important factors in a student's choice of a career. The authors tested the prediction that a higher perceived efficacy of the parents will lead to structured academic activities, improving the level of their children's academic efficacy. This view was based on many previous research studies that demonstrated that, when compared with parents who considered that they could not have a beneficial impact on their children's development, those parents who actually trusted their ability to have a positive influence had a higher tendency to be also more proactive and more capable of encouraging and improving their children's competencies. (Bandura, et al., 1996, 2001;

Coleman & Karraker, 1997; Elder, 1995; Gross, Fogg, & Tucker, 1995; King & Elder, 1998; Schneewind, 1995; Teti & Gelfand, 1991). These statements proved to be true in different settings, such as across a variety of socio-economic statuses, cultures, or family structures.

The conceptual model proposed in Bandura et al.'s (1996) study discussed above implies that one's academic self-efficacy will be a determinant factor that will contribute to the build-up of future self-efficacy in several domains of activity or careers, such as "scientific and technical, educational-medical, artistic-literary, and commercial-managerial careers because they all call for advanced knowledge and high-level cognitive skills" (Bandura et al., 2001, p.190). While it is not the purpose of the present study to insist on occupational self-efficacy or on parental influence on children's choice of careers through increasing or decreasing their levels of self-efficacy, some of these aspects were mentioned because their common denominator may be closely related in some cases at least, to self-efficacy in the area of mathematics.

Two terms, "confidence" and "self-efficacy" will be used to mean roughly the same thing throughout this study. "Confidence," or more specifically, as Fennema and Sherman (1976, p. 325) called it, "confidence in learning mathematics" refers to one's confidence that s/he can learn mathematics. Chronologically, "confidence in learning mathematics was defined prior to e Bandura's 1977 work in which the term "self-efficacy" was coined; its definition is generally accepted today. Although "confidence in learning mathematics" and mathematics self-efficacy are similar terms, there is a thin line that differentiates one from the other. While "confidence in learning mathematics" can be interpreted as an overall estimate of how well a subject expects to perform in mathematics in general based on past or present experiences, “self-efficacy” is a term that particularly refers to the confidence in the subject’s ability to perform in a specific mathematics course, or when completing a specific task in mathematics. Although there is a difference between the two terms, the qualitative character of this study will allow the identification of nuances that may occur in students’ view of these terms; as such, the terms will be used interchangeably for the purposes of this study.

Development of Self-Efficacy

Although many of the observations regarding self-efficacy are true in certain settings, such as different cultures, ethnic groups, races or socio-economic statuses, not all such studies referred to the topic of the present paper, and not all studies showed identical results, some of them having a general character that would not be fully suitable for this study. As a result, only relevant works will be described.

Mentoring and Interaction with Faculty

In 2010, Denson and Hill published a study examining the influence of a mentorship program in engineering on African-American male high school students’ perception of engineering as a future career choice. The important part of this study was that two of the three indicators was students’ self-efficacy in the area of mathematics and their perceptions of engineering. The study was quantitative, and the research questions were focused on differences in perceptions of engineering and differences in self-efficacy for students who participated in the mentoring program compared to students who did not participate in the mentoring program. Similarly to the parents’ intervention, Denson’s investigative study used as a foundation the theory of mentoring developed by Kram and Isabella (1985), according to which “mentoring is a relationship between an experienced member of an organization and an understudy where the experienced employee acts as a role model and provides support and direction to the protégé" (Denson & Hill, 2010, p. 104). The particularities of the methodology used in this study can be noticed when observing the way the participants were chosen: for this experiment the researchers focused on an alternative high school in North Carolina; the alternative school was a same sex high school providing small classes and using settings that were aimed at increasing students' self-esteem, where at risk students were offered better opportunities for a decent future. The conclusions drawn from these data were based on the fact that participants, rather than covering a large spectrum of gender, socio-economic status or ethnic groups, were at-risk students, limited to one sex and one single race. Twelve students completed the mentorship program and were used as a control group, while ten students provided the data for the treatment group. With respect to students' perceptions of engineering, which was the subject of the first research question, there was no significant difference among students, possibly due to the brevity of mentorship and maybe also due to short mentorship sessions. The findings about the question regarding students' self-efficacy showed that also differences were not significant in group mean scores. This was also explained by researchers as a result of the specific protocol that implied culturally relevant challenges to be developed by mentors and participants. It was considered eventually that this strategy was not totally leading the study in the expected direction, most likely because some of the participants were reluctant to become more involved in the actual learning process. The study did not find an increase in levels of self-efficacy or an improvement in perceptions about engineering, raising the possibility of targeting a more diversified technical field, in particular engineering. Moreover, the mentorship proved to be ineffective, at least in how it was designed for this particular study, so changes were considered in the future. Overall, the conclusion of this study was that due to practical limitations of studies in general, such as the amount of time available, “a longer mentoring experience should be examined to determine potential impact on student perceptions and self-efficacy” (Denson & Hill, 2010, p.121).

DeFreitas and Bravo (2012) published the results of a research study focused on mentoring as a factor of increasing self-efficacy and consequently increasing academic achievement. There were 249 participants enrolled in this study, of which 105 were African American and 144 were Latino. The authors used the Self-Regulated Learning scale of the Multidimensional Scales of Perceived Self-Efficacy developed by Bandura (1990) to assess participants’ self-efficacy. Two other variables were assessed: mentoring, using the Mentoring scale, which measured students mentoring relationships within the university (Gloria, Robinson Kurpius, Hamilton, & Wilson, 1999), and involvement with faculty (Millem & Berger, 1997). Students were asked to answer questions about how often they met with faculty in general, or during office hours. Similarly, mentoring was studied by analyzing the score on a four-point Likert scale to certain statements, such as “there is someone at [university name] that you consider a mentor or role model” and “there is someone at [university name] that cares about your educational success” (DeFreitas & Bravo, 2012, p. 4).

The results of DeFreitas and Bravo’s (2012) study showed that “self-efficacy was positively related to mentoring and involvement with faculty for both African American and Latino students” (DeFreitas and Bravo, 2012, p. 4). The study included also students' GPA as a variable, and the researchers found that the involvement with faculty and GPA were significantly correlated, meaning that to higher student interaction with the faculty corresponded with a higher GPA. Also, self-efficacy was found to be as good a predictor of GPA, since students with higher self-efficacy obtained significantly higher GPA scores. Finally, and most importantly, the authors concluded that student-instructor interaction was a predictor of self-efficacy. Although mentoring per-se was not found to be a predictor for academic achievement, involvement with faculty was related to better academic achievement. Furthermore, the authors stated that "academic self-efficacy was a mediator of this relationship between faculty-student interaction and improved academic achievement" (DeFreitas & Bravo, 2012, p. 7).

Although mentoring is known to have a positive influence on the mentored students' performance (Paglis, Green, & Bauer, 2006), more research was necessary to determine if mentoring was also a factor that impacts students' self-efficacy. Paglis et al. (2006) explores the possibility of such a relation. One of the three hypotheses (the other two are not of particular interest for this study) tested was that "after controlling for students' research self-efficacy at entry and productivity midway through the doctoral program, adviser mentoring will be positively related to research self-efficacy 5.5 years after they begin their doctoral programs" (Paglis et al., 2006, p. 460). The study design involved surveys administered at three different times to participants. The participants in the study were doctoral students from 24 departments at a university in the Midwest. Although 357 participants were sent surveys at Time 1 (within three weeks after starting their doctoral program), only 130 participants completed all three surveys and returned them after Time 3 (after 5.5 years since participants started the doctoral program), with a diversity distribution showing 77% males, 62% Whites, and 60% US citizens. Using a 10-item scale, participants were asked to assign a score to their level of confidence with respect to performing different research task. Measures for *research self-efficacy* were collected as control variable (at Time 1) and outcome variable (at Time 3). At the end of the second academic year, or Time 2, both mentoring variables, *psychosocial* and *career mentorships* were measured. Similarly with the previous study discussed in this sub-section where the GPA score was included in the study as a variable (DeFreitas & Bravo, 2012), this time the authors included the GRE scores as variables, but found no significant influence of these scores on measures calculated at Time 3. The results of this study offered support, being in agreement with some of the previous findings. Although the authors could not determine the existence of a relationship between mentoring and research career commitment as measured at Time 3, a correlation between psychosocial mentoring and self-efficacy as measured at Time 3 could be found. Paglis et al. (2006) summarized their findings as follows:

> Turning to the regression analysis that controlled for relationships among predictors, the baseline research self-efficacy measure was the strongest positive predictor of self-efficacy 5 ½ years later. Of particular interest, however, was the finding that psychosocial mentoring positively predicted Time 3 research self-efficacy ($p<.10$), controlling for baseline self-efficacy and acceptances midway through the program. Thus, partial support was obtained (p. 460).

Mathematics Anxiety

It was previously stated that mathematics anxiety has a powerful influence on students' attitude towards mathematics (Wright & Miller, 1981). Fennema (1977) also found that mathematics anxiety is correlated with confidence in mathematics, and influences the choice of careers:

> Although both confidence and anxiety have been defined as separate traits, it appears in relation to mathematics, they are very similar. In the Fennema-Sherman study- an attempt was made to measure both confidence and anxiety. A high rating on the confidence scale correlated highly (r = .89) with a low rating on the anxiety scale (Fennema, 1977, p.17).

Hendel (1980) found that self-efficacy or self-estimated mathematics ability was strongly correlated with mathematics anxiety, and also strongly related to mathematics performance. These observations were valid not only for the general population, but also were gender-related. As Hackett (1985) mentions:

> Betz and Hackett (1983) found gender differences in math self-efficacy to be correlated with gender differences in attitudes toward mathematics and choice of math-related college majors. Hackett and Betz (1984) reported moderate correlations between mathematics performance and math self-efficacy, and significant gender differences on both variables (p.49).

Among the variety of conclusions drawn by Hackett, a few concern the present study. For example, ACT scores were adequately predicted by the student's sex and the number of years he or she had mathematics in high school. Also, the ACT math score, the number of years of math in high school, and the male-sex factor explained much (R^2

= 0.54, or 54% of the variance) of the variability in respect to self-efficacy. The researchers found that sex did not influence mathematics self-efficacy directed, but indirectly, through math preparation and achievement. Hackett and Betz (1982) acknowledged that female students “take significantly fewer math courses than do males in both high school and college, and far fewer women than men elect to major in mathematics” (Hackett & Betz, 1982, p.2), and tried to explain the phenomenon; their explanation is similar to what it was discussed already in this paper a few paragraphs above, and was previously mentioned by Hackett and Betz (1982).

Math avoidance has been most frequently explained as the result of negative attitudes and affective reactions in relationship to mathematics (Fennema & Sherman, 1977; Hendel, 1980; Sherman & Fennema, 1977). In particular, the counseling literature has focused on the concept of math anxiety, defined, for example, by Richardson & Suinn (1972) as “feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations” (p. 2).

Previous Academic Performance

A study conducted by Hall and Ponton (2005) focused on determining the differences in respect to self-efficacy for developmental mathematics students as compared to students enrolled in calculus, at a four-year institution. The authors analyzed data using the Mathematics Self-Efficacy Scale (Betz & Hackett, 1993), and the results showed that students who were taking the calculus course not only had better mathematical skills, which was expected, but also demonstrated “a more powerful sense of self-belief in their ability to succeed in a college mathematics course” (Hall &

Ponton, 2005, p. 26). The primary concern when this study began was that during the last 30 years the number of students who enroll in developmental mathematics courses increased steadily, reaching approximately three out of ten students shortly before the study was completed (Breneman & Haarlow, 1998; Smittle, 2003).

Hall and Ponton (2005) acknowledge that developmental mathematics education has the purpose of improving students' mathematics skills. As a result, finding relationships among certain factors pertaining to students enrolled in such courses would be of particular importance. One of these factors may be self-efficacy. The authors stated that "a significant difference between the level of mathematics self-efficacy of freshman students enrolled in Calculus I and Intermediate Algebra was demonstrated" (Hall & Ponton, 2005, p. 28). It was discussed previously in this paper that the higher levels of self-efficacy, the higher probability will be that students to take responsibility for being unsuccessful rather than blaming external factors. Hall's study includes also such element of discussion, and goes one step further, trying to emphasize the importance of identifying the factors that may limit students' success.

In an effort to determine a relationship between self-efficacy in mathematics and class enrollment at college level, Hall and Ponton (2005) conducted a research study comparing the self-efficacy levels of college freshman students enrolled in Developmental Mathematics (which is an intermediate level of Algebra between high school Algebra and College Algebra, usually known as "remedial math") vs. those enrolled in Calculus I. Such studies could help colleges and universities to develop methods of instruction and programs aimed at shaping students with better perceived ability to successfully complete mathematical assignments or tasks.

In addition, Hall and Ponton (2005) also focused also on mathematics anxiety and attitude toward mathematics. On the one hand, they asserted that:

> correlations between mathematics anxiety, test anxiety, and lack of confidence in one's ability to complete mathematical tasks do exist and may possibly indicate that student achievement is not only related to external factors, such as the faculty member and their instructional style, but also to student attitudes toward mathematics (p. 27).

On the other hand, significant differences between otherwise similar studies can be found in the type of mathematics classes in which students are enrolled. For example, while high school students must attend regular classes specific to their age and course curriculum, such as Algebra I, Algebra II, or Geometry, in the first year of college students not only become aware of differences in their ability to perform in mathematics, but Hall mentioned that some authors (Bassarear, 1986; Higbee & Thomas, 1999) also found that “there is a stigma associated with being labeled as a remedial math student” (Hall & Ponton, 2005, p. 27). Moreover, this labelling has a negative effect on the perception of mathematics mainly of female and minority students.

A brief description of Hall and Ponton’s (2005) study will be helpful for a better understanding of certain aspects of this research. The study was conducted in 2001 at a Southeastern rural state research university. Two categories of students were considered for this study, one of them being those enrolled in Intermediate Algebra, the other being students enrolled in Calculus I. Each category was represented by about 400 participants. Students were assigned to one course or to the other based on their ACT score; those who scored 25 or above were allowed to enroll in Calculus I, while those who scored 16 or below had to enroll in the remedial course Intermediate Algebra. Samples of 80 and respectively 105 students were drawn from each category, with slightly more female students than males. A Mathematics Self-Efficacy Scale (Betz & Hackett, 1983) containing 75 items was used in this study. Hall and Ponton (2005) drawing on previous studies (Betz and Hackett, 1993) examined a variety of factors that influence confidence and self-efficacy, and noted that:

> The content validity for the MSES has been demonstrated through research that validates each area measured by the instrument. They note that there were positive correlations between the MSES and other mathematics scales such as math anxiety ($r = .56$), confidence in doing mathematics ($r = .66$), perceived usefulness of mathematics ($r = .47$), and effectance motivation in math ($r = .46$), thus enhancing the concurrent validity of the instrument (p. 27).

Upon successful verification of normality assumptions for the data, a two-sample t-test was conducted showing that the mean MSES score of students in Intermediate Algebra was 5.33 with a standard deviation of 1.4464, while the mean score of students in calculus was 7.08 with a standard deviation of 1.1411. It was concluded that for the $t = 8.902$ and $p < 0.001$, the two means are not equal, so the students in calculus I had a higher level of mathematics self-efficacy than students enrolled in Intermediate Algebra. The authors were interested in determining if there was any correlation between the MSES score and individual ACT score. Moderate correlation was found for students enrolled in calculus, while no significant correlation was determined for students enrolled in Intermediate Algebra.

It was discussed previously that self-efficacy is a mediating factor with respect to professional choices or academic majors chosen by female students. Since this was also a concern in Hall's study, other t-tests were conducted to see how gender differences may influence the results. Briefly, the researchers found no significant differences for as a result of gender factor, neither in Intermediate Algebra nor in Calculus I. Similarly, a two-way ANOVA determined no gender main effect, and no significant interaction between gender and course enrollment on mean MSES score. The two-way ANOVA supported the previous findings of the t-test that "the mean MSES score of Calculus I students is unequal to the mean MSES score of Intermediate Algebra students, thereby suggesting a greater self-efficacy for the Calculus students" (Hall & Ponton, 2005, p. 28).

Hall and Ponton (2005) suggested that students who were not particularly successful in mathematics in high school will feel even more pressure in college freshman year, when they will become exposed to developmental mathematics classes. Even more, researchers (Trusty & Niles, 2003) determined that there was a relationship between success in mathematics and college success in general, which emphasizes even more the importance of developmental mathematics classes reaching their goals. Self-efficacy is also a measure expected to be used by learners in establishing the quantity and quality of effort they need to put into learning in order to become successful in completing a certain task. Just as it was discussed previously in this paper about confidence in mathematics in general, students have a tendency to associate their self-efficacy with previous experiences they had in mathematics classes (Bandura, 1997).

Being exposed to mathematics can be a determinant factor in raising the level of self-efficacy. Similarly, Hall and Ponton (2005) assert that:

> In essence, it is difficult for students to objectively evaluate themselves on topics for which they have little knowledge. Therefore, exposure to mathematics with positive outcomes increases mathematics self-efficacy, whereas exposure to mathematics with negative outcomes decreases self-efficacy provided the positive outcomes are attributed to increase in personal capability and/or effort by the student (, p. 28)

Similarly, Turgut (2013) investigated self-efficacy beliefs with respect to academic performance of a group of undergraduate students. The results revealed a significant effect of academic performance on the “Academic Self – efficacy Scale” (ASES). In contrast, a previous study completed by Lindley and Borgen (2002) examined the relations of generalized self-efficacy and academic performance. They defined generalized self-efficacy as defined as “an individual’s confidence in his or her abilities to summon the motivation, cognitive resources, and courses of action necessary to maintain general control over life events” (p.303). Academic performance was measured by both the ACT score and GPA. The authors concluded that the neither the ACT score nor the GPA was related to generalized confidence.

Such studies are relevant for practice. When referring to future professional careers, the generally accepted view is that more or less, everybody needs a certain amount of mathematics in order to be successful in their field of work. While only a relatively small percentage of students need to take advanced mathematics, everybody needs enough skills and ability in the mathematical field to make him or her comfortable with the available options for their chosen professional career. It becomes obvious that one of the most important roles of Intermediate Algebra will be to increase students' ability in mathematics. Unlike the situation of students who were successful in taking rigorous mathematics courses in high school, students enrolled in Developmental Mathematics did not succeed at the same level, so it is imperative for them to succeed now, or otherwise they will face a greater probabilities of failure in college, or later in their careers. Creating an environment that emphasizes the importance of mathematics, teaching the connections between mathematics and real-life applications, or encouraging students to feel comfortable to ask questions about an area in which they feel weak are just a few methods that educators of developmental mathematics should be using in order to increase students' self-efficacy.

Past and/or Present Teaching Environment

Students' academic performance depends on many aspects of their life, such as academic preparation, but also it depends of non-academic factors, including social integration, motivation, and confidence (Astin, 1993; Karp, Hughes, & O'Gara 2010; Tinto, 1987). There is also a proven correlation between confidence and students' aspirations, motivation, and persistence (Cech, Rubineau & Silbey, 2011). The definition of confidence or self-efficacy as used by other authors will be defined in this study as students' confidence in their skills and abilities to perform a certain task provided they intend to perform that particular task (Pajares, 2000), or in other words, based on Bandura's (1997) definition for self-efficacy, ''refers to beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments'' (p. 3).

For the last few decades, many studies evaluated the influence of both, student-faculty and student-peer interactions on academic self-confidence (Astin, 1991a; Astin 1991b; Astin, 1993; Pascarella, 1985; Pascarella, Smart, Ethington, & Nettles, 1987). Smart & Pascarella, 1986; Pascarella & Terenzini, 1991). More recently, Plecha (2002) studied the impact of student-faculty interaction at college level based on data extracted from the Cooperative Institutional Research Program (CIRP) database for two previous studies: the 1996 Student Information Form, and the 2000 College Student Survey. Performed on a sample of 7440 first-time, full-time students, the study showed that "the hypothesis that negative interactions with faculty would have an impact on students' academic self-confidence was not supported, but student-faculty interaction of a positive sort did help students increase their academic self-confidence" (Plecha, 2002). The same results pertained to peers interactions, and the importance of the conclusions is obvious, since the educational environment at college level can be easily modeled to allow these conditions of positive interactions. Plecha (2002) mentioned that according to previous research (Parajes, 1996; Zimmerman, 1995) "it is important to develop these relationships because previous research shows that academic self-confidence in an important factor in student achievement and persistence" (Plecha, 2002).

