Developmental Mathematics College Students? Experiences of Mathematical Practices in a 4-week Summer Learning Community using Local Communities of Mathematical Practices

Bhupinder Naidu
Georgia State University

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The Dissertation Advisory Committee and the student’s Department Chairperson, as representatives of the faculty, certify that this dissertation has met all standards of excellence and scholarship as determined by the faculty. The Dean of the College of Education concurs.

_________________________________________  _______________________________________
Christine Thomas, Ph.D.                                            Iman Chahine, Ph.D.
Committee Chair                                                  Committee Member

_________________________________________  _______________________________________
Pier Junor Clarke, Ph.D.                                            Jennifer Esposito, Ph.D.
Committee Member                                                  Committee Member

_________________________________________
Rebecca Casey, Ph.D.
Committee Member

_________________________________________
Date

_________________________________________
Dana L. Fox, Ph.D.
Chair, Department of Middle-Secondary Education and Instructional Technology

_________________________________________
Paul A. Alberto, Ph.D.
Interim Dean
College of Education
AUTHOR’S STATEMENT

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Bhupinder Naidu
10415 Shallowford Road
Roswell, GA 30075

The director of this dissertation is:

Dr. Christine Thomas
Department of Middle-Secondary and Instructional Technology
College of Education
Georgia State University
Atlanta, GA 30302-3965
CURRICULUM VITAE

Bhupinder Naidu

ADDRESS: 10415 Shallowford Road
           Roswell, GA 30075

EDUCATION:
Ph.D. 2013 Georgia State University
       Teaching and Learning
M.B.A 1988 University of Texas at San Antonio
       Business
B.S.  1982 Leicester Polytechnic and University
       Mathematics and Statistics

PROFESSIONAL EXPERIENCE
2003 - Present Assistant Professor of Mathematics
Department of University Studies
Cagano State University, Cagano, GA

1996 – 2003  Instructor of Mathematics/ Mathematics Lab Coordinator
Department of University Studies
Cagano State University, Cagano, GA

1991 – 1995  Mathematics Lab Coordinator/Instructor of Mathematics
Midland Community College, Midland, Texas

PRESENTATIONS AND PUBLICATIONS:


Naidu, P., (2011, March). Learning Styles, Workshop Session presented as part of a Pre-Conference Workshop on Tutor Training, Association for the Tutoring Professional, Orlando, FL.


AWARDS/HONORS

2009-2010 Recipient of the Outstanding Service Award as Chair of the Research Committee, Association of the Tutoring Professional,

2006 Recipient of Kenneth and Catherine Kiesler, Service Award

2004 Recipient of Department Distinguished Teaching Award,

2003 Honoree of the Freshman 4.0 Luncheon

PROFESSIONAL SOCIETIES AND ORGANIZATIONS

2010-present National Association of Developmental Educators

2006-present Association of the Tutoring Professional

2000-2006 The Georgia Tutoring Association
ABSTRACT

DEVELOPMENTAL MATHEMATICS COLLEGE STUDENTS’ EXPERIENCES OF MATHEMATICAL PRACTICES IN A 4-WEEK SUMMER LEARNING COMMUNITY USING LOCAL COMMUNITIES OF MATHEMATICAL PRACTICES

by

Bhupinder Naidu

The research literature concerning traditionally aged college mathematics students’ who require remediation, in beginning Algebra topics, states that these students lack confidence in their mathematical skills, have experienced failure and frustration in the past, have low self-confidence issues with respect to mathematics and often lack basic studying skills (Hall & Ponton, 2005; Young & Lee, 2002; Zimmerman, 2008). Most research studies on developmental mathematics students have used quantitative methodologies that have not provided the depth or explanation of students’ perspectives of mathematical practices that a qualitative study such as this study provides (Kinney, Stottlemeier, Hatfield & Robinson, 2004).

The purpose of this study was to examine traditionally aged developmental mathematics college students’ experiences of mathematical practices, in a 4-week summer learning community, using a qualitative case study approach (Yin, 2009). This study used the methodological framework of Local Communities of Mathematical Practices (Winbourne & Watson, 1998) to help sort and analyze data, the conceptual theory of situated cognition (Brown & Duguid, 1988), and the theories of communities of practice (Lave & Wenger, 1991), and learning communities (Tinto, 1997). The goals of the study were to inform instructors and administrators as to the contextual factors that allow developmental mathematics college students to be academically successful as evidenced by their mathematical practices (Ball, 2003). The research question for this
The qualitative, explanatory single case study was: *How does participating in a 4-week summer learning community shape developmental mathematics college students’ experiences of mathematical practices?*

The participants of this case study belonged to one group of four women enrolled in a 4-week summer learning community at a university. I collected data in the form of video and audio tape of classroom interactions, student and instructor personal observations and reflections, and two individual interviews per participant. Analysis of the data revealed that participants’ mathematical practices were shaped in part by: a) the way students identify with mathematics relates to their ‘success’ or ‘failure’ in the mathematics course; b) the students level of participation within the community; c) the students collaboration with purpose, discussion, and reflection gave rise to understanding; d) the students shared repertoire confirmed the consensus of knowledge; e) the students mutual engagement played a large part in their motivation to succeed, and f) the students joint enterprise within the learning community was a significant factor in their learning. Findings suggest that the 4-week summer learning community shaped these developmental mathematics students’ mathematical practices’ by allowing the students to: 1) view themselves as navigating mathematics successfully; 2) create an environment in which to ask questions; 3) connect to the entire community; 4) participate in various activities while in groups; which 5) lead to a self supporting system these students could rely on. This study illuminated for these students that learning is the intersection of activity, concept, and culture (the classroom).
DEVELOPMENTAL MATHEMATICS COLLEGE STUDENTS’ EXPERIENCES OF MATHEMATICAL PRACTICES IN A 4-WEEK SUMMER LEARNING COMMUNITY USING LOCAL COMMUNITIES OF MATHEMATICAL PRACTICE

by

Bhupinder Naidu

A Dissertation

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Atlanta, GA
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CHAPTER 1
INTRODUCTION