Other studies showed that an important factor impacting the academic confidence is dictated by "past academic experiences and expectations of college upon entry" (Bickerstaff, Barragan, & Rucks-Ahidiana, 2012, p. 2). Bickerstaff et al. (2012) examined students' confidence before starting college, and observed noticeable shifts in their confidence short time after college started. They analyzed data gathered from almost 100 interviews to determine a number of approaches that could be used in colleges to improve student success by positively modifying student confidence. It must be mentioned at this point that a significant difference exists between conditions specific for students in community colleges compared to those in four-year residential institutions. Unlike their counterparts in four-year colleges, the subgroup of students enrolled in two-year colleges usually comes from communities with low tradition in higher education, and have lower ties with the campus life, having more off-campus responsibilities, such as jobs or families to support. At the same time, Bickerstaff et al. (2012) citing Clark's (1960) research, showed that community colleges have a more open-access admission policy. The authors also stated that :

> "their dual mission as transfer and vocational institutions, and the limited resources available to students result in decreases in student ambitions. Specifically, students may assume blame for the obstacles they encounter that can deter them from focusing more intently on their academic pursuits" (Bickerstaff et al., 2012, p. 4).

According to the same authors, these students experience a decrease in aspirations and consequently in their confidence.

Teaching Approaches

Recent literature also showed that teaching methods in high school compared to mostly lecture-type classes in college environments can greatly influence knowledge gain, one classical example being the inquiry based learning, which has repeatedly been proven during the last decades to be superior to traditional lecturing instruction methods (Chalice, 1995). The existence of factors that may impact students' self-efficacy has preoccupied researchers over the last few decades. Stevens, Harris, Aguirre-Munoz, and Cobbs (2009) examined how teachers' mathematics knowledge or pedagogical qualities can be increased, and also the best strategies for increasing students' levels of self-efficacy. Stevens et al. (2009), drawing on a previous study (Siegel, McCoach, & Betsy, 2007), suggested that "the students of teachers who completed their two-hour professional development activity demonstrated higher levels of math self-efficacy than students of teachers who did not receive this training; however, they too did not report which aspects of their teacher training were most effective" (p. 904). It seems apparent from these findings of this study that self-efficacy depends on teachers' approaches and teaching methods employed. The only problem is that the researcher could not positively identify the approaches leading to better results in respect to self-efficacy levels.

Researchers were aware that teaching methods may have an impact on students' self-efficacy. Teachers who participated in Stevens et al.'s (2009) study were grouped in three categories, based on their preference for a certain teaching approach: those who favored strategies emphasizing basic knowledge, those who mostly used strategies emphasizing applied knowledge, and those who used a mix of basic and applied strategies where some peer interaction also existed. These preferences for teaching strategies were dependent also on another variable included in this research study – autonomy. Preferences for teaching strategies changed whenever the content was changed, so the teaching strategies would be modified each time to meet the needs of different subjects imposed it. With respect to the findings of this study, Stevens et al. (2009) concluded:

> If systemic, sustainable change in mathematics education is to be achieved, researchers must not only assess increases in important quality variables, such as content knowledge for teaching and self-efficacy knowledge but also work to understand what aspects of professional development are responsible for those increases from subjective as well as objective sources (p. 912).

Use of Technology

Calculus courses represent a step up in the process of learning mathematics. From my previous experience, most students consider calculus as a "different" type of class, more abstract and more difficult to grasp than the vast majority of mathematics classes they had taken before. This view is not specific to a certain group of students, but it is largely accepted by almost everyone. The expected outcome would be lower confidence about performance in mathematics, unless the instruction process is associated with some particularly useful teaching and learning methods and strategies. One such approach that was successfully implemented in classrooms is the use of technology. Different studies conducted in US as well as outside of US supported the opinion that technology can contribute decisively to improving students' understanding and achievement. (Pierce & Stacey, 2012; Attard, 2011; Andrade-Aréchiga, López, & López-Morteo, 2012)

Andrade-Arechiga et al. (2012) discussed the advantages of using a certain learning instrument in order to help students to perform better when learning calculus concepts. The learning technological platform was based on Java developed software, designed to offer access to a variety of Internet portals. The Interactive Platform for Learning Calculus (PIAC) was able to cover vast learning objects (LO) defined by the authors as “educational resources that can be used for curricular proposals in various teaching–learning methodologies” (Andrade-Aréchiga et al., 2012, p. 596). This short description suggests that the electronic learning environment was created to be beneficial to students who were trying to learn calculus, and to improve the efficiency and effectiveness of learning.

In addition, Andrade-Arechiga et al. (2012) focused on two samples of students and two control groups enrolled in a calculus course. There were 102 participants in this study, and results supported the idea that the interactive platform used for improving learning of calculus new concepts had a positive effect on students’ understanding and performance, including a good acceptance of using this platform in class. Moreover, technology was found to have a beneficial impact on students’ motivation. The authors concluded that using PIAC supported significantly technology as instructional aide, and showed clearly better performance obtained by the experimental groups of students as compared with the control groups.

There are methods of teaching such as use of technology that can influence in positive ways students’ confidence and motivation in college level calculus courses. Modern software, such as Maple and Mathematica are especially designed for these purposes. The instructor has to find the best approach to engage students, and create the appropriate conditions to implement technology or any other method to stimulate students’ interest. Continuous interaction, visual aids, technology, are some examples of means that can be used in a classroom for better performance, motivation, of increase in students’ confidence about their mathematics abilities.

Relations between Self-Efficacy, Teaching Approach, and Achievement

The study of possible correlations among mathematics self-efficacy, mathematics achievement, and learner or teacher-centered environments in undergraduate mathematics education has preoccupied researchers for decades. Classroom climate is a central piece in many of these research studies (Fraser, 1989, Pratt, 2002). While the teacher-centered approach is concerned with content and delivery in order to assess behavioral objectives, the learning-centered approach is supposed to make the student the centerpiece of the learning process. Thus, the main characteristics of the learning-centered approach is that it focuses on students' needs and provides them with support and guidance, positive feedback and encouragement, empathy, and mutual trust and respect (Pratt, 2002), while the teacher-centered counterpart can be described by stronger emphasis on the transmission of knowledge by instruction, while the needs of students are of a secondary importance.

Direct Correlations

In a recent study on the correlations of classroom environment and achievement, Peters (2011) found that "[a] review of the literature revealed a lack of empirical research directly related to whether classroom climate influences self-efficacy and/or achievement in an undergraduate mathematics class it does link learner-centered environments to increased self-efficacy" (p. 462). In one of the few available studies, Stipek, Feiler, Daniels & Milburn (1995) analyzed the differences in students' perception of abilities and expectations for success as functions of learner-centered vs. teacher-centered environments. The study showed that participants from the group that used learner-centered strategies rated their abilities and expectations for success significantly higher than the group that used a teacher-centered approach was used. Similarly, Walberg (1981), and Walberg, Fraser & Welch (1986) found that for high school seniors classroom environment was a strong predictor of student achievement. These conclusions explain in part some of the results of the current study.

Many studies have focused on the correlation between class environment and student achievement, attempting to determine if the relationship between them is a direct or an indirect one. Once again, although the teaching approach was found to be a good predictor of achievement, the correlation was indirect, through the mediation of self-efficacy. Citing the results of a study completed by Fast et al. (2010), Peters (2011) noted "that students who perceived their classroom climates as caring and challenging had higher levels of student mathematics self-efficacy and achievement, thus supporting mathematics self-efficacy as a mediator of classroom climate and mathematics achievement" (p. 463). Reyes et al. (2012) reported identical findings, and determined "a positive relationship between class climate and achievement mediated by student engagement" (Peters, 2011, p. 463). Despite rather sparse research supporting relationships between teaching approaches in undergraduate mathematics, mathematics self-efficacy, and achievement, previous research has established already a direct relationship between mathematics efficacy and achievement (Peters, 2011). Using a model previously created by Hackett (1985), Peters (2011) collected data from 117 participants, all undergraduate students, to study self-efficacy as a mediator in the choice of mathematics related majors. The results showed a positive relationship between mathematics ACT scores and mathematics self-efficacy. In addition, sex influenced both the self-efficacy and mathematics achievement. Male participants showed higher mathematics self-efficacy levels and higher achievement that female participants; also, higher levels of self-efficacy were more likely to determine a participant's choice of a career linked to mathematics (Peters, 2011).

Although consistent with previous studies that found a relationship between teaching styles or classroom climate and student mathematics self-efficacy (Fast et al., 2010; Stipek, Feiler, Daniels, & Milburn, 1995), as well as a relationship between student mathematics self-efficacy and achievement (Hackett, 1985; Hall & Ponton, 2005; Pajares & Miller, 1994), Peters (2011) also reported results that differ both qualitatively and quantitatively from previous research. For example, while Brown (1960) and Stipek et al. (1995) found that learner-centered environment led to higher levels of mathematics self-efficacy than teacher-centered approach, Peters (2011) found the opposite. Some possible explanations include students' demographics, age, level of education, and an extremely high percentage (83%) of students who had already taken high level mathematics courses during high school and prior to enrolling in college algebra.

Other important inconsistencies are summarized in what follows:

> Previous research has also reported that classroom climate had a direct influence on student achievement (Brown, 1960; Walberg et al., 1986), which was not substantiated by these findings. However, similar to the findings reported by Fast et al. (2010), results from the current study suggest that classroom climate indirectly influenced mathematics achievement through mathematics self-efficacy. In other words, it would appear that the influence of classroom climate

on mathematics achievement is being mediated by student mathematics self-efficacy (Peters, 2011, p. 475)

Finally, Peters (2011) contradicted previous findings on the influence of teaching style as a mediator on the strength of the relationship between self-efficacy and achievement (Trautwein, Lüdtke, Köller & Baumert, 2006).

For the purpose of this dissertation, the most important findings in Peters (2011) are as follows:

- Participants who exhibited high levels of mathematics self-efficacy also exhibited high levels of mathematics achievement
- The greatest level of mathematics self-efficacy was reached by participants from the teacher-centered classroom
- Teaching styles – neither learner-centered nor teacher-centered, were not strong predictors of mathematics achievement
- Male participants exhibited higher levels of self-efficiency than female participants
- Mathematics achievement was not influenced significantly by participants' gender

Inverse Correlations

Interestingly, research indicates that in many occasions self-efficacy and achievement have an inverse relationship. For example, a number of studies suggested that students often erroneously estimate their grades on examinations as well as their final grades at the end of a college-level course (Nowell & Alston, 2007; Grimes, 2002; Miller, 2008). Findings of such studies consistently showed that a variety of factors influence students' tendency toward overconfidence. Among such factors, Nowell and Alston (2007) reported grading practices, teachers' pedagogies, and students' GPA as important. However, Isley and Singh's (2005) found that teachers' grading practices may suffer due to their observations over time that students' average evaluations of teaching tend to be "higher in classes where students expect higher grades" (Nowell & Alston, 2007, p. 132). These conclusions were consistent with those of previous studies conducted by Millea and Grimes (2002), who found that "both *expected grades* and *actual grades* influence students' evaluations of their economics professors" (Nowell & Alston, 2007, p. 132).

Nowell and Alston (2007) aimed at reproducing similar results to those mentioned above. The study included a survey of students in 32 different courses at the economics department at a large public university, and was conducted during the last week of the semester. Students were requested to estimate their grades in a particular course. At the same time, faculty members were also surveyed about their general grading practices, as well as about interaction with students with respect to grading and feedback they provided to students about grades received during the semester. Moreover, researchers received from the faculty members the actual grade of each student, which allowed them to measure how accurately students predicted their true grades. The authors measured student overconfidence as the difference between the predicted or expected grade, and the actual, true grade they received. The data can be seen in Table 1 (Nowell, 2007, p. 134), below:

Table 1

Actual grade vs. expected frequency

Expected grade	Actual grade					Total (expected)
	A	B	C	D	E	
A	153	63	4	1	0	221
B	38	164	111	15	0	328
C	0	22	93	29	6	150
D	0	0	4	5	4	13
E	0	0	1	1	1	3
Total (actual)	191	249	213	51	11	715

Only 58% of students received the grade they expected. While about one third expressed overconfidence, predicting a greater grade than the one they received, almost one tenth of the students exhibited lower confidence, expecting lower grades than what they received. One of the most important aspects of interpreting the results was related to the segment of the students who consistently overestimated their grades. Since at this particular university the lowest acceptable grade for receiving credit for the class was C, it can be noticed that only six students out of 62 who actually received a non-credit grade of D or E predicted their grade correctly, which leads to a very large percentage (approximately 90%) of students who expressed overconfidence.

Overconfidence of those whose scores are ranked below average was also reported in other studies (Bol, Hacker, O’Shea, & Allen, 2005; Burson, Larrick, & Klayman, 2006; Hacker, Bol, Horgan, & Rakow, 2000; Kelemen, Winningham, &

Weaver, 2007; Krueger & Mueller, 2002; Kruger & Dunning, 1999; Nietfeld, Cao, & Osborne, 2005). Miller and L. Geraci (2011) deserve particular mention. They conducted two sub-studies on overconfidence among students at A&M University, one with 91 participants, the other with 139, who estimated the grades they would receive after a certain exam. Both samples showed strong diversity: “72% are European American, 5% are African American, 17% are Latino or Hispanic American, 5% are Asian American, and 1% […] in an ‘other’ category” (Miller & Geraci, 2011, p. 2). The study had two parts; during the first, participants were asked to provide the letter grade they believed they would obtain after the exam. During the second, a different group of participants were required to provide instead of a letter grade, the number associated with the grade they believed they would receive. For example, while during the first part, student “X” provided C as the expected grade on a particular exam, during the second question student “X” provided 72 as the actual numbered grade associated with that C, showing a “low-C” grade.

Analyzing the data collected from both sub-sections of the study showed that in both cases high-performing students were able to predict the scores on their exams with better accuracy than low-performing students did. A logical explanation as of why lower-performing students consistently predicted better results than they really obtained, was suggested by Kruger and Mueller (2002) through the larger margin above the actual score these students may have available to predict. For example, while a high performing student believes he or she may score 96%, that students has a margin of only 4% overestimation, while a low performing student who believes the actual score may be around 70 will have 30% margin for overestimation, and may in fact predict very easily a grade of high C, or 78.

A similar study was performed at Mississippi State University with a sample of 253 participants, all enrolled in a macroeconomics course during a 16-week fall semester (Grimes, 2002). Participants were asked to predict their scores on a regular mid-term exam, in order to analyze the impact of different demographic data and certain other variables on accuracy. The results showed a significant degree of overconfidence, especially for those students who have obtained credits for previously completed economics courses, as well as for those students showing low values of "predictive calibration," where predictive calibration was defined by Grimes (2002, p. 23) as:

$$Predictive\ Calibration = \frac{(Actual\ Score - Expected\ Score)^2}{Expected\ Score}$$

Figure 1. Formula for Predictive Calibration as defined by Grimes (2002).

The results that are mostly important for the present discussion are related to the academic performance of participants. The researcher found that "student's GPA had a significantly negative effect on the probability of student overconfidence prior to the examination. This finding is consistent with previous studies that reported an inverse relationship between overconfidence and measures of academic ability" (Grimes, 2002, p. 24).

Factors that Influence Success

Knowledge and Understanding

Ferrini-Mundi and Graham's (1991) study examined student knowledge and understanding of several areas of calculus; among other aspects, they focused on understanding of basic calculus concepts in four domains: function, limits and continuity, the derivative, and the integral. The results were not satisfactory with respect to function understanding. While many students understood a function as a formula, they had difficulties in interpreting the same function as a graph. Switching between representations changed students' capability to perform well in that area. Similarly, derivatives were seldom correctly interpreted geometrically, and the intuitive understanding of the derivative concept was very low. The same thing happened with the integration process, which, from the students' perspective was based on applying a formula for integration rather than making a conceptual connection with the process of using limits. Other studies showed that there was a correlation between lack of homework completion and low rate of success in calculus courses, (Zerr, 2007), while another study (Edge & Friedberg, 1984) suggested that one of the most important factors in determining students' success in calculus was their ability to performing algebraic operations fluently: "The original hypothesis that algebraic skills play a significant role in the prediction of calculus achievement was supported by all the regression models which were computed for the three groups" (Edge and Friedberg, 1984, p. 140).

Attitude towards Mathematics

Finally, attitude toward mathematics should be considered when discussing student success in relation to such components like self-confidence, and motivation (Kulm, 1980; Tapia & Marsh, 2004). Unfortunately, negative attitudes toward mathematics are wide-spread among American students, “with 93 % indicating that they experience some kind of negative attitude toward learning mathematics” (Pyzdrowski et al., 2013, p. 532). This is an important factor that negatively influences students’ retention in fields involving mathematics. As such, studying students’ attitudes toward mathematics and self-confidence is important given that 93 % of American students indicated that they experience some kind of negative attitude toward learning mathematics.

In general, understanding of calculus concepts is related to student retention in fields that require mathematics, such as Science, Technology, Engineering, and Mathematics (STEM). The importance of retaining students in STEM is obvious. There are certain indicators of success for entry-level students of calculus. Pyzdrowski et al. (2013) used such instruments as “mathematics inventory, course performance, readiness assessment, and student interviews” to analyze factors that led to students’ success in the course. The study involved 107 students, predominantly white males enrolled in Calculus I at a northeastern university in the US. A Mathematics Readiness Assessment was administered to students about 10 days after the semester started, and an Attitudes Toward Mathematics Inventory was administered also early in the semester. The researchers interviewed both students and the instructor during that semester, asking students such questions as: “Do you feel that you were appropriately placed to enroll in

Calculus? Why or why not?" and "What indicators led you to believe that you were ready for the course?" In addition, the instructor was asked such questions as: "What do you think contributes to your students' success in Calculus?" or "Do you think that most are appropriately placed? Why?"

After analyzing all qualitative data, the authors found that students had already identified a number of difficult concepts during the first semester. Such topics included but were not limited to limits, rate of change, and consequently derivatives. Some students mentioned that they were simply afraid to ask questions, and this had a negative impact on their ability to do their homework. Some students stated that their attitude toward mathematics impacted negatively their ability to perform well in the course. Instructors' comments supported also the idea that students' attitudes were important in their success in the Calculus I course.

Interviews with instructors can sometimes show a more negative perspective than interviews with students. Mesa (2012) suggested that "This discrepancy suggests that instructors might not be taking advantage of the high confidence and motivation to learn that their students bring to the mathematics classroom" (p.46). This study was conducted on 777 participants enrolled in remedial courses as well as other mathematics courses at a community college in the Midwest. Twenty-five instructors were also involved in the study. Several weeks after the semester started, a survey was administered to students. The survey included seven scales from the Patterns of Adaptive Learning Scales (PALS) (Midgley, Maehr, & Hruda, 2000), such as Student Mastery, Student Performance, Teacher Mastery, Teacher Performance, and Academic Self-Efficacy) and four scales from Views about Mathematics Survey (Carlson, 1999), which were Mathematics Self-Concept, Attitudes, Towards Problem Solving, Talent, and Effort.

Mesa (2012) found that from the students' perspective, self-efficacy was positively correlated with mastery goals, and negatively associated with mathematics self-concept. Students' answers also suggested that their goals were to improve knowledge, competence and understanding. They were not as interested in external evaluation of their abilities, which can be translated into academic achievement based on grades received. At the same time, the instructors were asked before the final scores in the course were released to make predictions with respect to students' performance, after which, when the scores were available, they were asked to comment on the differences between the predicted scores and the real ones. Instructors consistently, instructors predicted that students' orientation toward mastery and their self-efficacy were lower than what the students had predicted. Most instructors were surprised by the significant differences between their predictions and the real scores, but in fact one of the conclusions of interest for my study is that "these findings reveal potentially missed opportunities for instructors to capitalize on the goal orientation that students bring to mathematics classes in the community college" (Mesa, 2012, p. 66).

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

Theoretical Support for Design and Methodology of the Study

The purpose of this study was to determine and discuss the impact of a Calculus and Analytic Geometry I course on students' self-efficacy. Previous studies (Betz and Hackett, 1983; Hackett and Betz, 1989; Pajares, 1996) used quantitative research methods to explore similar questions, revealing that changes in self-efficacy among individuals from large populations were due to a variety of reasons. Quantitative methods alone did not provide insight into why and in what way these changes occurred. This was the main reason for the use in this study of qualitative methods together with the quantitative methods, despite their limitations on population size or generalization of the findings, which will be briefly discussed later in this chapter.

The present study used an "explanatory sequential design" approach, as defined by Creswell (2015). A typical model of explanatory sequential design that will be used in this paper can be seen below, in Figure 2 (Creswell, 2015, p. 39).

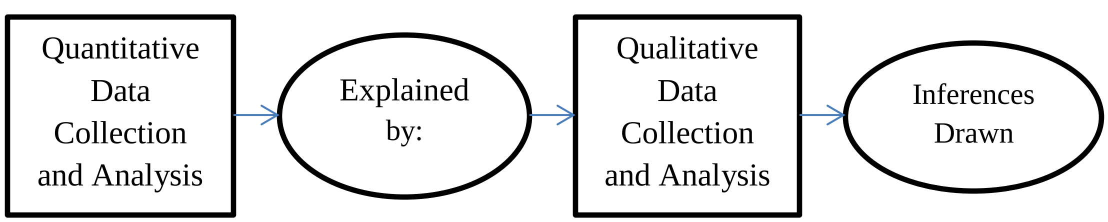

Figure 2. Structure of explanatory sequential design.

The model used for this research was an explanatory sequential mixed methods research, answering questions based on both quantitative and qualitative data (Creswell, 2015). Data were collected from various sources, which included a) a two-stage survey administered to a sample of participants; b) observations of a classroom teaching and learning environment; and c) interviews conducted with a group of participants purposefully selected. The surveys and interviews aimed at capturing participants' perceptions of different factors that may have influenced their self-efficacy levels before and after the course, respectively.

Two identical sections of the same course (MATH-2104-TR32S and MATH-2104-TR66S) were used for this study; the first one started at 10:30 AM and ended at 12:20 PM, while the later started at 2:30 PM and ended at 4:20 PM, every Tuesday and Thursday during the 16 week spring semester of 2015 at a small urban community college. The model used for this research was a mixed that sought to answer questions with both a quantitative and qualitative data (Creswell & Clark, 2006). The study was centered on a sample of participants who answered a number of questions organized in a survey form. The focus of these questions was to capture participants' perception of their confidence with respect to success in mathematics and related subjects. The answers to these questions provided data to assess participants' views on their mathematics self-efficacy during the senior year of high school compared to their current mathematics self-efficacy during the freshman year of college.

The research questions used in this study are:

1. Is there a significant change in students' mathematics self-efficacy levels over the necessary time period for completing a Calculus and Analytic Geometry I course?

2. How do students view the transition from mathematics classes previously taken in high school or in developmental mathematics to college-type instruction in a Calculus and Analytic Geometry I course?

The rationale for conducting an explanatory sequential mixed methods design will be explained in more detail in this chapter. Also, this chapter will highlight the most significant elements of the research methodology, such as describing the settings, the participants, the procedures used for collecting the data, and general information about the data analysis process.

This study employed a mixed methods research design (Creswell, 2015), one of the most common types of studies encountered in education, wherein the researcher uses quantitative data in concert with qualitative data. Qualitative data are typically gathered through interviews, observations, surveys, or document analysis. The qualitative portion of this type of study typically emphasizes how people interpret their experiences, how people construct their worlds, and what meaning they attribute to their experiences (Merriam 2009). This research was focused particularly on a Calculus and Analytic Geometry I course at a community college; there will be a rich description of the participants, their general academic background as well as particular backgrounds information related to their lives that may be meaningful to the study.

The participants in this study were students between 18 and 25 years old, enrolled in a Calculus I and Analytic Geometry I course at a community college, in the Midwest. The results are specific to these particular settings, and will be described shortly in more detail. The study has a particularistic character, partially being focused on a specific course, Calculus and Analytic Geometry I, and on students' self-efficacy as impacted by a multitude of factors, such as the teaching style employed by the instructor or school environment observed by the researcher during this course or by participants during this course as well as during high school years. An important part of the research work was based on the qualitative aspects of research, so this study is strongly descriptive, including many factors that may be considered when discussing teaching styles or class climate. Such a study is expected to have a heuristic character as well, offering a clear perspective on the transformation under investigation, and details that will describe the way students perceive their evolution from high school to college, based on their mathematics self-efficacy, and factors that may have influenced this self-efficacy.

In general, the results of this type of study are useful for observing and improving the levels of mathematics self-efficacy of students in similar situations, emphasizing the particularistic character of the study (Merriam, 1998). Engaging those interested in the process of understanding how certain college level mathematics courses may or may not impact students' mathematics self-efficacy reflects the heuristic value of the research (Rossman & Rallis, 2003). Besides the two characteristics mentioned above, the rich descriptive nature should also be mentioned. Rich description of all aspects offers as much information as possible to the readers, empowering them to decide whether or how to apply strategies that may increase student self-efficacy as a result of taking higher level mathematics courses (Rossman & Rallis, 2003). Likewise, Rossman and Rallis (2003) indicated that the particularistic, heuristic, and descriptive aspects of such a study are its most important characteristics.

Mixed Methods Research

It is generally accepted today, per the fundamental principle of mixed methods design, that researchers should consider combinations of methods that have complementary strengths and do not have overlapping weaknesses. When the decision was made to conduct mixed research for this study, several strengths and weaknesses of qualitative and quantitative research were considered. Johnson and Christiansen (2007) stated that “testing hypotheses that are constructed before data are collected, providing precise, quantitative, numerical data, and being useful for obtaining data that allow predictions to be made” (p. 441) are only a few strengths that are specific to quantitative research. Of course using solely a quantitative design may have some disadvantages, and the researcher must be careful to avoid situations where these disadvantages might become prohibitive. Typical examples include using theories that are not in agreement with local culture or understanding; the possibility that researchers may overlook some phenomena due to focus on certain theories they were testing instead of focusing on generating a hypothesis; or, high levels of generalization or elements of knowledge that are too abstract and cannot be applied directly to real life individuals or conditions (Johnson & Christiansen, 2007).

Similarly, the qualitative design can improve the strength of a study by limiting the number of cases analyzed in depth, by allowing individual case observation and suggesting how participants view certain constructs, such as self-esteem or IQ. However, qualitative research cannot be necessarily generalized or extended to other conditions, settings, or populations. The credibility of qualitative studies may be questionable especially by program administrators or commissioners, mainly because of the awareness that the results can be more easily influenced by the researcher's personal biases and idiosyncrasies (Johnson & Christiansen, 2007).

In response to the strengths and weaknesses of quantitative and qualitative studies, mixed methods research studies were developed in order to improve certain areas of strength, despite potential limitations. For example, a mixed methods research study has numbers associated to explanations, views, narratives or words in general; numbers offer a better degree of precision to some statements. The researcher can elaborate and verify a grounded theory during a mixed methods research study, and using qualitative and quantitative research simultaneously may lead to more complete knowledge necessary to offer support for theory and practice. Compared to the strengths associated with the mixed research, the weaknesses are minor and related mostly to elements that do not actually decrease the outcome of the study or the reliability of the results. The disadvantages are mainly related to it being a more time consuming method, as well as more expensive for this reason. There is also a higher degree of difficulty for one single researcher to complete successfully such a design, and, according to Johnson and Christiansen (2007) "some of the details of mixed research remain to be fully worked out by research methodologists" (p.442).

After a careful analysis of the conditions and requirements for this study, I determined that an explanatory sequential mixed methods research would provide more complete data about the transition through which students go from high school to college, offering opportunities to draw conclusions based on a limited number of participants. Administrating surveys to volunteering participants before and after the course, and using a Likert scale to evaluate their change in self-efficacy, allowed me to select categories of students, whose scores varied within certain limits, creating a future premise for an effective qualitative study through interviews. Using a mixed methods approach to data collection allowed for participants to elaborate on the interpretation of abstract notions, such as self-efficacy. Despite being more complex in general, the mixed research study may help the researcher to shed light on a particular, bounded case, making it possible to draw inferences for similar situations. Although specific theories were not elaborated in the past, some research studies noted inconsistencies in the relationship between teaching styles and self-efficacy in the field of mathematics. Such results were detailed in Chapter 2. The steps used in the mixed research study in this paper will follow Figure 3, in the diagram below (Johnson & Christiansen, 2007, pg. 389):

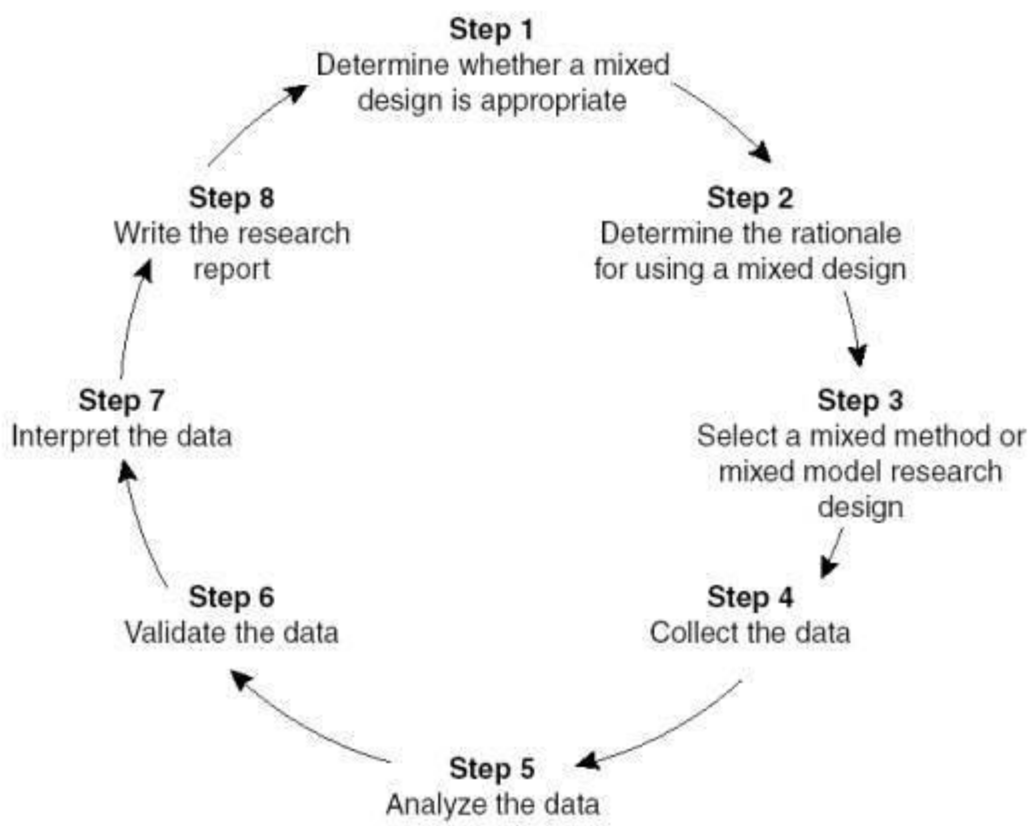

Figure 3. Steps of a mixed research study

Combining Qualitative and Qualitative Data into a Unique Design and Method

The explanatory sequential mixed methods design used in this research study involved collecting and analyzing both quantitative and qualitative data. While quantitative data was represented by a series of closed-ended information related to such factors as self-esteem, confidence, or performance, qualitative data was represented by open-ended information concluded following interviews or surveys where participants described in their own words feelings, impressions, and so forth. (Cresswell & Clark, 2006). The mixed research design provides a variety of options.

Although both qualitative and quantitative sets of data are present in the study, they provided complementary data on the same topic. According to Creswell, “the intent of the explanatory sequential design is to begin with a quantitative strand and then conduct a second qualitative strand to explain the quantitative results” (Creswell, 2015, p.38).

The first step of the procedure followed in this study required quantitative data collection and analysis. During this phase, one survey was administered to participants during the first two weeks of the semester, and a second survey was administered during the last two weeks. Both surveys asked the same questions about participants’ confidence in solving daily mathematical tasks, as well as about performance in courses involving mathematics. The second step was focused on the analysis of the quantitative data, in order to determine any significant changes in participants’ self-efficacy (which will be discussed in the qualitative part of the study), as well as to determine which questions to ask during the qualitative stage. The third step was the beginning of the qualitative part. Data collection and analysis were employed for the purposes of explaining the quantitative results. Finally, during the fourth step I drew inferences with respect to the qualitative data, explaining how these data were related and explained the quantitative results. These inferences were drawn not only from interviews with participants, but also from class observations during the semester. Creswell (2015) mentioned these steps in developing an explanatory sequential design of a mixed research study, and emphasized that one of the challenges is to determine “which quantitative results need further explanation” (p.38). This issue was solved by associating participants’ quantitative answers with a Likert scale, and consequently by constructing a table reflecting meaningful interpretations, such as: students whose self-efficacy increased significantly, students whose self-efficacy decreased significantly, students whose self-efficacy didn’t change significantly, remaining at a low level, and finally, students whose self-efficacy didn’t change significantly, remaining at a high level. More information about how this table was designed and interpreted follows below.

Settings, Participants, Data collection, and Data Analysis

Settings

The setting of this study was a department of mathematics and science at a community college, in a large urban area of the Midwest. The college serves more than 28,000 students annually and is accredited by the state’s Higher Learning Commission. The two-year college covers a large variety of areas of study, offering over 80 associate degree programs in technology/engineering, healthcare, the arts, humanities, and social sciences. The faculty-to-student ratio of 1:20 is slightly better than in most high schools.

The study was conducted during a 16-week semester, and the participants were 26 mathematics freshman students enrolled in the “Calculus & Analytic Geometry I” course, taught by an instructor, other than myself with extensive experience in teaching at this community college. This course was selected because, based on my experience teaching previous courses at the same institution, students enrolled in “Calculus and Analytic Geometry I” are accustomed to high school teaching approaches, and yet also adapt quickly to the college teaching and learning style; as such, they represented a good sample of possible participants with reliable views in both aspects.

Many students enrolled at this community college aim to complete an associate degree in their field of study, after which they may transfer their credit hours towards a bachelor’s degree at a four-year college or university. Therefore, most students taking the “Calculus and Analytic Geometry I” course are interested in obtaining a good grade, which will allow them not only to maintain a reasonable GPA in order to graduate, but also to get credit for this course upon future transfer. Calculus and Analytic Geometry I (to which I also simply referred for convenience as Calculus I) is part of the associate degree in engineering track, and students who pursue this degree track need to take in the future the Calculus II, Calculus III and / or Differential Equations as well, therefore for most students Calculus I represents the foundation of their future mathematical background.

At this community college courses are taught in classes of a maximum capacity of 35-40 students. While the College Preparatory Mathematics classes (CPM) are taught by two teachers who cover the lecture as well as small-group class work, courses such as College Algebra, Calculus, Statistics, or Differential Equations are taught by a single teacher. The method of teaching may vary from instructor to instructor, being centered either on lecture, group work and heavy interaction, or both. Typically, technology is used in the classroom to emphasize aspects related to the lecture, like graphs or 3-D representations, through use of software specifically developed for college level (e.g., Maple, MathLab, etc.). A large Mathematics Lab is available to students more than 40 hours a week, offering use of graphic calculators (TI-83, 84, 89), textbooks used in mathematics courses, manuals with solutions to problems, as well as with free tutoring provided by specialized personnel. Students who have questions related to mathematics can also be helped via telephone. In addition, the Mathematics Lab provides more than 100 computers with internet access, for students who need to use them on school premises. The lab has wireless internet access for students who prefer to work on their personal laptops. In conclusion, the community college provides all necessary accommodations for students who are enrolled in mathematics courses and are interested in success.

Participants

This community college has a large variety of two-year majors, such as Business, Political Science, Biology, Nursing, Psychology, or Engineering. Each of these degrees comes with specific requirements with respect to the level of mathematics courses required for completion. Some fields of study limit students' mathematical background to College Algebra, while others extend their mandatory courses to Calculus II, Calculus III and/or Introduction to Differential Equations. Students who desire to follow an associate degree in engineering must complete a succession of calculus courses, starting with Calculus and Analytic Geometry I.

Based on their mathematical background, students have to complete certain prerequisite courses, and some of them may have needed to take the College Preparation Mathematics (CPM) courses in order to qualify for enrolling in calculus. Most students who enroll in Calculus and Analytic Geometry I (or Calculus I, as it is widely known) are freshmen, although a small number may be sophomores. A typical class has a maximum capacity of 35 students, with exceptions from the rule allowing very few students to enroll over this limit; most of the time classes have a slightly lower enrollment, especially after a number of students will drop out of the course. The vast majority of these students are full time students, being enrolled in approximately 12 credit hours, with a few students enrolled in nine credit hours or less, and working part-time jobs in the meantime.

The participants in this study were students enrolled in Calculus & Analytic Geometry I course. There were two identical sections of that course from which I selected the participants according to their age (between 18 and 25 years old) and willingness to participate in the study. The two sections were scheduled from 10:30 AM to 12:20 PM, and from 12:30 PM to 4:20 PM, respectively. There is significant diversity with respect to age, gender, ethnicity, race or socio-economic status at this college. However, the overwhelming majority of students enrolled in this particular course were freshmen; some of them were full time students, others were part-time students who worked to support themselves or their families. Some students returned to school after a period of time during which they lost contact with both high school and/or college. I did not include in the study students who were older than 25, because I considered that information about their perceived confidence in doing mathematics during high school would be altered by the greater amount of time passed between their leaving high school and enrolling in Calculus and Analytic Geometry I. I also did not include in the study students who did not meet the legal criteria of consent (e.g., age). Overall, the range of participants' age in the quantitative part of the study was from 18 to 25. There were 21 male participants and five females. Their age and gender distribution per course section and overall are presented in Tables 2 through 6, below.

There were 21 participants in the morning section of the course, who completed the *before* part of the survey.

Table 2

Participants in the "Before" survey for the morning class (Sect. 1B)

Categ.	Age18	Age19	Age20	Age21	Age22	Age23	Age24	Age25
Age	7	3	3	4	0	4	0	0
Males	7	2	3	4	0	4	0	0
Females	0	1	0	0	0	0	0	0

From this set of participants, four students (two of them were 23 years of age, one was 20 and the fourth one was 18), all males, chose not to participate eventually in the later portions of the study. As a result, the first (morning) section of the course had 17 participants in the whole quantitative portion of the survey.

There were 11 participants in the afternoon section of the course who completed the *before* part of the survey. Only half of the students volunteered to complete the survey as compared to the morning section, although the total enrollment in the two classes was about the same. This may be easily explained by the fact that when the second section ended (at 4:20 PM) the majority of students did not have another class to attend, and many were just looking forward to leaving.

Table 3

Participants in the "Before" survey for the afternoon class (Sect. 2B)

Categ.	Age18	Age19	Age20	Age21	Age22	Age23	Age24	Age25
Age	2	2	2	3	1	0	0	1
Males	1	1	1	2	1	0	0	0
Females	1	1	1	1	0	0	0	1

From this set of participants, two students (one 22 years old male and one 20 years old female), chose not to participate eventually in the later portions of the study. As a result, the second section of the course (afternoon) contributed with 9 participants to the whole quantitative part of the survey. In conclusion, there were 17 participants in the morning section of the course, who completed the *post* - survey. Their age and sex distribution can be found in the table below:

Table 4

Participants in the "After" survey for the morning class (Sect. 1A)

Categ.	Age18	Age19	Age20	Age21	Age22	Age23	Age24	Age25
Age	6	3	2	4	0	2	0	0
Males	6	2	2	4	0	2	0	0
Females	0	1	0	0	0	0	0	0

Also, there were 9 participants in the afternoon section of the course, who completed the *post* part of the survey.

Table 5

Participants in the "After" survey for the afternoon class (Sect. 2A)

Categ.	Age=8	Age19	Age20	Age21	Age22	Age23	Age24	Age25
Age	2	2	1	3	0	0	0	1
Males	1	1	1	2	0	0	0	0
Females	1	1	0	1	0	0	0	1

The overall age and sex distribution for participants who volunteered to participate in both the before and after portions of the survey can be found in the table below:

Table 6

Total participants in the surveys for both classes (Sect. 1+2)

Categ.	Age18	Age19	Age20	Age21	Age22	Age23	Age24	Age25
Age	8	5	3	7	0	2	0	1
Males	7	3	3	6	0	2	0	0
Females	1	2	0	1	0	0	0	1

Quantitative Data Collection

The procedure used in this study was based on a similar one originally developed by Betz and Hackett in 1983, who designed a modified Mathematics Self Efficacy Survey (Betz and Hackett, 1993) which has been employed in many other self-efficiency research studies (Burnham, 2011). Two stages of quantitative data collection were used for this study. The purpose for a two-stage design is that, first, at the beginning of this course, information was needed to determine how confident participants were with respect to their capability of solving daily tasks related to mathematics calculations, and also how confident they were about completing courses that would require some mathematical background. Second, when the first semester of college was over, I aimed to determine if participants' level of self-confidence has changed. Based on this general design, early in the semester, and at the end of the semester respectively, two identical surveys were administered by me to the students enrolled in Calculus & Analytic Geometry I, in an effort to seek their views on their confidence about mathematics before and after completing this particular course.

Although initially Betz and Hackett (1983) designed the Mathematics Self Efficacy Survey (MSES) based on 52 questions divided into three self-efficacy subscales (mathematics problem solving, everyday math tasks, and math courses), this study utilized an alternative and revised version of this survey by eliminating one of the subscales (mathematics problem solving). According to the instructions for these surveys, participants had to rate their mathematics self-confidence based on a Likert scale that ranged from *total lack of confidence* (0) to *total confidence* (9). As Burnham (2011) mentioned in his study,

> Both the full scale original survey and its subscales have been independently validated with coefficient alphas 16 ranging from .72 to .96 (Betz and Hackett, 1983; Walsh, 2008). Revised versions of the MSES have also been tried and

tested with coefficient alphas between .90 and .95 (Lent, Lopez, & Bieschke, 1991; Kranzler & Pajares, 1997; Pajares & Miller, 1995) (p. 16).

26 participants completed both surveys; 17 from the morning section, and nine from the afternoon section. Of the original 32 participants after the first survey, six either dropped the course or declined to participate in the second survey. Each participant was asked to answer two categories of questions, one referring to their confidence in solving daily tasks related to mathematics, and the other referring to their confidence in performing well or not in courses related to mathematics. Their levels of confidence or mathematics self-efficacy were compared before and after the Calculus and Analytic Geometry I course. There were four possible categories of interest for this study: students for whom self-efficacy increased, decreased, remained low, or remained high. Students who fell into each of these categories were selected for being interviewed in the future to determine possible causes for those results. There were 18 questions in the "Everyday Math Tasks" category of the survey, and 16 questions in the "Math Courses" category. The full two survey categories can be found in Appendix A and Appendix B respectively. A short sample of questions from the first category of questions, as well as from the second category is presented below:

Survey - Category I: Everyday Math Tasks (sample):

How much confidence do you have that you could complete successfully? (You <u>do not need to actually solve anything</u>. Only <u>estimate</u> your <u>confidence</u> about being able to solve, if asked to).

- Add two large numbers (e.g., 5379 + 62543) in your head.

- 2. Determine the amount of sales tax on a clothing purchase.
- 3. Figure out how much material to buy in order make curtains.
- 4. Determine how much interest you will end up paying on a $675 loan over 2 years at

14.75 % interest.

Survey - Category II: Math Courses (sample):

Please rate the following college courses according to <u>how much confidence you have that you could complete the course with a final grade of "A" or "B</u>." Circle your answer according to the 10-point scale below: [note: same scale as Part I]

19. Basic College Math

20. Economics

21. Statistics

22. Calculus

23. Business Administration

Qualitative Data Collection

At four different times separated by approximately by three weeks in time from each other, observations were conducted during each class period, two during the first section of the course, and two during the second section. The interviews and the observations were the two most important instruments that I used in order to collect data for the qualitative part of the study. These data allowed me to explain some of the variations in students' self-confidence.

Determining the perception of student confidence in mathematical abilities *before* the Calculus and Analytic Geometry I course compared to *after* completing the course was particularly important to the study. As previously mentioned, qualitative data is usually drawn based on observations, interviews, artifacts, and so forth. In this study, participants were asked questions related to their experience in high school and their responses provided information about students' perception with respect to a variety of aspects that may have influenced their mathematics confidence, such as school environment, teaching methods used in the past in their classrooms, connections with other students, among others.

The interview questions (see Appendix C) were formulated in such a way as to encourage students to describe the environment during their mathematics classes, how nurtured they felt, how much interaction their teachers ensured for them, and how much help they received from the teacher to succeed. Basic elements of the highly effective teaching methods and strategies drove the interview questions design. When I formulated the interview questions, I began with the idea that a good teaching approach, whether in high school or in college, implies the existence of an environment that supports active student engagement, with potential for individual growth. The focus of teaching should be the individual learner, rather than the volume of knowledge. This can be achieved by specific techniques, such as encouraging collaboration and cooperation rather than competition, allowing students to take responsibility for their own learning, or making learning relevant to particular experiences of students' daily life. Assuming that the notion "teaching style" can be best described by the multitude of qualities and skills an educator employs regularly in the classroom in order to teach different materials, then, the next logical step is to define the learner-centered teaching style, based on the extensive literature on the topic. For example, Dupin-Bryant (2004) defines learner-centered teaching style as “a style of instruction that is responsive, collaborative, problem-centered, and democratic in which both students and the instructor decide how, what, and when learning occurs” (p. 42). Such general guidelines correlated with many other aspects observed in class or mentioned by participants in their interviews were important in drawing conclusions about the effectiveness of different approaches to teaching. In this paper, learner–centered approaches were also analyzed, following discussions with eight participants in the study, to determine if for this particular course taught at this college, the impact of a certain teaching strategy was significant from the student’s point of view. Furthermore, following the theoretical guidelines and correlating them with students’ views gave me a wealth of information about changes or lack of change in participants’ self-efficacy. A small sample of questions selected from the interview protocol can be found below:

Sample Interview Questions:

How many years has it been since you graduated from High School (HS)?

Describe your mathematics background

- What math courses have you previously taken?
- Do you feel comfortable about these classes and the material you covered?

Tell me how mathematics was taught in high school.

- Was teaching interactive? If so, in what ways? Describe.

  (Time spent one-on-one with the teacher, concepts were easy to understand, etc.).

- How did you feel about courses being (or not being) interactive?

- Were you engaged and interested in the subject during classes?

- Were you optimistic about doing well in mathematics in the future?

Describe a typical mathematics class period in high school

The class observation part of the study followed the Reformed Teaching Observation Protocol (RTOP) developed by Sawada and Piburn (2000) at Arizona State University (see Appendix D). It includes five sections: background information, contextual background and activities, lesson design and implementation, content (with respect to both prepositional and procedural knowledge), and classroom culture (referring to interactions and student-teacher relationships). The protocol allowed for rich data to be collected via observations and discussions, to make the link between participants' views on past teaching and school environment as compared to the present, in the college course.

As mentioned previously, based on the results of the quantitative data analysis, some participants were purposefully selected to be interviewed. The interviews provided the final stage of the data collection and included not only standard questions, but a discussion with each participant about his or her past experience in mathematics classes in high school, in present college classes, past impressions about majoring in fields related to mathematics, present views of being in a major involving mathematics, etc. This line of questioning provided rich information related to students' opinions with respect to their past and present feelings about the mathematics subject as part of their profession. The vast majority of the questions in these interviews were open-ended, and participants were asked to explain and elaborate on the answers, in order to collect as much information as possible. Finally, the qualitative data obtained from interviewing participants was correlated with the qualitative data from class observations in order to look for reasonable explanations and categories in the data about participants' modified or stagnant levels of self-efficacy.

Quantitative Data Analysis General Procedure

Bandura (2006) stated that there is "no all-purpose measure of perceived self-efficacy," (p. 307) and as a result, "scales of perceived self- efficacy must be tailored to the particular domain of functioning that is the object of interest" (p. 308). Items used for evaluating self-efficacy should accurately reflect the construct, being formulated in terms of "can do rather than will do" (p. 308). The self-efficacy scale that was used in the present study, just like any other scale that is part of self-efficacy assessment, has a strong predictive utility, or otherwise the research would not have yielded a strong enough predictive relationship.

An important element of measuring student self-efficacy implied also the use of so-called safeguards that have the role of eliminating or minimizing possible motivational effects of self-assessment (Bandura, 2006). This includes the identification of the self-efficacy scale by a code number rather than by a name, informing the participants in the study that responses would remain completely confidential, and emphasizing the importance of the research study and its accurate results. Literature is specific about the use of scales in performing such assessments. Using only a few step scales is less effective than using scales that have 10 or even one hundred response options, because the first are less sensitive and less reliable (Pajares, Hartley, & Valiante, 2001). Students' mathematics self-efficacy was assessed based on their answers to several questions that were developed by researchers and scholars in the past.

For each of the two parts of the quantitative study, a paired sample t-test was performed before and after students completed Calculus and Analytic Geometry I. These results were used to compare the samples' means. Also, individual results were compared to the sample mean, which helped determine which participants would be useful in the interview stage.

After analyzing the two sets of quantitative data associated with the *before* and *after* results, I was interested to determine if upon taking Calculus and Analytic Geometry I, the sample's mean level of self-efficacy changed. In order to determine this, I performed a paired sample t-test for each of the two sets of questions that were used for the quantitative part of the study. Part I of the quantitative survey, in which participants were asked to evaluate their confidence with respect to *Everyday Math Tasks* showed that there was a significant difference between the two means. Detailed results of the quantitative analysis will be presented in the next chapter. Despite results showing a general increase in self-efficacy of the mean per sample, there were individual participants whose self-efficacy either was stagnant, or decreased. I selected those participants who showed the most significant increase (I), decrease (D), similar-low-level (LL), or respectively similar-high-level (HH) to participate in an interview session, during which I asked questions that could explain the shift or the constant character in participants' self-efficacy.

A second quantitative analysis was performed in order to determine if the second part of the survey, "Mathematics Courses" showed any change in participants' levels of self-efficacy with respect to their confidence in performing well in future hypothetical courses that may involve mathematics. This analysis was also performed using a paired sample t-test, in order to compare the sample means. The analysis of the "Mathematics Courses" category of the quantitative survey showed that there was no significant difference in students self-efficacy before and after taking the "Calculus and Analytic Geometry I" course. The reasons for this behavior were discussed after collecting the data coming from interviews and observations. It must be mentioned that an important part of the qualitative analysis came from class observations that provided rich data about teaching and learning in the Calculus I class.

Qualitative Data Analysis General Procedure

Qualitative data were collected through interviews and observations, after which data were organized based on the factors of interest suggested by the research questions. Since there were a multitude of data drawn from interviewing and observations, all pieces of information were first reduced to units of data, categories, or common themes, first. The data analysis then focused then on forming meaningful categories. Recurring themes and patterns were the objects of interest during data analysis. The approach for interpreting the data was based on data coding and looking for common or similar words and for thematic groups related to the research questions. Data were presented in the form of textual display showing categories that have emerged upon organization and data analysis, as well as patterns emerged between and across groups of participants (Merriam, 2009).

Eight students who accepted to take part in the interview session, two students from the HH group, three students from the LH group, two students from the LL group, and one student from the HL group. Five of these participants were Caucasian males who graduated from high school in the US, one was a Caucasian male student who graduated from high school in Spain and moved to the US before starting college, one was a male student of Asian descent who completed high school in China, and one was a Caucasian female student who graduated from high school in the US. The age, gender, and ethnicity distribution with respect to each of the four categories that showed self-efficacy behavior are shown in the table below.

Table 7

Self-efficacy variation based on age, gender, and ethnicity

Sect 1+2								
Category	I	I	I	D	HH	HH	LL	LL
Age	18	20	21	19	21	21	19	21
Gender	M	F	M	M	M	M	M	M
Ethnicity	C(US)	C(US)	C(US)	A(Ch)	C(US)	C(Sp)	C(US)	C(US)

In this table M = male, F = Female, A(Ch) = Asian who was raised and completed the HS in China, C(Sp) = Caucasian who was raised and completed the HS in Spain, and C(US) = Caucasian who was raised and completed the HS in USA.

It should be mentioned here that the most significant group of participants in the quantitative study who showed stagnant low self-efficacy was formed of four students of Asian descent, who unfortunately declined to participate in the interview session.

Whether or not it was related to their low confidence about mathematics in general was not the object of the present study, but it should be mentioned that Nowell and Alstom (2007) concluded that "students with high GPAs were significantly more likely to have completed the survey than students with lower GPAs" (p. 139).

Summary of Chapter 3

The focus of this chapter was to present the methodology used in this study, including the general design, collection of the data, and several important aspects of the data analysis. The research questions were presented, incorporating both aspects of the study – the quantitative part aiming to determine is participants' self-efficacy changed significantly after taking the Calculus and Analytic Geometry I course, as well as the qualitative part, aiming to determine in what way the course may have influenced students to view their self-efficacy with respect to mathematics. The research questions were formulated as follows:

1. Is there a significant change in students' mathematics self-efficacy levels over the necessary time period for completing the Calculus and Analytic Geometry I course?
2. How do students view the transition from mathematics classes previously taken in high school or in developmental mathematics to college-type instruction in a Calculus and Analytic Geometry I course?

The settings where the study took place were described; the participants and the distribution of their age, gender, and ethnicity were presented, and the selection rationale for interviewing certain subjects was outlined. Table 8 below shows the timeline for data collection.

Table 8

Schedule of surveys, observations, and interviews

Sect 1+2 Category	Morning Class	Afternoon Class
Survey "Before"	Feb 03, 2015	Feb 03, 2015
Survey "After"	Apr 20, 2015	Apr 20, 2015
Observation 1	N/A	Feb 03, 2015
Observation 2	Feb 25, 2015	N/A
Observation 3	N/A	Mar 23, 2015
Observation 4	Apr 20, 2015	N/A
Interviews	Apr 29, May 04, 2015	Apr 29, May 04, 2015

CHAPTER 4 - RESULTS AND ANALYSIS OF FINDINGS

Research Questions

The purpose of this study was to determine if the self-efficacy of students enrolled in a Calculus and Analytic Geometry I course changed between the beginning and the completion of the course and to analyze what factors may have been involved in students' view on their perceived mathematics self-efficacy. The study involved both quantitative and qualitative analyses, combined as an explanatory sequential mixed methods research study that answered the following two research questions:

1. Is there a significant change in students' mathematics self-efficacy levels over the necessary time period for completing a Calculus and Analytic Geometry I course?

2. How do students view the transition from mathematics classes previously taken in high school or in developmental mathematics to college-type instruction in a Calculus and Analytic Geometry I course?

Class Observations and Setting for the Study

As a part of this study, four classroom observations were conducted. The Reformed Teaching Observation Protocol (Sawada & Piburn, 2000) was the instrument used for these observations. The Reformed Teaching Observation Protocol (RTOP) includes 25 items that formed three sets: Lesson Design and Implementation, consisting of five items, Content, consisting of 10 items grouped in two subsets of five items each – Propositional Knowledge and Procedural Knowledge, and finally Classroom Culture, consisting of 10 items also grouped in two subsets of five items each – Communicative Interactions and Student/Teacher Relationships. A score from zero to four was associated with each item, with a zero score corresponding to a “never occurred” situation, and a score of four corresponding to a “very descriptive” item with respect to its use in the classroom. The four observations were conducted during the semester, three to four weeks apart, and aimed at identifying elements that were characteristic to the class environment of the Calculus and Analytic Geometry course. Common elements were analyzed in order to be included whenever necessary in the same categories where similar data occurred from interviewing the participants.

For example, following this line of thought, out of all 25 items, among those with the highest scores were items 2, 21, and 24, or “The lesson was designed to engage students as members of a learning community,” “Active participation of students was encouraged and valued,” and “The teacher acted as a resource person, working to support and enhance student investigation,” respectively. The key words that helped building a category were “engage,” “participation,” and “student investigation.” Inductively, these elements, together with other similar answers obtained from interviewing participants led me to determine that a general category associated with all these aspects was “Perceived interactivity of mathematics classes.” In a similar manner the RTOP (Sawada & Piburn, 2000) instrument contributed to identifying the other two categories mentioned as main findings in this research.

During the first class observation, the instructor began class by discussing several homework problems, and noticed that some of the students’ solutions either were identical with the answers from the “Answers” section at the back of the book, or were limited to “yes” or “no” when the question was “Determine if the following function is differentiable.” Instead of accepting the “yes” or “no” answers or correct or incorrect, students were asked to form groups to discuss and explain to one another why the answer was affirmative or negative, after which a student from each group went to the board and solved the problem with appropriate explanations, before the whole class. Similarly, for a different homework problem, students were required to “show a function that is continuous but not differentiable for $x = 2$.” Most students came up with the same answer that was also found at the back of the book: $f(x) = | x-2 |$. The instructor’s approach was identical, discussing whether this was the only possible answer, and asking if anyone else had a different function. Eventually, working in groups and presenting their findings on the board, it was clarified that $f(x) = | x-2 |$ was only one of an infinity of solutions, and the students were reminded of the conditions of continuity and differentiability.

The approach used in the two situations described above was engaging for students, allowing them to explore concepts and their applications to mathematics, and to value new ideas based on intellectual rigor and constructive criticism. The strong focus on understanding could also be noticed on another occasion shortly after the grades of an examination were posted. The instructor advised students to check their exams and see where they made mistakes; she announced that grading was not very harsh for “little” mistakes, such as a lost minus sign, but she subtracted more points for conceptual mistakes. It was obvious from students’ visible reactions that they were happy about this.

The class routine did not always following the same strongly interactive pattern, though. During three out of four class observations, the lectures were combined with problem solving routines, where students worked in groups in order to solve problems, with solutions leading to rich discussions, and concepts explained not only by the instructor, but by students as well. This created the overall feeling of a very interactive class, which participants in the interviews declared to be ideal for increasing their understanding and confidence in mathematics. However, on one occasion near the end of the semester, when the last chapter to be studied was introduction to “vectors” a review of trigonometry was necessary. Students were given reading assignments and a number of problems to solve at home. All these problems were eventually discussed in class, since some of the students either were not able to complete the homework or had questions about the concepts involved. There were 21 questions in the reading assignment, which represented a review from trigonometry concepts needed for the work with vectors. A short description of the main class moments is found below.

By the time the instructor finished covering all concepts of the reading assignment, there was no interaction with students, such as discussions, questions and answers, or group work. Students were not involved in any way in this part of the lesson. After about 30 minutes of lecturing, the instructor presented the first problem, starting with simple questions, making sure that students mastered basic concepts, such as Cartesian coordinates: “Where do I place P(-1, 2) on a Cartesian system of coordinates?” The teacher showed very quickly the correct answer to the questions, after which she moved on to the second problem. Although students should have been able to solve this problem, since the concepts were covered in the reading assignment, the teacher solved the problem by herself. The pattern occurred with several other problems; when some interaction took place, such as the instructor asking the whole class a question, it seemed that only one particular student was answering, while all others were waiting passively for the correct answer to be written on the board.

This approach was more or less expected, because this was only a review of past concepts covered by most students in previous courses, and also there were a variety of concepts to be discussed along with the 21 problems. Yet, part of students' lack of participation could be understood more clearly when the teacher began to ask questions, and some students became more engaged. It became obvious that many students either did not do the reading assignment, or, when they attempted to complete it, did not understand some of the basic concepts. For example, one student asked, "Is it allowed in the vector notation < 8, 0 > to skip the 0 and leave only <8>?" The student did not understand that in < 8, 0 >, 8 and 0 have two very well-defined meanings, showing the magnitudes of components in the x and y coordinates for a two-dimensional coordinate system, while with < 8 > there would only be one component, valid only for a one-dimensional system, such as a line. The teacher explained clearly that both components must be present in a 2-D coordinate system, and the matter was clarified.

As concepts presented that day became more and more advanced, the problems became more difficult. Some of them required either very good conceptual understanding, or simple knowledge of the reading assignment, and both seem to be the main challenge for students. When the teacher asked, "How do we know that two vectors are parallel?" no student came up with an answer within a reasonable amount of time, so, again, the instructor had to explain. The question implied basic knowledge about slope, which is a concept that should have been known from previous classes. Similarly, there was no answer to the question, "How do we find the magnitude of a vector in 2-D?" Rather than using the Pythagorean Theorem as a method for determining the hypotenuse of a right triangle, the vast majority of students looked back in their notebooks or textbooks, trying to find either the answer to the question, or the definition of the "magnitude or a vector." The same pattern followed when another problem asked for the magnitude of a vector in 3-D. The instructor calmly guided the class through the right steps, showing the approach for solving these types of problems.

Eventually, an application of vectors was presented. A conceptual discussion started when the application was shown on the projector board, involving the speed of the wind and a plane, as well as the speed of the water of a river and a boat sailing on that river. These types of problems were limited to vectors sums. The first question was, "If a plane flies from East to West at 320 miles/hour, how can we put this in vector form?" Since there was no timely answer, the instructor explained that since the direction is from East to West, this is associated with a displacement oriented from right to left, at a 0-degree angle with the x-axis, with a magnitude of 320 units: < -320, 0 >. Similarly, another example involved a vector at an angle with the x-axis, asking for x and y - components, respectively. Although a few students seemed to be familiar with the concept of vector components, most of them were not, so more class discussion about this concept was necessary. By the time all the questions from the reading assignment were accomplished in class, the class came to an end and assignments for the next week were announced.

This class observation was included in order to provide a more reflective picture of this instructor's teaching practices. Despite not being as interactive as other class sessions, the instructor's approach was in alignment with most students' expectations and the available time. While most classes had an interactive pattern, this one in particular emphasized the concepts and the steps followed to solve different problems involving vectors. There was no reason to make this class more interactive, such as assigning groups and doing teamwork, since students were not comfortable with the basic concepts in the first place, and obviously the instructor became aware of this very fast. She did not ask students to think out of the box, but she covered the material in a manner that allowed them to understand basic ideas, and apply them to finding solutions.

Results of Quantitative Data Analysis

A more detailed presentation of the data analysis procedure is necessary for an easier review of the methodology and better understanding of the results. The first question suggested a classic, quantitative study. The quantitative data were collected based on a survey about students' confidence in solving basic mathematics problems. Students were not actually required to solve the problems, but only to answer how confident they were about solving them. The two steps of the survey were conducted by administering a set of questions (see Appendix A for more information on the survey questions) *before* the Calculus I course, or during the second week of the course, and *after* the Calculus I course, or during the last week of course, basically when the course was completed.

The survey followed a modified version of the Mathematics Self-Efficacy Scale, MSES (Betz and Hackett, 1993) developed originally by Betz and Hackett (1983). The survey contained two parts. In Part 1, or Everyday Math Tasks, participants were asked to indicate how much confidence they had that they could successfully accomplish certain mathematical tasks by circling the number according to a 10-point confidence Likert scale. The scale ranged from 0 to 9, with 0 corresponding to *No Confidence At All* level, and 9 corresponding to *Complete Confidence*. For interpretation purposes and generalizing of results later in this chapter, the following guidelines were followed:

Table 9

Scale for confidence

Score	Description for confidence
0	No confidence at all
1, 2, 3	Very little confidence
4, 5	Some confidence
6, 7	Much confidence
8, 9	Complete confidence

As an example of the questions in the first part of the survey, Question 1 is shown below:

How much confidence do you have that you could successfully complete the task?

1. Add two large numbers (e.g., 5379 + 62543) in your head 0 1 2 3 4 **5** 6 7 8 9

Circling number 5 (highlighted or bold representation above) in this example indicated that the students had *some confidence* in completing this task.

There were 18 questions similar to the one presented above, covering a wide area of mathematical daily tasks, from purely mental calculations with numbers, to practical applications of mathematics in completing daily jobs: estimating car gas mileage, determining interest, interpreting graphs, or other basic technical skills. The MSES (Betz and Hackett, 1993) survey was administered at the end of class, using paper and pencil to students enrolled in the Calculus and Analytic Geometry I course of spring 2015 at a large community college in a Mid-Western state. Only those students who volunteered to take the survey became potential participants in the final study. If a student participated in the first (before) survey but chose not to participate or was not in class during the second (after) survey, he or she was discarded completely, and the first survey was not used in the study. Similarly, only students who participated in the first survey were asked to take the second survey.

Two sections of the same calculus course were chosen for this study, both of them taught by the same instructor, and both of them taking place twice a week, Mondays and Wednesdays, during the daytime; one section started at 10:30 a.m. and ended at 12:20 p.m., while the other started at 2:30 p.m. and ended at 4:20 p.m. In the morning course there were 21 students who volunteered to participate in the first section of the survey (before) during the second week of the semester, and four of them did not participate in the second part of the survey (after) during the 14^{th} week of the semester. As a result, there were 17 students from the morning section of the course who participated in both (before and after) surveys. In the afternoon course, there were 11 students who volunteered to participate in the first section of the survey (before) during the second week of the semester, and two of them did not participate in the second part of the survey (after) during the 14^{th} week of the semester. As a result, there were nine students from the afternoon section of the course who participated in both (before and after) surveys. Based on this overall participation, there were students who participated in both surveys, and whose data were analyzed in the quantitative part of the study.

More information about the age distribution can be found in Chapter 3, where the methodology was presented.

The object of the first research question was to determine if before the course participants had lower, higher, or approximately the same mathematical self-confidence as they had when the course was completed. Each question in the Everyday Math Tasks portion of the survey had the same weight, so the before (or after) score for a particular participant was the mean of the Likert scores for all 18 questions. The data for the Everyday mathematics tasks was obtained from surveying 26 participants at the beginning of the Calculus and Analytic Geometry I course, and at the end of the semester, when the course was completed. For each participant and for each portion of the survey (“before” and “after” the course) the mean of scores of the 18 questions was calculated, after which the paired sample t-test was performed. The “before” portion of the Everyday mathematics tasks survey showed a large range of individual means, between 3.00 and 9.00, with 11 participants’ scoring means being situated between 7.00 and 8.99, and three means between 8 and 8.99. The “after” portion of the Everyday mathematics tasks survey suggested an improvement, with only nine individual means being situated between 7.00 and 8.99, while eight participants’ scoring means were between 8.00 and 8.99.

In order to perform this analysis, a paired sample t-test on the two sets of data was the statistical method I chose, where $N = 26$ represented the number of participants in the sample of interest, and the means of the before and after sets of data were compared, using $\alpha = .05$. The software used for this study was the IBM SPSS Statistics 23.

The hypothesis tested was if at $\alpha = 0.05$ level of significance there was significant difference between means of the "before" and "after" Calculus I course sets of data for participants' levels of self-efficacy :

$$H_0: \mu_d = 0$$

$$H_1: \mu_d \neq 0$$

The results obtained after running the SPSS software for a paired sample t-test are shown below in Tables 10, 11, and 12:

Table 10

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Part1MeanBf	6.8715	26	1.40791	.27611
	Part1MeanAf	7.2612	26	1.39255	.27310

Table 11

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Part1MeanBf & Part1MeanAf	26	.878	.000

Table 12

Paired Samples Test

	Paired Differences							
				95% Confidence Int. of the Diff.				
	Mean	Std. Dev.	Std. Err. Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1 P1 Mean BA	-.389	.691	.135	-.668	-.110	-2.87	25	.008

The data show that the mean self-efficacy scores for the "before" part of the Everyday Math Tasks survey was 6.87, with a standard deviation of 1.41, while the "after" part of the Everyday Math Tasks survey had a mean of 7.26, with a standard deviation of 1.39. The α level of significance of 0.05 was greater than the value for "Sig. (2-tailed)," so the null hypothesis was rejected, and I concluded that there is a statistically significant difference between the mean of the scores for participants' self-efficacy before taking the calculus course and participants' self-efficacy after taking the course. The effect size was relatively large ($d = -.56$). The important conclusion of this test was that participants' mathematics self-efficacy in Everyday Math Tasks before taking the Calculus and Analytic Geometry I course was lower than their mathematics self-efficacy after completing the course.

The second part of the survey, "Mathematics Courses," examined participants' self-confidence about performing well or not well in a series of courses that require at least some mathematics. The participants were the same students who answered the set of questions from the first part of the survey. Using a similar Likert scale that was used in Everyday Math Tasks (see Appendix A) participants were asked to evaluate their confidence about how they would perform in a variety of mathematics-related courses, including but not limited to: Basic College Mathematics, Economics, Statistics, Computer Science, Accounting, and Advanced Calculus.

The data for the Mathematics Courses was obtained from surveying 26 participants at the beginning of the Calculus and Analytic Geometry I course, and at the end of the semester, when the course was completed. For each participant and for each portion of the survey ("before" and "after" the course) the mean of the scores was calculated, after which the paired sample t-test was performed. The "before" portion of the Mathematics Courses survey showed a range of individual means between 3.25 and 8.88, while the "after" portion of the Mathematics Courses survey showed mean scores between 5.25 and 8.44.

Similarly to the previous case, the hypothesis tested was if at $\alpha = 0.05$ level of significance, there was significant difference between means of the "before" and "after" Calculus I course sets of "Mathematics Courses" data for participants' levels of self-efficacy:

$$H_0: \quad \mu_d = 0$$
$$H_1: \quad \mu_d \neq 0$$

The results obtained after running the SPSS software for a paired sample t-test are shown in Tables 13, 14, and 15:

Table 13

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Part2MeanBf	6.9069	26	1.34858	.26448
	Part2MeanAf	7.0900	26	.92390	.18119

Table 14

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Part2MeanBf & Part2MeanAf	26	.685	.000

Table 15
Paired Samples Test

	Paired Differences							
				95% Confidence Int. of Difference				
	Mean	Std. Dev.	Std. Err. Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1 P1MeanBA	-.183	.982	.192	-.579	-.213	-.951	25	.351

The results of the paired samples test show that the mean self-efficacy scores for the “before” part of the Mathematics Courses survey was 6.91, with a standard deviation of 1.35, while the “after” part of the Mathematics Courses survey had a mean of 7.09, with a standard deviation of .92. The α level of significance of 0.05 was less than the value for “Sig. (2-tailed),” so the null hypothesis is accepted, and I concluded that there is no statistically significant difference between the mean of the scores for participants’ self-efficacy before taking the calculus course and participants’ self-efficacy after taking the course with respect to their perceived future performance in certain courses involving mathematics. The effect size was small-medium (d = -.18). The important conclusion of this test was that participants’ mathematics self-efficacy in Mathematics Courses before taking the Calculus I course was not significantly different from their mathematics self-efficacy after completing the course.

A table showing the distribution of the number of participants’ scores in each of the five categories is presented below (Table 16). Figure 4 shows a shift toward the fourth and the fifth categories (Much confidence → Complete confidence) and is much easier to visualize.

Table 16

Confidence scale table for Everyday Mathematics Tasks

Everyday Mathematics Tasks	No confidence at all (0)	Very little confidence (1, 2,3)	Some confidence (4, 5)	Much confidence (6, 7)	Complete confidence (8, 9)
Before calculus course	0	1	4	17	4
After calculus course	0	0	4	13	9

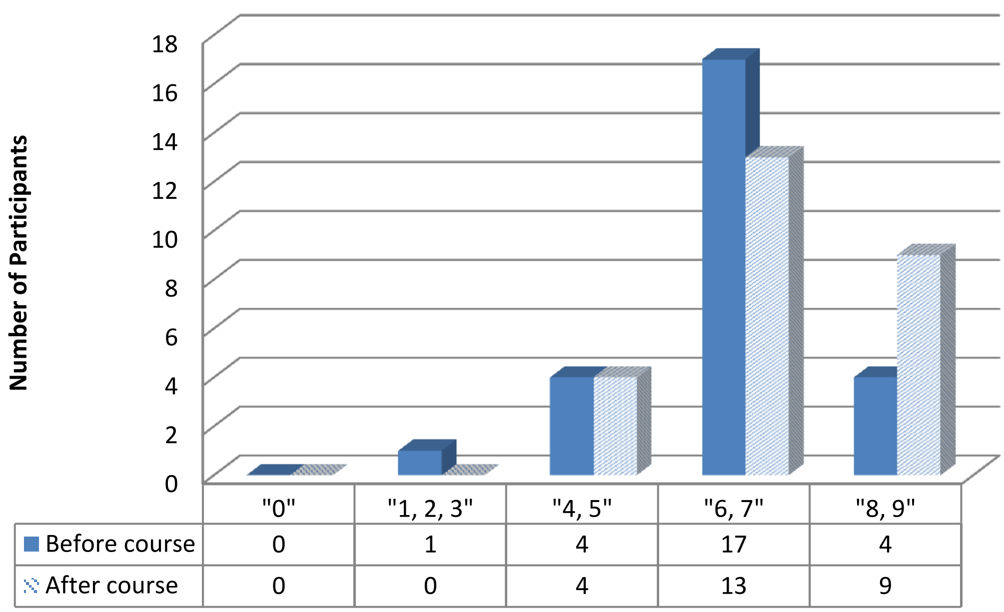

Figure 4. Everyday mathematics tasks, showing the confidence scale graph for Everyday Mathematics Tasks.

Table 17 below presents the participants' distribution with respect to scores in the Mathematics Courses part of the survey. Figure 5 shows a shift in the means of "before" and "after" scores that is not obvious, supporting from a visual point of view the findings described above.

Table 17

Confidence scale table for Mathematics Courses

Mathematics Courses	No confidence at all (0)	Very little confidence (1, 2,3)	Some confidence (4, 5)	Much confidence (6, 7)	Complete confidence (8, 9)
Before calculus course	0	2	3	15	6
After calculus course	0	0	4	17	5

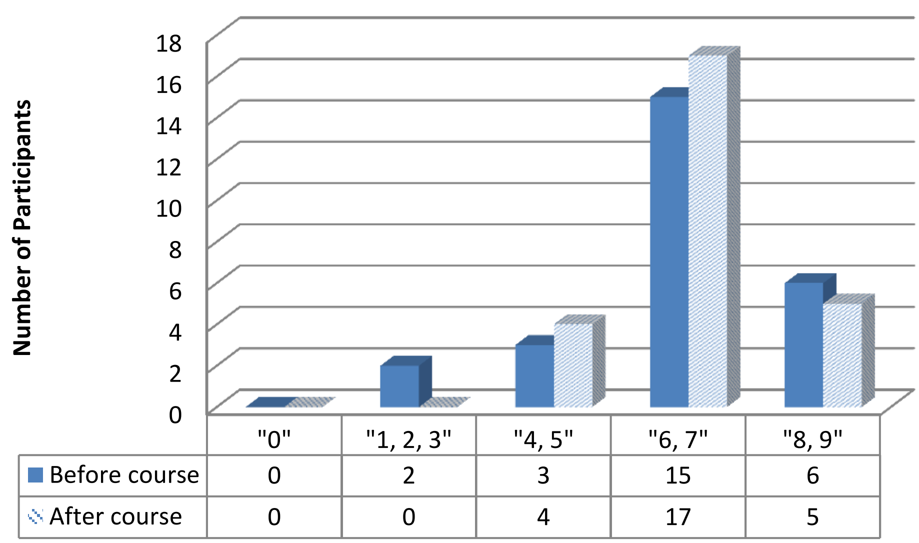

Figure 5. Mathematics courses, showing the confidence scale graph for Mathematics courses

On the one hand, Table 16 and Figure 4 show that in the case of Everyday Mathematics Tasks, most participants (17 out of 26) manifested “much confidence” before taking the calculus course. While no participant completely lacked confidence (zero score), there was one who had “very little confidence,” while “some confidence” and “complete confidence” were equally distributed, with four participants each. After taking the Calculus I course, it is obvious from the graph that there was a shift to the right in the distribution, with several students who showed initially “much confidence” manifesting now “complete confidence,” which led eventually to the conclusion of significant improvement in self-efficacy scores, previously presented in the SPSS analysis, in Table 12.

On the other hand, in the case of Mathematics Courses, most participants (15 out of 26) manifested “much confidence” about doing well in future courses involving mathematics before taking the calculus course. Similarly to the previous discussion, while no participant completely lacked confidence (zero score), two participants manifested “very little confidence,” while “some confidence” was shown by only three participants, as compared to “complete confidence,” manifested by six. It is interesting to observe that after taking the Calculus I course, the shift to the right in the distribution noticed in Everyday Mathematics Tasks did not occur, while the number of students who showed initially “much confidence” remained approximately the same (with a slight jump from 15 to 17). With respect to the “complete confidence” zone, not only was there no increase in the number of participants, but there was a slight decrease, from six to five, with no significant changes in the area of “some confidence,” either. In conclusion, after taking the Calculus I course, it can be inferred from the graph that there was no shift to the right or for that matter to the left in the distribution, with the vast majority of students scoring about the same as they did before taking the course. This interpretation supports the conclusion of no significant improvement in self-efficacy scores, as presented in the SPSS analysis, in Table 15.

Quantitative Analysis as Foundation for Qualitative Data

Chapter 3 outlined the data collection and methodological approach for this explanatory sequential design mixed methods research study (Creswell, 2015). All participants in this study provided quantitative data. These data were analyzed for the purpose of selecting participants who could shed light on their levels of self-efficacy through qualitative data collection.

In order to determine which participants might provide helpful information in answering the research questions, the individual mean scores of participants were analyzed before and after taking the course. Although most participants showed an increase in self-efficacy, there were others whose self-efficacy levels either decreased or remained at a low or high level. Since the Mathematics Courses section did not show any significant change in students' self-efficacy, data resultant from the Everyday Mathematics Tasks were used to help determine key informants.

In many cases participants showed an increase, but only within the limits of the same category, such as "much confidence." For example, "Student 1" showed an increase of self-confidence from 6.83 to 7.56, while "Student 2" presented an increase from 7.06 to 7.89. In both cases self-confidence was within the "much confidence" limits, covering everything from 6.00 to 7.99. In other cases, students showed a change in self-confidence that crossed the borders of a certain category, the difference being either smaller or larger. For example, “Student 4” had an increase in self-confidence from 7.28 to 8.67, which in terms of self-confidence category showed a shift from “much confidence” to “complete confidence.”

One aim of this study was to examine the reasons for a change of participants’ self-efficacy based on scores showing significant changes. These changes did not always follow a very clear pattern, such as an obvious increase from a low self-efficacy to a high self-efficacy. Many times scores had a significant change, being both “before” and “after” at a higher or respectively lower level. In such cases personal judgment was necessary to assess the change. Participants’ pre- and post-mean scores are shown below, in Table 18:

Table 18

Scores of participants before and after the Calculus I course

Participants	Mean before course	Mean after course
Student 1	6.83	7.56
Student 2	7.06	7.89
Student 3	6.44	7.11
Student 4	7.28	8.67
Student 5	5.72	6.00
Student 6	8.06	8.44
Student 7	7.67	8.50
Student 8	7.39	7.33
Student 9	7.50	8.56
Student 10	8.61	8.72
Student 11	7.50	7.50
Student 12	4.72	6.00
Student 13	4.72	4.56
Student 14	7.22	8.17
Student 15	4.39	4.72
Student 16	6.89	6.67
Student 17	3.00	4.44
Student 18	6.44	5.11
Student 19	6.11	7.50
Student 20	7.78	8.50
Student 21	7.89	7.78
Student 22	7.89	8.72
Student 23	7.72	7.39
Student 24	6.50	6.17
Student 25	8.33	7.78
Student 26	9.00	9.00

The description presented above was made in preparation for the next step of the quantitative study, which was the construction of a table containing the appropriate number of participants based on their scores in the “before” and “after” sections of the Everyday Mathematics Tasks survey. As described in the methodology chapter, the table should include four main areas: participants who scored lower before taking the course and higher after, participants who scored higher before taking the course and lower after, participants who scored low in both “before” and “after” surveys, and participants who scored high in both “before” and “after” surveys. Graphically, the table is similar to the one below (Figure 6):

LOW-LOW Participant “A” Participant “B” Etc.	**HIGH-HIGH** Participant “C” Participant “D” Etc.
HIGH-LOW Participant “E” Participant ”F” Etc.	**LOW-HIGH** Participant “G” Participant “H” Etc.

Figure 6. Conceptual structure of self-efficacy variation “before” and “after” calculus course

Ideally, all participants in the study would have agreed to be interviewed. However, most participants did not agree to participate in the interviews either from the very beginning when they received the informed consent, or decided not to be interviewed at a later date. Ultimately, eight students who consented to be interviewed met the criteria to serve as informants to explain their self-efficacy changes.

There were few examples of participants in both the “before” and “after” sections of the survey whose low levels of self-efficacy would have represented a very interesting point of discussion. All three, “Student 13” (score 4.72 before course and 4.56 after course), “Student 15” (score 4.39 before the course and 4.72 after the course), and “Student 17” (score 3.00 before the course and 4.44 after the course), declined to be interviewed.

There was also a case of a participant who completed the whole survey, and the mean scores were maximum “9” in both sections, being a complete outlier, suggesting that either the participant did not complete the survey in total faith, or the participant’s self-confidence was absolutely outstanding. I had no opportunity to discuss with this student, because also, the participation in the interviewing process was declined.

Purposeful Selection of Participants for Interviews

Selecting participants for the interviews and classifying them into appropriate categories required careful analysis of the quantitative data, and some degree of compromising between what we generally understand by different concepts, such as “high score,” “low score,” or “increase.” While a drop from a score of 8.5 to 7.8 can be interpreted as a decrease in self-efficacy, it can be argued that it represents maintaining a high score overall, since scores of 8 or 9 represent the highest scores possible to achieve on the scale used in this study. Also, since the average of self-efficacy scores oscillated around 7, it can be argued that a variation from 6.2 to 7 may represent an increase in self-efficacy, but also it represents a relatively steady low score before as well as after the Calculus course.

Following this reasoning, the eight participants who were interviewed were placed in the following categories:

Category I: Participants who maintained a high score before and after the calculus course:

Kevin:	High – High (8.05 – 8.44)
Pedro:	High – High (7.89 – 8.72)

Category II: Participants who maintained a low score before and after the calculus course:

Andrew:	Low – Low (6.44 – 7.11)
Patrick:	Low – Low (6.89 – 6.67)

Category III: Participants whose scores before and after the calculus course increased:

Robert:	Low – High (7.66 – 8.50)
David:	Low – High (7.50 – 8.50)
Julia:	Low – High (6.11 – 7.50)

Category IV: Participants whose scores before and after the calculus course decreased:

Chen:	High – Low (6.44 – 5.11)

The categories III and IV, “low” and “high” should interpreted as “relatively low” and “relatively high” respectively, rather than strictly “low” and “high” scores as we might be tempted to do. It is easy to notice for example, that David’s score before the Calculus course is 7.5, which is already a relatively high score, but I was more interested in the full one point increase to 8.5, so I categorized this as an increase, rather than a stagnant high score. Similarly, Chen's score before the course was 6.44, which represents a relatively low score, but I was also more interested in the dramatic change to 5.11, so I categorized it as a decrease in self-efficacy, rather than a stagnant low score.The following participants agreed to be interviewed:

Table 19

Participants who agreed to being interviewed

Participant	Score before the course	Score after the course
Student 3	6.44	7.11
Student 6	8.05	8.44
Student 7	7.66	8.50
Student 9	7.50	8.50
Student 16	6.89	6.67
Student 18	6.44	5.11
Student 19	6.11	7.50
Student 22	7.89	8.72

The following distribution table was created for future qualitative data analysis:

LOW-LOW Student 3 Student 16	**HIGH-HIGH** Student 6 Student 22
HIGH-LOW Student 18	**LOW-HIGH** Student 7 Student 9 Student 19

Figure 7. Real structure of self-efficacy variation “before” and “after” Calculus course

Qualitative Data Analysis

The way questions were formulated had a major impact on obtaining data that could help answer the second research question. There were assumptions about certain aspects (such as the amount of time students lost contact with mathematics after high school, the degree of interaction being supposedly higher in high school than in college, or difficult transition from high school to college for most students) that needed to be verified in an objective way, and the only way was to interview the participants. There were 10 major questions to which participants had to answer during interviews. The questions aimed at identifying the differences between a student’s views on mathematics before and after the calculus course, confidence, optimism, etc.

This section discusses the qualitative aspects of participants' change in self-efficacy, suggesting why they experienced significant or minimal such modifications. A description of the analysis process follows below, explaining how categories and sub-categories were determined and interpreted, through a series of inductive and deductive iterative steps (Creswell, 2014). Data were collected via individual interviews and class observations. Interviews were conducted with selected participants, whose scores were of particular interest following the quantitative part of the study previously described in the first part of this chapter. The interview questions (see Appendix C), were formulated such that participants would describe their learning experiences, beliefs, and feelings related to their mathematics confidence in high school as well as in college. Class observations, previously presented, followed a validated instrument, the Reformed Teaching Observation Protocol (RTOP), developed at the University of Arizona by Piburn and Sawada (2000).

Qualitative data collected for this study were analyzed following an inductive and deductive analysis approach in an effort to search for categories and subcategories (Cresswell, 2015). Upon completion of the interviews with eight purposefully selected participants, I had an inductive sense of possible categories. Based on those loosely formed categories I began to analyze transcribed interview data in an effort to deductively create an image about the way participants were exposed to certain learning experiences, such as group learning, interactivity, or use of technology. Next, I read the individual interviews, looking for trends especially in the case of common aspects mentioned by participants who were located in the same quadrant for purposeful participant selection (See Figure 7). For example, let us assume that several participants whose difference in self-efficacy before and after the course and was high mentioned that one of the factors that had positively affected them was better use of technology in college. In this case, technology would be an initial category worth examining further. So, relying on my observations and other students' interview data, I examined the data to determine if technology were in a category represented across the data. If this idea is supported, then the use of technology in high school teaching environment vs. college settings becomes a category in the findings.

The data analysis procedure used for the qualitative portion of this study involved inductive and deductive analysis in a search for categories and subcategories. In order to synthesize all data and determine common aspects and trends that would form the categories and subcategories data were considered holistically (all interview data simultaneously) and individually (individual interview data). Categories of ideas were loosely formed and noted upon completion of each interview using an inductive analysis approach. Based on the inductively created categories, all data were analyzed and coded. Using a deductive analysis approach, I returned to the data using coding to determine if categories could be supported with evidence or if the category needed to be split into different sub-categories. In these cases I analyzed each category separately to determine if a new category emerged or if this was a subcategory of a previous finding. This coding helped form the main findings of the study. For example, if several students mentioned technology as an issue, I initially noted that this might form a category. Later on, I might notice that some participants stated that integrated learning platforms were very helpful in college but not used in high school, while other technology issues, such as graphic calculators, projectors, or Power Point presentations were scarcely distributed among participants. Then, the use of integrated learning platforms in college would become a category by itself, and would be examined carefully to see the impact on students' self-efficacy. An inductive and deductive analysis of data approach can be a tedious process involving visiting and revisiting the data, examining and re-examining, in a search for categories and sub-categories or themes that represent participants' experience. An example that reflects the procedure described in this paragraph can be seen below, in Figure 8.

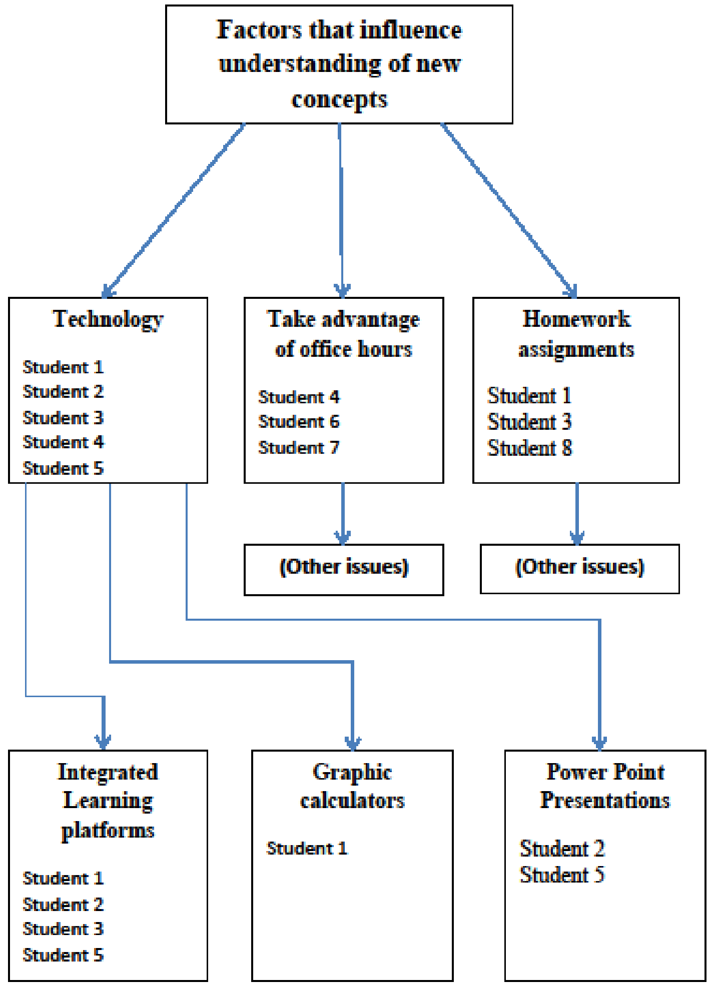

Figure 8. Example of structure of categories and sub-categories in the qualitative data analysis.

The important categories that resulted from this analysis were formed in an effort to provide insight to help answer the second research question. This question referred to students' view of the transition from mathematics classes previously taken in high school or in developmental mathematics to college-type instruction in an engineering calculus course as a factor affecting their self-efficacy levels. This question did not refer to individual students' self-efficacy levels, but rather to the whole set of factors that influenced students and impacted them in different ways. Due to the multitude of personalities and learning styles, understanding self-efficacy is a complex endeavor. Factors that may have contributed to an increase of self-efficacy in some participants could have influenced in a negative way the levels of self-efficacy of other students. The timeframe of each step of the study was provided in Table 8.

Results from Qualitative Data Analysis

The results revealed three categories that impact students' chances of maintaining a high level of self-efficacy. In the next sections, I will discuss the findings described above, elaborating on the three major categories that impacted significantly participants' self-efficacy in mathematics: **background with respect to mathematics course levels completed before calculus I**, **interactivity of the calculus course as compared to previous experiences from high school or CPM classes, and procedural approach (algorithms and step-by-step solutions) as compared to conceptual approach in problem solving**. The intertwining character of the answers to the interview questions offered a vast field of possible interpretations, and my final conclusions were drawn after considering all possible aspects, for example, assuming that a male student improved his mathematics confidence from the beginning to the end of the study, stating that in high school classes were very interactive, just as in Calculus I. Without further investigation, this does not lead to any logical conclusion based only on teaching and learning styles. However, considering other questions and answers where the student mentioned that he was not interested in paying attention to class in high school because of his self-admitted immaturity, while now he is interested because he considers himself more mature and ready for a career, things can be seen in a different light, and conclusions may be drawn. There were many such situations during the interviews, and the most significant results will be discussed in detail below.

Mathematics courses taken. The first category is **the level of mathematics courses participants took before Calculus I**, particularly those courses taken in high school. Consistently, those students who completed AP Calculus or Calculus courses previously in high school entered the course with elevated confidence levels, and their confidence about doing well in mathematics never decreased. Participants who stopped taking mathematics courses upon completing Pre-Calculus, Trigonometry, or those who needed College Preparation Mathematics (CPM) courses before Calculus, started with a lower self-efficacy, and it did not improve it significantly over the length of the study. There were no indications that the relative time between high school graduation and taking this course impacted students' initial self-efficacy, although some participants indicated that maturity may make a difference. In other words, analyzing the answers to Question 1:

How many years has it been since you graduated from High School?

Correlating them to further data, did not suggest any significant change in students' view on their self-efficacy solely due to the length of time since students graduated from high school. Although both students who maintained high self-efficacy took Calculus I after three and respectively four years after high school, this does not seem to be an important aspect, since there were other participants with a similar time gap who scored low or relatively low. However, some students' responses to another questions correlated with responses to Question 1 indicated that students can be aware about their being more mature, but still had low mathematics self-efficacy:

"Researcher: And how do you think mathematics is being taught in college as compared to high school, and how do you feel about this?

Patrick: Mm, I think the difference is just the people itself. People are more mature."

Patrick graduated from high school four years before taking Calculus, just like Kevin, but unlike Kevin, who maintained high levels of self-efficacy, Patrick began the course with low self-efficacy and also completed the Calculus I course with low self-efficacy. Based on such findings, and considering that the one mentioned above was not singular, I concluded that the number of years since high school was not an important factor in explaining participants' self-efficacy. This may have occurred because for some students the length of time they are out of school may action as a deterrent with respect to their willingness to do mathematics at a certain level, while for others the few years may contribute more on their maturity, and impact their drive about a future career. Which one is true cannot be determined from a simple interview, and this was exemplified very well when Patrick admitted to being more mature, but his self-efficacy score was still low.

The second question of the interview referred specifically to participants' mathematical background, and how comfortable they were about the material covered:

Question 2: Describe your mathematics background

a. What math courses have you previously taken?

b. Do you feel comfortable about these classes and the material you covered?

The data collected via the interview was based solely on participants' statements, reflecting their own voices and opinions. The question had two parts: the first part asked about the "per se" mathematical background of participants, while the second part requested more information about how comfortable students were with the classes they had completed in the past. This approach was necessary, because taking a high-level mathematics class might not necessarily guarantee superior self-efficacy, unless it was correlated with other factors, such as success or better comfort with the material. By simply taking the advanced course and not succeeding in completing it, or feeling uncomfortable during that particular course may lead for example to mathematics anxiety, and consequently to lower self-efficacy.

The mathematical background of participants was found to be a defining indicator of self-efficacy. In general, according to the high school curriculum for mathematics, the highest level of instruction in high school is traditionally AP Calculus. Only two out of the eight participants interviewed completed such mathematics classes in high school. The first participant introduced above, Kevin, took and passed successfully AP Calculus in high school, while Pedro, who was schooled in Spain during his high school years, took and successfully completed courses that were similar to the American curriculum involving main concepts found in Calculus I, II, III, and IV. All other participants stated that their a maximum level of instruction was either Pre-Calculus , or other courses situated at a lower level than Calculus I, such as College Algebra or Contemporary Mathematics. There was no consistency in claiming certain background as being associated repeatedly with any of the four categories mentioned above (HH, LL, LH, and HL), except the two students who passed AP Calculus in high school, with respect to the first category, (HH). Not only did both students start Calculus I with a strong self-efficacy level, but they maintained it during the course. Kevin declared that he felt very comfortable with high school mathematics, while Pedro was sometimes overwhelmed by the volume of mathematics involved:

"Researcher: Did you feel comfortable about these classes and about the material, how did you feel at the time?

Pedro: Felt a little, it was I felt a little weird because it was it was so much information. That I got, everything was thrown at me just at once."

Pedro's feelings about how comfortable he was are understandable, when considering the amount of material students had to cover. Calculus I through IV is taught in the United Sates throughout college years. Although most mathematical concepts in high school curriculum in Spain are similar to those found in Calculus I - IV in the US, there are also significant differences; during his high school years, Pedro studied only part of the material found in the American curriculum for Calculus I-IV. In contrast, learning and understanding the important concepts offered him a solid mathematical background. As a general conclusion, the participants whose mathematical background was less extensive had lower chances to develop and maintain a strong self-efficacy in Calculus courses they took later. With respect to their being more or less comfortable during their high school mathematics classes, besides Kevin and Pedro, who felt comfortable, the rest presented uniformly distributed comfort level. For example, there were participants who despite feeling very comfortable with high school mathematics developed a low level of self-efficacy and maintained the same level throughout Calculus I. At the same time, other participants who felt comfortable in the past, despite developing a low level of self-efficacy, improved it significantly during Calculus I. To support these statements, I will present shortly the interview questions and answers with Andrew (LL) and Julia (LH):

"Researcher: Did you like mathematics?

Andrew: At the time, yeah. I mean, I was good at it."

"Julia: Mathematics has always been my best course.

Researcher: So did you feel always comfortable in math?

Julia: Yes."

Although Andrew does not literally state that he felt comfortable in mathematics, it is obvious from his statement that "I was good at it" that he implied a high degree of comfort with mathematics. Similarly, there were other participants who stated that their level of comfort was lower or higher before or after taking Calculus I, which correlated with other statements that suggested their self-efficacy was lower or higher, improving or decreasing in the long run. Overall, for the second question, the only idea that deserved to be mentioned is that the mathematical background was involved in students' self-efficacy levels only when participants were able to complete high school mathematics at the highest level provided by the curriculum. In such cases, participants in Calculus I at the college level started with high self-efficacy, and maintained high self-efficacy until the end of the course.

Perceived interactivity of mathematics classes. The second category that emerged from the data and impacted participants' self-efficacy was **the level or interactivity during mathematics classes**. Unexpectedly, the vast majority of participants stated that mathematics is more interactive in this college course than in high school. While most students considered mathematics classes in high school as being either fairly interactive or not interactive at all, this particular college-level Calculus I course was seen as very interactive by most students, and this impacted in a positive way their engagement and optimism about doing well in mathematics. Despite this finding, an interactive mathematics experience was not necessarily a determining factor of participants' improvement in self-efficacy levels. There were a few aspects that will be discussed later in this chapter with respect to participants' learning styles. First, in general, participants who scored high before taking the calculus course and maintained high levels of mathematics self-efficacy were proponents of group studying. They not only enjoyed group study, they also declared that their performance and understanding improved. Second, in contrast, a statement made by a participant who initially scored low and maintained a low self-confidence at the end of this study suggested that algorithms were very helpful in performing well in problem-solving. In a few words, some students preferred the mathematics class where the instructor models a problem after which students repeat the procedures in a similar way, until they learn how to solve certain types of problems. Third, two out of three participants who began with a low score and improved it more or less, and another student who began with a higher score but whose levels of self-efficacy decreased mentioned that they prefer and believe they perform better when working independently rather than in groups.

Results like these mentioned above may be related to few other factors, such as conditions under which a student considers that he or she performs, and also students' definitions of success. When asked under what conditions they perform better, some participants mentioned group work in general, but when asked how they would define success, they were limited to identifying success with good grades only. Although other participants were able to define success by the degree to which they managed to understand the concepts learned, they stated that individual study rather than group study would be their preference in matter of learning. These statements indicate once again that teaching and learning should not be treated like "one size fits all" factors, but should be adapted to individuals (Kondor, 2007; Ammar & Spada, 2006; Murray, Shea, 2012).

Several of the questions were formulated in such a way that would gather information about high school teaching and learning approaches at compared to college. The data were focused on several aspects, such as more interactive classes, student engagement, and optimism about doing well in mathematics courses in the future. Participants' answers were correlated with class observations to identify aspects that may contribute to their confidence in doing mathematics. It should be mentioned that many elements found in the classroom may be decisive in influencing student's views on mathematics, since some these elements were reported as very important with respect to the concept of success.

Questions #3, #6, and #10 were strongly interrelated, and offered an overall image on how mathematics was taught in high school, in college, and how the participant saw this difference, how this difference changed his or her views on mathematics, and how it impacted participants' self-efficacy. Question #3 was formulated, "Tell me how mathematics was taught in high school," while question #6 was similar with respect to the college mathematics class, but added an element of personal views about the difference between HS and college: "How do you feel about this?" Following the same pattern, question #10 referred to the same concept, which is the difference in approaches between high school and college, but went in more depth, asking participants to describe how interactive classes were, and how they felt about classes being or not being interactive. Since previously one of the questions (question #4) asked students to "describe a typical mathematics class period in high school," and the class observations offered me great data about how a typical Calculus I class was designed, I had enough information to relate all these data and draw conclusions about how participants' self-efficacy was impacted.

Correlating several questions and class observations was necessary, because on many occasions it was impossible to decide if an element was or not important in students' maintaining or modifying the level of self-efficacy. For example, question #3 was answered by Kevin and Pedro differently:

"*Tell me how mathematics was taught in high school.*

a. *Was teaching interactive? If so, in what ways? Describe. (Time spent one-on-one with the teacher, concepts were easy to understand, etc.).*
b. *How did you feel about courses being (or not being) interactive?*
c. *Were you engaged and interested in the subject during classes?*

d. *Were you optimistic about doing well in mathematics in the future?*"

Although both maintained a high level of self-efficacy, Kevin reported that in high school mathematics classes were not interactive while Pedro stated that his high school mathematics classes were. With respect to "engagement" and "optimism," the two participants responded in surprisingly different ways. Despite viewing his mathematics classes as not being interactive, Kevin answered that he was always engaged and optimistic about doing well in mathematics. Pedro, who considered his class interactive, was neither engaged nor optimistic about doing well in mathematics. These two participants' answers exemplified very well the reason behind performing the analysis as a whole rather than focused on distinctive questions and answers.

Unlike the previous section, where participants' mathematical background was presented based on students' voices only, the perceived interactivity of mathematics classes in students' background and in Calculus I course was described both by students' voice and through class observations. While a variety of elements of interactivity were presented as observed by me in the Calculus I class, participants' point of view was studied by several intertwined questions aimed at identifying the most important aspects related to interaction between students and between students and mathematics teachers in their previous classes as well as in Calculus I.

It was previously mentioned that several questions were strongly related to each other, asking for information about the interaction in class under different forms, to ensure students' correct interpretation of what was requested from them. For example, question #3 was not limited to asking, "*Was teaching interactive? If so, in what ways? Describe.*" Several other aspects were included in the researcher-student discussion, such as how engaged the participant was, how he or she felt about classes being or not being interactive, and how optimistic students were about those classes. Later on, question #6 asked students to describe, "*How is mathematics being taught in college as compared to HS.*" This approach was used in order to eliminate students' misunderstanding or different interpretations about what interactivity means, and to identify every possible aspect related to the way students viewed their mathematics classes in the past and present.

Overall, the answers to questions #3 suggested that for most students, mathematics classes in high school were not interactive, or were only fairly interactive. One particular student, Patrick, who maintained low self-efficacy before and after Calculus I, stated that his lack of interest in mathematics and immaturity was one of the reasons he was not doing well in high school:

"*Researcher: And in high school, was the teaching interactive? Try to tell me how mathematics was taught in high school. Was it interactive? In what way? Try to describe, like, time spent one on one with a teacher and discussions and so on.*

Patrick: Yeah, I remember, and I mean, I remember our classes. I went to a charter school, so it was maybe a little bit different than most kids. A charter school's a little different, but I don't know, we were always taught in class. We never really had one on one, but I definitely could have gotten one on one help if I needed it. The teacher's really not good there. But, it was also really easy to cheat. I remember I cheated a lot.[…] For that matter, then not, not really, [classes were] not very interactive then.

Patrick was neither engaged nor optimistic in high school:

“*Researcher: Were you engaged in high school in subjects such, such as mathematics? Were you engaged and interested? You were not interested in mathematics?*

Patrick: No, not interested.

Researcher: So how optimistic were you about doing well in mathematics in the future?

Patrick: Not very optimistic, not in high school.”

A typical example of a student who felt very comfortable in high school mathematics classes despite the lack of interactivity was Robert, who improved his self-efficacy significantly from a score of 7.66 to 8.50. Robert’s answers to question #3 suggested that in high school, his mathematics classes were not as interactive as in Calculus I, but he felt very comfortable because he was able to teach himself, by using the textbook. However, in Calculus I, his self-efficacy increased significantly, and he stated also that the class was much more interactive:

“Researcher: Did you feel comfortable? Yes.

Robert: I felt extremely comfortable. I, I never really paid too much attention to my math classes in high school. I just taught myself with… through the book.

Researcher: And…?

Robert: And then, I did pretty well that way.

Researcher: All right. And how was mathematics taught in your high school, was it interactive? Were there any discussions, group work, and so on?

Robert: Probably not as interactive as college in high school. There'd be like a, maybe a 15, 20 minute lecture on the material. And then, we would just get homework *over what she just lectured over. And then, we'd just turn the homework at the end of class. So it really wasn't much of as interactive as college is. The lack of interaction really didn't leave me engaged in high school, but I was interested enough in math.*

Researcher: So do you think that in college there is more interaction?

Robert: Definitely."

At the opposite side of the spectrum was Chen, who scored low on self-efficacy at the beginning of the course, and his level of self-efficacy dropped even more by the end of Calculus I, from a score of 6.44 to 5.11. Chen stated that, while in high school his mathematics classes were interactive, he preferred to work independently rather than in groups, and was prone to avoid interaction. This would explain his significant decrease in self-efficacy after taking Calculus I, because this college course was designed to be interactive. It is interesting to mention that Chen is the only participant in the interviews session whose self-efficacy actually decreased during the Calculus I course, so his statement seems to have some support. Chen's answers to question #3 are shown below:

"Researcher: And how did you feel about the course being interactive? Did you enjoy it?

Chen: I, I do enjoy math a lot. It is my favorite subject.

Researcher: But did you like the course being interactive or you would like a course that allows you to work more independently?

Chen: Yeah I prefer working in a, you know independently.

Researcher: Okay.

Chen: Instead of interactively.

Researcher: Okay.

Chen: Because that's, that is how I do it."

It may be interesting to mention that one participant from the group that scored low on self-efficacy both before and after Calculus I, was Andrew. Although his scores were in the lower range both before and after Calculus I, a slight increase could be noticed, from 6.44 to 7.11. Andrew stated that in high school his mathematics classes were interactive; he was engaged because he was an interactive type of student, and also very optimistic, because he wanted a good GPA and he wanted also to complete a minor in mathematics. However, he admitted that in college, also Calculus I was an interactive course, but he could not identify a significant difference between high school mathematics and college calculus:

"Researcher: I see. Now let's talk a little bit about college. How is mathematics being taught in college as compared to high school and how do you feel about this change?

Andrew: I mean, there, there's really not much of a difference, to me. I mean, I mean classes are about the same. And, I mean, the way the teacher talks about it, it's about the same. And they have their lecture and then they hand out the homework, or they have it on Moodle. So, I mean, it's, it's not much of a difference to me. I mean, when I first came to college, I was figuring I was going to be…, it's going to be way different but I soon found out that it's not really that big of a difference."

Although this may look like a counterexample, it is not; the conclusion that can be drawn from Andrew's interview is that there was no direct correlation between his self-efficacy and class being interactive or not, but other factors must have influenced his feelings in the long run, and these factors could be discovered again, when looking at the overall data. Unlike Chen, Andrew never mentioned that he would prefer working independently rather than in groups. On the contrary, he stated at one point that he was a proponent of interactivity in class:

"Researcher: Okay. All right, did you like these classes being interactive?

Andrew: Yeah.

Researcher: Or you, you prefer individual work?

Andrew: Interaction with others helped a lot when coming down to like, tests, I remembered a lot more.

Researcher: So, you're not a type of student who prefers to work by himself.

Andrew: I like working with other people because you can throw ideas off each other."

The bottom line is that most students were not impressed by their high school experience from the point of view of interaction between students and between students and teacher. Even more, most students stated that they were not only open to working in groups, discussions in class, and class or group activities, but they performed better under such circumstances. Some students who were never exposed to real interaction in class changed their views about mathematics once the teaching approach was different. The key for finding the difference in students' views was to analyze the data collected in questions 6 and 10 about the same idea. Some students realized during the calculus course that class discussions and group-work interaction could make a difference. Most participants declared that by the end of the course they considered college to be more interactive than high school, and also they stated that class interaction was decisive for their better performance and understanding. This may explain why so many students were more impressed with the Calculus I class than with the mathematics classes taken in high school, and also it may explain why overall student self-efficacy increased during this course. As previously mentioned, while most students stated during the interviews that their preference would be an interactive class, there were others who declared that working alone was better for them, or that following step-by-step problem solving and having concepts explained to them by the teacher were more helpful for them. In other words, an instructor who adapted his or her teaching style to all students would have better chances of being more successful in increasing their confidence about doing well in mathematics.   By comparison, in question #4, when asked to "describe a typical mathematics class period in high school," there was scarce reporting of group activities or interaction in general. The mathematics class periods were usually limited to lectures, and solving homework assignments in class. Only Julia reported that sometimes there was some kind of group activities involved:

"Julia: The beginning probably we would turn in homework and stuff like that. And, and then she would get right to the lecture. And we would usually have a little bit of a lecture type class. And then sometimes she would do like, group activities or gave us, you know, here's candy on your desk. What, what is, show me what to do, you know, kinda stuff like that. And then depending on how long the class took, you could, you know, spend the rest of the class working on homework or stuff like that and, and then the bell would ring and you would leave."

Most participants described classes where conceptual understanding, discussions, group activities, and interaction were missing. A typical mathematics period would involve 5-10 minutes of bell work, turning in the homework assignments, lecturing from the new lesson, and working on the homework assignments for the rest of the class. There were two participants who suggested that high school teaching methods would simply have no influence on their confidence or view on mathematics. One student, David, was homeschooled, and the parent who was helping him with mathematics had no mathematical background at all. David was trying to study from textbooks, but without real help he felt he was continuously in the dark:

"David: When I was homeschooled, all I had were math textbooks, and I was teaching myself. But whenever I ran into an issue, there was no one there to actually help me. My mother wasn't good at math."

It should be mentioned that talking Calculus I, David's self-efficacy increased significantly.

Procedural problem solving (algorithms or step-by-step) vs. understanding. Finally, the third category that seems to have had particular importance from students' point of view is the approach used in class for problem solving. It was previously mentioned that some participants mentioned that using algorithms and step-by-step problem-solving methods helps them follow the problem-solving strategy. One student mentioned that he was not good at "thinking out of the box," so step-by-step made him feel more comfortable. Although understanding was mentioned as a very important factor of success, several students emphasized that results in tests were important enough to make them value algorithms even more for problem-solving. Some students prefer to learn mathematics as a step-by-step procedure, rather than working to gain a conceptual understanding. Both Patrick (LL) and Julia (LH) stated that algorithms or step-by-step solutions for problems in mathematics either would have been their methods of choice for studying, or were the methods used in the classroom during high school. Patrick stated:

"Patrick: If I have steps, I know the steps of things.

Researcher: Do you prefer to have an algorithm (for solving mathematics problems)?

Patrick: Yes; chain rule, and all of that stuff. I love it. FOIL, how to factor and stuff, but when it, I don't know, yeah. Just when I have to make formulas or think outside the box really, the creativity in math I guess you could say is tough for me."

Similarly, Julia mentioned:

"Julia: My teachers wouldn't just write the problems. They'd be like, what's the next step?

Researcher: Trying to follow an algorithm?

Julia: Yes. They were trying to put us on the right path to solve the problems."

Although the procedural approach may not the best approach in mathematics education, experience shows that many teachers still use the procedures more than conceptual understanding, making algorithms, step-by-step problem solving, and memorizing types of solutions associated with certain problems the main methods used in the classroom. Many students in general, and some of the participants in this study in particular, were so familiar with these teaching methods that they accepted them and even preferred them over conceptual understanding because it was easier, and on many occasions led to better grades.

Another interesting aspect that suggests that some students, such as Julia, may value understanding more than pure procedural problem-solving was participants' view on success, and how this view may influence their confidence. Julia valued mastering the concept learned in mathematics, and was aware that a good grade does not automatically mean being successful:

"Researcher: How would you define success?

Julia: I don't think necessarily it's the grade. I just think if you come away with the concepts and you… like even if you make a D in the class, if you… if you've mastered… that class, then you're, you know… you have become successful."

I followed the concept "success" to understand if the meaning would be similar for all participants. I expected students in Calculus I to realize that success is related to more than passing the class or getting a good grade. Unfortunately, from my past experience as a teacher, high school students are familiar with the concept of being successful as a term related to passing the course, or the End of Instruction (EOI) examination, maybe even with a good grade. This idea was transmitted to students on a large scale, and in college many of them show a similar view on success. Andrew (who scored low before the Calculus I course as well as after) realized that grades do not always reflect student's knowledge:

Researcher: Do, do you think grades reflect always your knowledge or understanding?

Andrew: No; not usually. I mean, I've seen some people that are, I mean, great at math. But when it comes to test taking, they're not the greatest test takers. I mean they could study for hours and then, just do poorly on a test because they don't, they don't handle pressure well.

It should be noted that the same opinion was formulated by Julia, who improved her self-efficacy score in the before and after quantitative analysis.

The procedural approach constantly used in high school years may have had an influence on students' views on knowledge, achievement, and success. Knowing that following algorithms will systematically lead to a good test score, some students might have the tendency of sacrificing understanding. Aiming at pursuing this aspect, each participant was asked during the interview how he or she was feeling about upcoming mathematics courses, and I also discussed about success and how confident they were about doing well in mathematics. The results were interesting, and some of the answers may have explained some of participants' low confidence or significant decrease of confidence. Question #8 was formulated as follows:

"How do you feel about your upcoming college mathematics courses?

a. How would you define success in math courses?

b. How would you rate your confidence that you can succeed in college math courses?"

Both students who maintained a high self-efficacy believed that future mathematics courses will be very hard. Kevin felt excited about this being challenging, while Pedro seemed to be anxious, although comfortable otherwise, knowing already that this will require him to use all possible resources, such as mathematics labs, office hours, and extra time for study in order to be successful, but being ready to take the challenge. While most participants declared that they felt anxious but confident (with a self-estimated score of 8 on the same scale that was used for the quantitative study), the difference was seen in the way participants defined success. Success was considered by

Kevin as the capability of understanding the homework assignments, doing it, and being able to explain in front of the class how he solved the problems correctly. It can be noticed here that Kevin valued independent study, solving homework assignments, in this case, understanding, representation, and communication.

Yet, other participants did not make a true connection between knowledge, achievement, or performance, on the one hand, and success, on the other. For example, Patrick was sure that success was defined by a good grade:

"Researcher: How would you define success?

Patrick: I guess just a good grade. That's, you know, I believe in, I believe the grade reflects what you learned, most of the time."

This was in contradiction with the previous view mentioned by Andrew, but was almost identical with the opinion of Chen. In a similar manner, Chen stated that success meant getting good grades. When I tried to understand if this was really his opinion, or maybe he also valued understanding or knowledge, he seemed confused:

"Researcher: How would you define success?

Chen: …because I'm getting good grades.

Researcher: Other students say "because I understood the material." What do you think about this?

Chen: Yeah.

Researcher: Other students say because "I can apply my knowledge to real life situations." What do you think about this?

Chen: You have to… you know, read ahead and then pay attention in class. You know, you have some friends you work with… You work with your friends so you understand a lot more.

Researcher: All right. And, how do you know you are successful? Based on what?

Chen: Mm.

Researcher: If someone asks you, hey… Do you think you are successful in math? You, you will say yes, or no. Why do you answer yes or not? How do you know you are successful or not?

Chen: Yes, I am, because… I think. Hmm… Just for your career you know. You have to.

Researcher: How do you measure your success at this point? How do you know you are successful?

Chen: Do… do all my… my work and all.

Researcher: Well doing your work doesn't mean you are successful.

Chen: I know. How to answer this? [LAUGH]. Hm... I don't know.

Researcher: So which one do you think would be more important? Good grades or good understanding?

Chen: Good grades, and then you have to understand it. To apply it, to, to you know, to a higher level with math and all."

His entire answer to this question and the discussion that followed is presented to illustrate Chen's view on success, as related in his opinion to good grades and doing his homework. After talking to him for quite a while, he finally stated that understanding is also important, in order to be able to apply the knowledge to higher levels of mathematics. Unlike Chen, other participants declared that success is directly related to understanding, and to building a foundation of basic mathematics. Robert and David, both of them being part of the group that improved the self-efficacy levels, declared that building a strong foundation in mathematics is an important goal, and passing would be another goal:

> *"Robert: I'm hoping if I can go into Calc II and Calc III with a, a strong foundation of Calc I, that I feel pretty comfortable and confident about passing"*
>
> And respectively,
>
> *"David: But as I'm seeing it now, success is not only being able to succeed, actually succeed in getting the right answer. But success is more of being able to understand the concept, and then, when you get a wrong answer, being able to see how and where you got it wrong. So that the next time you're able to do it right… being able to learn from your past mistakes."*

Overall, it seems that participants in the study improved their self-efficacy due to factors identified in one or more of the categories described above. While some participants responded well to more interactive classes, others had a good opportunity to define their views on different other elements that may have contributed to their increased confidence, such as success. It was also suggested that previous mathematical background played an important role in maintaining high levels of self-efficacy. Individual learning styles and emphasis on understanding versus use of algorithms in problem solving were also elements that may have explained some of participants' increase or decrease of self-efficacy. Although the findings of this analysis should not be generalized, some of the participants considered that one important aspect that helped them feel more comfortable with college mathematics and with the new pace at which they had to study was related to becoming more mature.

Investigating the process of developing certain levels of self-efficacy is important mainly because it may suggest better approaches in teaching. Consequently, a variety of conclusions can be drawn from this research. Due to its particularities, the results are limited to the boundaries imposed by the design of this study. The implications and conclusions drawn from this study may be valuable in the future for similar settings and classes. These aspects are discussed in more detail in the next chapter.

CHAPTER 5: CONCLUSIONS AND IMPLICATIONS

Research in mathematics education has shed light on the influence of several factors on self-efficacy or achievement, including teaching approaches, the environment, diversity, or previous experiences. Data show certain causal relationships or simply correlations between the variables (Sherman & Fennema, 1977; Hackett, 1985; Hall & Ponton, 2005; Cech et al., 2011; Plecha, 2002). The literature review provided earlier outlined the relationships among only a few main variables: the class environment that also includes the teaching approach, previous experiences with mathematics, and achievement. However, some authors realized that certain variables, for example the teaching approach, influenced other variables, such as the achievement through an intermediate element, or mediator – self-efficacy (Bandura, 1986; Peters, 2011; Randhawa et al., 1993; DeFreitas & Bravo, 2012). The existence of such mediators is why self-efficacy became an important variable considered in this study.

Students come from different social and educational backgrounds. Educators in general and mathematics teachers in particular know that students can be easily encouraged or discouraged by the experiences they have in the classroom. From the educator’s perspective, the class climate can be a determining factor in influencing how much effort students will put into completing a task. Also, the class climate can influence students' persistence in solving a task, or generally speaking, whether students will be resilient in their completing a task or not. Students have a strong tendency to avoid tasks for which they do not feel competent. To accept a task and spend time and effort completing it, the student must feel he or she is confident. In addition, the student should have a good attitude about the subject in general (Randhawa et al., 1993).

It seems evident that a class environment that provides conditions for students to feel comfortable is expected to increase their confidence and to create a positive attitude toward mathematics. When students do not have the opportunity to enjoy the class environment or the teaching approaches in past mathematics classes, their mathematics self-confidence may decrease. Past research studies revealed some factors related to self-confidence, but these factors are neither part of the literature review presented above nor part of this dissertation. For example, Robbins, Lauver and Le (2004) and Le, Casilla, Robbins, et al. (2005) suggested that psycho-social resources, such as parents' and school personnel's encouragement, helped students develop positive attitude towards mathematics. Other studies found differences related to race or ethnicity with respect to students' psycho-social characteristics, and determined that students' self-efficacy and achievement were influenced by race and/or ethnicity (Conchas, 2001; Massey et al., 2003; Valenzuela, 1999), while Karaarslan and Sungur (2011) linked self-efficacy to students' socio-economic status.

Through a variety of strategies, teachers can have great impact on students' confidence in their mathematics skills in general and on their attitude toward mathematics and on their mathematics self-efficacy in particular. This study outlined concrete examples of learner-centered mathematics classroom strategies that are beneficial for students. A specific area of mathematics teaching, problem solving, is one of the most important parts of learning. It has a dual role: it brings a solid contribution to the learning of content, and it also has a decisive role in developing students' thinking skills. Most educators accept the fact that people use thinking skills and critical thinking in daily life, and their development is helpful in improving performance, and consequently in raising the levels of confidence and attitude toward mathematics. Ultimately, teachers are interested in raising students' motivation. According to Bandura (1977), the foundation of motivation is self-efficacy. As mentioned before, there are a multitude of factors that contribute to creating higher levels of self-efficacy.

This research aimed at identifying and explaining some of the factors that may influence students’ mathematics self-efficacy over the period of a semester during a Calculus I course. To present the implications of this study is necessary to review and insist on the most important results revealed upon performing the data analysis. The following research questions were the focus of this study:

1. Is there a significant change in students’ mathematics self-efficacy levels over the necessary time period for completing a Calculus and Analytic Geometry I course?

2. How do students view the transition from mathematics classes previously taken in high school or in developmental mathematics to college-type instruction in a Calculus and Analytic Geometry I course?

Changes in Students’ Self-Efficacy

The answer to the first question was a confirmation with respect to the Everyday Mathematical Tasks; participants' self-efficacy was improving during the course. Participants gained more confidence about being able to solve typical daily tasks involving mathematics. The same conclusion was not drawn about the Mathematics Courses; participants’ self-efficacy did not change significantly with respect to their belief that they would be able to perform well in future courses involving mathematics. Both categories of results are similar to those obtained by Burnham (2011) on a study that analyzed self-efficacy before and after an engineering course, largely attended by freshman students. The author used a similarly revised MSES (Betz & Hackett, 1993), where the Everyday Mathematics Tasks was replaced by Mathematics Problem Solving while the Mathematics Courses remained in the survey.

The present study concluded that after this calculus course, participants were more confident about being more able to solve future Everyday Mathematical Tasks involving mathematics than they were at the beginning of the course. In general, I interpret Everyday Mathematical Tasks as real life applications of an area in mathematical problem-solving. In this context, my quantitative results support Burham's (2011) findings that mathematics problem-solving self-efficacy increased significantly over the period of the course. Findings showing these kinds of relationships were expected based on previous research. This research study was meant to fill in the gaps of previous work that involved students' self-efficacy and higher level mathematics courses (Krbavac, 2006; Kelsey, 2009). A succinct discussion of similar findings will clarify in what ways my study relates to Krbavac's (2006) and Kelsey's (2009) research.

In 2006, Krbavac conducted a study that aimed to determine if increasing feedback to students enrolled in an introductory calculus course for social sciences majors would have any impact on students' self-efficacy. Although the object of the present dissertation is not to discuss the methodology of Krbavac's (2006) study, the conclusions showed that:

> An examination of the relationship between feedback and mathematics self-efficacy indicates that student's mathematics self-efficacy improved significantly between the beginning and the end of the semester. As there were

> no students who did not receive feedback, it is impossible to determine if the improvement in mathematics self-efficacy was due to the additional feedback. However, it is possible that student's mathematics self-efficacy improved as a result of feedback. (p. 10)

Despite noticing a significant increase in self-efficacy as a result of taking the calculus course, Krbavac (2006) could not determine if the cause was the course itself, or the improved feedback students received particularly for this study. The author performed a Pearson's correlation calculation, to compare the participants' self-efficacy levels at the beginning of the course and the end of the course. She found a significant relationship ($r = .41$, $p < .05$) showing that those students who scored high, respectively low on self-efficacy at the beginning of the course, also scored high, respectively low on self-efficacy at the end of the course. After conducting a paired sample t-test similarly to the method used in this paper, the author found a significant change in self-efficacy between the beginning and he end of the course. She concluded that the modification in score was unlikely to have occurred by chance (Krbavac, 2006).

Compared to Krbavac's (2006) work, this study did not involve any specific method, such as improved feedback, to speculate why self-efficacy increased. As previously mentioned, in the classes observed and included for this study, the instructor taught using the usual methods. In conclusion, the outcome cannot be attributed to any obvious change in participants' instruction between the beginning and the end of the course. A logical conclusion is that a significant increase in the level of self-efficacy would have likely occurred in Krbavac's study regardless the improved feedback. While most likely both "t" and Pearson's correlation still would have shown a significant relationship it is possible that those values would have had different values. A suggestion for studies that are similar with Krbavac's would be the use of a control group. Although one cannot use the sample of participants of the present paper as a control group of a different study, the results suggest that most likely students' self-efficacy would reach higher levels regardless increased feedback.

Kelsey (2009) discussed the accuracy of the results with respect to increasing self-efficacy during a calculus course when the instructor uses a group work format. The author mentions:

> I expected that using a group work format in the discussion sections associated with the large lecture business calculus class that I taught in Fall 2009 would improve the mathematics self-efficacy of my students. However, the results of my study indicate that rather than improving their self-efficacy, the group work format increased the accuracy of their self-beliefs. (p. 2)

Kelsey (2009) admits that the size of the group used for the study (n = 41) did not allow drawing strong conclusions about the results. Moreover, while the results cannot be generalized, the author still mentions that "employing the pedagogy of group work does not necessarily improve mathematics learning self-efficacy in this environment, but rather makes it more accurate" (p. 8). This statement suggests that in similar environments, group work strategies may favor correct estimates of students' self-efficacy. Similarly to Krvabac's (2006) research work, where modification in self-efficacy was not determined as direct result of improved feedback, the current study does not conclude that self-efficacy changed solely because group work was part of a particular teaching strategy. My results suggested that the mean of participants' self-efficacy was higher at the end of the course as compared to the beginning so that these findings may complete in some way Kelsey's conclusions.

Although the overall mathematics self-confidence increased with respect to Daily Mathematics Tasks, the data analysis involved in this current study suggested there was no significant change for participants' self-efficacy with respect to Mathematics Courses. This observation also supports the results of Burham's (2011) study, which drew an almost identical conclusion: "Students indicated a significant increase in math problem-solving efficacy, but no increase in math courses efficacy" (p. 61).

Students' Perception of Transition from High School to College

While the quantitative data analysis provided information about participants' self-efficacy scores, it could not answer questions about why this happened, or how students feel about changes in their teaching and learning environment. Also, there was no definite answer about the ways in which these changes affect their beliefs, attitudes, and self-confidence with respect to mathematics. For answering these questions, interviews were conducted with each participant mentioned in Figure 7, and I drew several conclusions after interviewing the participants. Each of these conclusions will be discussed in more detail in this sub-section.

First, it was easy to notice that participants who had a strong background in mathematics had the tendency of starting with a high level of self-efficacy and maintained this level of self-efficacy during the course. I noticed this behavior in the case of Kevin and Pedro, whose scores approached the maximum values of self-efficacy. These two participants were the only ones who completed calculus courses successfully during high school. Similarly, Hall and Ponton (2005) concluded that "Research conducted by Trusty and Niles (2003) indicates that high school students completing rigorous mathematics courses have much higher levels of success in college than students who do not earn credit in such a course" (p. 26).

Second, most participants stated that in high school teaching was not as interactive or learner-centered as it is at college-level. As a result, most participants who preferred working in groups and interact in class with the instructor or with other students were positively influenced from the perspective of the levels of self-efficacy. In the literature that discussed this subject in the past, authors found that the learner-centered approach, for which interactivity is a typical characteristic is more effective than the traditional approach (Smart, Witt, & Scott, 2012; Sesen & Tarhan, 2011; Blanchard et al., 2010). Since students stated that the instruction was more traditional in in high school than in college, the results were expected.

However, one student, Chen, clearly favored non-interactive settings over a more learner-centered environment. His results with respect to self-efficacy showed a deviation from the norm, decreasing significantly between the beginning and the end of the course. Not only this was the only participant whose scores for self-efficacy decreased during the calculus course, but his starting level was also significantly lower than the average of the sample of participants. Although there was another participant who showed preference for individual work rather than interaction with other students or teacher, this participant's scores were at high level before as well as after the course, so the impact of the class environment could not be determined. There were several other students who completed the survey, and their results showed very low self-efficacy levels both before and after the course. Although some of these students showed a significant decrease in self-efficacy, they did not agree to be interviewed, so their data could not be collected.

Third, several students felt comfortable and declared that in general they felt more confident about doing well in mathematics problem solving when problems were solved using algorithms. Another favorite approach was when the instructor solved a problem on the board first and gave them a similar problem to solve using step-by-step procedures. While I do not entirely agree with the effectiveness of this approach, it can be noticed that some students prefer this instructional method. It can be argued that using a procedural approach rather than a conceptual one depends on the type of problem. Cadez and Kolar (2015) suggested that:

> If the relationship between the (everyday life) problem and the mathematical concept can be established, the reasoning type of generalization prevails. If, on the other hand, it is not possible to establish a clear connection between the problem and a certain mathematical concept, operating only with numbers takes place, resulting in the inductive type of generalization. (p. 295)

Implications

While this was an explanatory sequential mixed research case study, some information may be valuable enough to be used in the future for similar settings. The most important conclusion that resulted from this study and from previously mentioned works is that the vast majority of students who enrolled in the calculus course either improved or maintained their levels of self-efficacy. Since there was no control group involved, there was no reason to assume that certain variables influenced the outcome more than others. Taking the course is the only overall factor that influenced the self-efficacy in the present study. It seems obvious that students who started college level mathematics courses with a **previous background in high school advanced mathematics**, such as AP Calculus, would have better chances of feeling more confident in college mathematics. Consequently, one may consider that taking advanced mathematics classes in high school would automatically lead to better self-efficacy and/or more success in mathematics classes later, in college. In fact, students need to complete and perform well in other prerequisites of the AP Calculus to understand more advanced concepts. I would recommend McDonald's (2013) study, where Step-By-Step Teaching (SBST) is used to improve students' performance, attitudes towards mathematics, and mathematics self-efficacy. As McDonald (2013) stated, "in SBST, information is explored in a step-by-step manner so that the learner has to show understanding of previous information before moving on" (p. 359). Similarly, not all high school students can be possibly enrolled in advanced mathematics courses unless they master the fundamentals of mathematics, starting with arithmetic and going through all other concepts including those taught in algebra and pre-calculus. It is the teacher's duty to identify as early as possible misconceptions and gaps in students' knowledge to perform the appropriate instruction.

In general, the interviews suggested that **students prefer more interaction in class and outside school hours when studying mathematics**. It is well-known that certain concepts are more difficult to grasp than others. Most students agreed that talking to peers or the instructor helps with better understanding, higher performance in problem-solving and improved mathematics confidence. Although sometimes the results of research studies may be contradictory or unclear with respect to some correlations between certain variables (Kelsey, 2009; Di Fatta, 2009), the interviews conducted for this paper showed that students' self-efficacy increased with group work and interactive approaches, in general, from interaction with peers or teacher to interactive technology used in the classroom.

Kelsey (2009) aimed at determining the influence of group work on students' confidence in their ability to perform well in mathematics. The study showed that group work had a strong impact on the correlation between participants' self-efficacy and their final grade. This observation suggested that despite the lack of information about group work increasing students' learning self-efficacy itself, it did contribute to students' accuracy in estimating their mathematics abilities. Trying to increase student achievement in mathematics, Di Fatta (2009) conducted a study to determine if group work as an intervention could help students perform better in homework completion and testing. Although the author used other interventions as well during the study, only group work proved to be effective, and "the majority of the students felt that being in a collaborative setting helped to improve their learning in mathematics" (Di Fatta, 2009). Di Fatta's observation is also consistent with Pyzdrowski et al.'s (2013) statement that:

> The teaching strategies outlined in the discussion (i.e. encouraging the use of metacognition, incorporating more conceptual questions into class discussions, and setting up opportunities for study groups and recitations) provide avenues that affect students' attitudes and hence their course performance. (p. 551)

Based on all previous studies and my own set of surveys, interviews, and observations, I concluded that group work, collaboration, and interactive environments contribute in general to an improvement in students' self-efficacy and on some occasions in better mathematics performance.

Finally, I discussed the **procedural vs. conceptual approach** in problem solving. As already mentioned, I am a proponent of the conceptual approach. I consider that in order to ensure fluency, students should prove good understanding first, and then use procedures after having mastered the concepts, and only as tools for solving problems faster and more accurately. Sometimes students are in disagreement with this approach, many of them trying to solve problems based on models presented in class by the instructor. The disadvantage of this strategy is obvious. From my experience, students who dismiss or do not focus enough on concepts have a tendency to rely on identifying new problems only with the old ones they already solved in the past. The result is mostly confusion when the student is confronted with a new type of problem, although the concepts involved are identical or similar.

There are situations when the procedural approach only seems beneficial to students, although students prefer it. Some studies showed that for certain settings and types of problems, students do not perform better in procedural problems than they do in the conceptual ones. Despite students' being more confident in performing procedural problems than conceptual ones, Engelbrecht (2005) mentioned that, despite students being more confident in performing procedural problems than conceptual ones, "…these students do not perform better in procedural problems than in conceptual problems" (p. 701).

With respect to the appropriate approach, it is my conviction that an instructor should be able to identify when a strategy is better than the other in a classroom.

Moreover and most importantly, the instructor should be able to identify those students for whom a certain strategy may be more beneficial in the future. Based on my personal experience, this can be easily achieved through pre-testing and determining each student's background and level of understanding of previous concepts, preferences in problem solving, or other issues.

Given the nature of the study, one cannot generalize the results beyond the settings where the researcher conducted the study. Multiple variables must be taken into account, such as personal issues, socio-economic status, friends or the general environment outside school. The implications of this study are theoretically limited to the some suggestions for these settings. Such suggestions mean constructing a solid background in advanced mathematics of students. If necessary, college preparation courses proved to be effective for those students who lack the proper knowledge at the time of enrollment in college. Also, group work and collaboration between peers and between students and instructor showed better outcomes than solely individual work. Finally, although procedural-based problem solving is not accepted by everyone as an effective method (although many students prefer it) instructors should reach a balance between the amounts of procedures vs. conceptual approaches. These approaches should target students who are more inclined to respond better one way or another.

Recommendations for Future Studies

Due to the character of all studies discussed in this chapter, the results are specific to certain conditions. More research is necessary to target variables that I did not include, including course level of difficulty, particularities of participants' background, participants' majors and minors, or other factors. Provided that appropriate resources are available, similar studies may involve extensive data collection and variables that were not included in this study. Such approaches would lead to more accurate data analysis and results, although the limited characteristics of a case study will remain. Future research in this area is recommended in order to determine better strategies in teaching. Methods of conducting more complete studies include but are not limited to using control groups for identifying the strategies that made a difference in participants' self-efficacy.

A number of factors were not taken into consideration in this study. Continued research on this topic would require introducing several variables, among which the most important would be: the individual mathematical aptitude of students; mathematics achievement of students, measured by using previously validated instruments; degrees of preparedness of participants with respect to the relatively high level of the Calculus I course; participants' background in mathematics, including factors that contributed to past mathematics anxiety episodes; and degree of encouragement received from family and teachers, just to name a few.

It would be interesting to examine students' self-efficacy by employing some of the variables mentioned above, as well as selecting a larger sample of participants, including different Calculus I courses, such as Business and Life Science Calculus I versus Engineering Calculus I. Using certain instructional approaches may help identify particularities for each career track, and suggest certain strategies for each case. In addition, it would be useful to take into consideration how well teaching strategies reach some particular characteristics of students, for example visual learning delivered by appropriate use of technology.

In conclusion, it is evident that the framework of this type of research study is always open for improvement. While using several main variables led to meaningful results, the outcome can become more accurate and reliable by studying many other factors involved in teaching and learning. Many of these factors, previously mentioned in the literature review, have a direct effect on self-efficacy, or are mediators that indirectly intervene in modifying the level of self-efficacy. It is the researcher's job to identify the true relationships among these variables, and to eliminate as much as possible the bias that may occur in a qualitative research study.

Limitations

Due to the characteristics of this study the findings of this research should not be extended beyond the settings where the study took place. The participants were students enrolled in two sections of Calculus I, both sections being taught by the same instructor; as such, some limitations apply, and are related to the teaching approaches used on a regular basis by this teacher, or to the content area specific to this particular course. Provided that a different instructor was assigned, and this instructor was a proponent of lecture-based classes, most likely the findings would have modified, especially due to class interactivity changes.

Interpretations of the interview questions and answers were dependent on the researcher's expectations or views on certain phenomena. One researcher may consider the identical statement of two participants as significant with respect to one aspect studied, while another researcher may need much more information in order to draw conclusions. These differences might be reflected at the end of the study in the findings.

Finally, as mentioned in the previous section, the greatest limitation of this study relate to the availability of resources, mainly time and the number of participants. With more extensive resources the findings would gain more in reliability and chances to be more accurate would also be higher.

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APPENDIX A

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Mathematics Self-Efficacy Scale Instrument and Scoring Guide

by

Nancy E. Betz

and

Gail Hackett

Published by
Mind Garden, Inc.

info@mindgarden.com

There are two parts to this instrument: Part I and Part II.
Please read all instructions and respond carefully and completely.

Score: ______

Please provide the following information:

Name or I.D.____

Date____________________Age____________________Gender
(*Please Circle*): **F** **M**

Part I: Everyday Math Tasks

Please indicate how much confidence you have that you could successfully accomplish each of these tasks by circling the number according to the following 10-point confidence scale.

Confidence Scale:

No Conf at all	Very little Conf			Some Conf			Much Conf		Complete Conf
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

Now turn to the next page and begin Part I. Be sure to answer every item.

Name or I.D.____

Part I

No Conf at all	**Very little Conf**			**Some Conf**			**Much Conf**		**Complete Conf**
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

How much confidence do you have that you could successfully:

1. Add two large numbers (e.g., 5379+62543) mentally	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
2. Determine the amount of sales tax on a clothing purchase.	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
3. Figure out how much material to buy in order to make curtains	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

Go on to Part II.

APPENDIX B

Name or I.D.____

Part II: Math Courses

Please rate the following college courses according to how much confidence you have that you could complete the course with a final grade of "A" or "B". Circle your answer according to the 10-point scale below:

No Conf at all	Very little Conf	Some Conf	Much Conf	Complete Conf
0 1	3	4 5	6 7	8 9

19 Basic College Math	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
20 Economics..................	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

You have now completed the
Mathematics Self-Efficacy Scale.

Thank you for your cooperation.

Directions for Scoring

The MSES yields three scores, a score for Part I, Mathematics Task Self-Efficacy, a score for Part II, Math-Related School Subjects Self-Efficacy, and a Total Mathematics Self-Efficacy Score.

1. The score for Mathematics Task Self-Efficacy is obtained by summing the response numbers given to each of the 18 items in the scale and dividing that sum by 18, to derive an average score. For example, if the examinees responded with a “5” (“Some Confidence”) to all 18 items the sum would be 90, which divided by 18 would yield an average score of “5”.

2. The score for Math-Related School Subjects Self-Efficacy is obtained by summing the response numbers given to each of the 16 items on this part of the scale and again dividing that sum by 16, to derive an average score. For example, if the examinees responded with a “5” (“Some Confidence”) to all 16 items the sum would be 80, which divided by 16 would yield an average score of “5”.

3. TOTAL SCORE. The total score is the sum of all 34 items in the scale divided by 34 to get the average.

4. MISSING RESPONSES. If the examinee failed to respond to one, two, or three items, simply sum the responses to the items that were completed and divide by the number that were completed. For example, if the examinee omitted responses to two of the items, the total score would be the sum of the 32 responses that were provided. If more than three items were omitted, the scale can no longer be considered valid. Re-administering of the scale after discussing the reasons for omission of so many items, or if necessary, removal of the individual from the data set (if the MSES is being used for research) should be considered in such cases.

The most useful score is the Total Mathematics Self-Efficacy Scale score, based on responses to all 34 items, because it includes both types of item content (math tasks and school subjects). The percentiles provided in Table 2 of the MSES Manual are based on the Total Scores. Thus, although there may be times when one or the other subscale score is used alone, we advise use of the total scale and the total score for most purposes.

For Dissertation and Thesis Appendices:

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Authors: ***Nancy E. Betz & Gail Hackett***

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APPENDIX C

INTERVIEW

1. How many years has it been since you graduated from High School (HS)?
2. Describe your mathematics background
    a. What math courses have you previously taken?
    b. Do you feel comfortable about these classes and the material you covered?
3. Tell me how mathematics was taught in high school.
    a. Was teaching interactive? If so, in what ways? Describe.

       (Time spent one-on-one with the teacher, concepts were easy

       to understand, etc.).
    b. How did you feel about courses being (or not being) interactive?
    c. Were you engaged and interested in the subject during classes?
    d. Were you optimistic about doing well in mathematics in the future?
4. Describe a typical mathematics class period in high school
5. Describe your experiences that led to your success in HS mathematics.
    a. Under what conditions do you perform well in math?
    b. Under what conditions do you perform less well? Why?
6. How is mathematics being taught in college as compared to HS. How do you feel about this?
7. Tell me about settling in to your college mathematics classes. Did you find the transition easy?

   Difficult? Explain / tell me more.
8. How do you feel about your upcoming college math courses?
    a. How would you define success in math courses?

b. How would you rate your confidence that you can succeed in college math courses?

9. Have your views about mathematics changed since graduating high school? Describe.

10. Overall, how is teaching in college different from teaching in HS?

    a. Is teaching interactive? If so, in what ways? Describe.

    b. How do you feel about courses being (or not being) interactive?

APPENDIX D

Reformed Teaching Observation Protocol (RTOP)

Daiyo Sawada
External Evaluator

Michael Piburn
Internal Evaluator

and

Kathleen Falconer, Jeff Turley, Russell Benford and Irene Bloom
Evaluation Facilitation Group (EFG)

Technical Report No. IN00-1
Arizona Collaborative for Excellence in the Preparation of Teachers
Arizona State University

I. BACKGROUND INFORMATION

Name of teacher__________________ Announced Observation? (yes, no, or explain)

Location of class ____
(district, school, room)

Years of Teaching________________________ Teaching Certification_

Subject observed__________________ Grade level _________

Observer________________________ Date of observation __

Start time_______________________ End time ___________

II. CONTEXTUAL BACKGROUND AND ACTIVITIES

In the space provided below please give a brief description of the lesson observed, the classroom setting in which the lesson took place (space, seating arrangements, etc.), and any relevant details about the students (number, gender, ethnicity) and teacher that you think are important. Use diagrams if they seem appropriate.

Record here events which may help in documenting the ratings.

III. LESSON DESIGN AND IMPLEMENTATION

		Never Occurred				Very Descriptive
1)	The instructional strategies and activities respected students' prior knowledge and the preconceptions	0	1	2	3	4
2)	The lesson was designed to engage students as members of a learning community.	0	1	2	3	4
3)	In this lesson, student exploration preceded formal	0	1	2	3	4
4)	This lesson encouraged students to seek and value alternative modes of investigation or of problem	0	1	2	3	4
5)	The focus and direction of the lesson was often determined by ideas originating with students.	0	1	2	3	4

IV. CONTENT

Propositional knowledge

6)	The lesson involved fundam. concepts of subject.	0	1	2	3	4
7)	The lesson promoted strongly coherent conceptual	0	1	2	3	4
8)	The teacher had a solid grasp of the subject matter content inherent in the lesson.	0	1	2	3	4
9)	Elements of abstraction (i.e., symbolic representations, theory building) were encouraged	0	1	2	3	4
10)	Connections with other content disciplines and/or real world phenomena were explored and valued.	0	1	2	3	4

Procedural Knowledge

11)	Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to	0	1	2	3	4
12)	Students made predictions, estimations and/or hypotheses and devised means for testing them.	0	1	2	3	4
13)	Students were actively engaged in thought-provoking activity that often involved the critical assessment of	0	1	2	3	4
14)	Students were reflective about their learning.	0	1	2	3	4
15)	Intellectual rigor, constructive criticism, and the challenging of ideas were valued.	0	1	2	3	4

Continue recording salient events here.

Time	Description of Events

V. CLASSROOM CULTURE

Communicative Interactions	Never Occurred				Very Descriptive
16) Students were involved in the communication of their ideas to others using a variety of means and media.	0	1	2	3	4
17) The teacher's questions triggered divergent modes of thinking	0	1	2	3	4
18) There was a high proportion of student talk and a significant amount of it occurred between and among students.	0	1	2	3	4
19) Student questions and comments often determined the focus and direction of classroom discourse.	0	1	2	3	4
20) There was a climate of respect for what others had to say.	0	1	2	3	4

Student/Teacher Relationships					
21) Active participation of students was encouraged and valued.	0	1	2	3	4
22) Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.	0	1	2	3	4
23) In general the teacher was patient with students.	0	1	2	3	4
24) The teacher acted as a resource person, working to support and enhance student investigations.	0	1	2	3	4
25) The metaphor "teacher as listener" was very characteristic of this classroom.	0	1	2	3	4

Additional comments you may wish to make about this lesson.