Problem Statement

Russell (2008) in her policy brief for The American Association of State Colleges and Universities (AASCU) suggested that the K-12 system was never designed to prepare all students for college. The need for an educated workforce has led to more and more students considering college entering academia under-prepared. This in turn has given rise to an increasing number of students requiring developmental or remedial courses in Mathematics, English, and/or Reading. While the majority of developmental mathematics students enroll in community colleges, data from the Pell Institute for the Study of Opportunity in Higher Education, cited in The Chronicle of Higher Education (6/16/08), states that:

Six years after starting college at a four-year public college, 34 percent of low-income, first-generation students have earned a bachelor’s degree. This compares to just five percent of similar students who began at a community college, despite the fact that nearly two-thirds of these students who began at a community college said they intended to earn at least a bachelor’s degree. (p. 40)

Therefore, providing access to a higher education at a four-year university for all students impacts not only future economic and labor needs but also graduation rates of developmental mathematics students. Funding from several organizations—such as the Carnegie Foundation, the Bill and Melinda Gates Foundation, the William and Flora Hewlett Foundation and the Lumina foundation—is also aimed at helping students complete developmental mathematics classes on the way to graduation at local community colleges, (Carnegie Foundation, 2010). Funding often drives new studies; however, many of these studies are focused on remediation via Computer Assisted Aid
(CAA). Studies in CAA frequently focus on quantitative outcomes and test results, not on the in-depth dynamics of teaching and learning of students researched using qualitative methods.

This study researched the community of developmental college students within the classroom and the affect community has on mathematical practices. Specifically, this study proposes to examine developmental mathematics college students’ experiences of mathematical practices in a 4-week summer learning community, using the notion of Local Communities of Mathematical Practices (LCMP); a framework developed by Winbourne and Watson (1998) to evaluate the mathematical practices occurring within a classroom. (A detailed explanation of LCMP’s is given later in this chapter.) The guiding research question for this case study was:

*How does participating in a 4-week summer learning community shape developmental mathematics college students’ experiences of mathematical practices?*

The purpose of this qualitative case study was to illuminate students’ mathematical experiences while immersed in a community of practice. The goals of the study were to inform instructors and administrators as to the contextual factors that provide more opportunities for developmental/remedial mathematics college students to be academically successful as evidenced by their mathematical practices.

This chapter is divided into the following four main sections for easier reading. First, I provide a background discussion of national and state concerns, followed by specific issues that surround developmental education at 4-year universities in the state where this study was held, Second, I provide a discussion of terms. Third, I explain the
purpose, the research question, the rationale and significance of the study. Fourth, I explain the conceptual and theoretical frameworks used in this study.

**Background**

**National Overview**

The 2011 National Center for Educational Statistics (NCES) report states that nationally 75% of all higher learning institutions (technical schools, community colleges, and four-year private, public, and research colleges) offer developmental/remedial mathematics courses. Developmental mathematics courses at the institution at which this study was conducted are defined as courses offering a review of topics from Algebra I and Algebra II or introductory and Intermediate Algebra. It is known that 100% of all community colleges that provide open enrollment offer a developmental or remedial course, and 78% of all four-year public universities offer at least one developmental course. Developmental mathematics students’ current success rates (obtaining ‘C’ or better) of in these courses average 50% (NCES, 2004). Of the students who achieve success in a developmental mathematics course, only 40% actually graduate (NCES, 2004).

According to the NCES (2012), students are placed in these courses by means of an institutional or standardized placement test such as the COMPASS test (American College Testing [ACT], 2002). Placement issues confound discussions of interventions for this group of students. While Miller (1990) suggests that early intervention and attention is necessary for the success of this group of students, he does not suggest what that intervention or attention might be. Also debated is the question of how to teach this group of students. At most institutions developmental courses are typically structured as
lecture type courses offered over a 15-week semester (Boylan, Bonham, & White, 1999). Little research exists to suggest that this format (15 week lecture) is effective in teaching developmental students, national figures suggest just the opposite (NCES, 2004).

Driving changing policies, course redesigns, and pedagogy evaluations for remedial courses at the national and state levels is the cost of developmental education. Cost debates hinge on the question, are we teaching these students twice (Bahr, 2008)? Cost figures published by Brenneman and Haarlow (1998) found that the United States spent approximately $1 billion dollars annually on developmental education including English as a Second Language, basic skills courses, and remediation in Mathematics, English, and Reading.

Given the above figures of increasing populations of underprepared college students, the lack of empirical studies in this area, and the current interest in providing a cost effective solution to educating these students, this study endeavors to provide insight on potential recommendations based on students’ mathematical practices that emerge as they engage in learning within a community of practice. I now highlight issues that are specific to the Southern state in which this study resides.

State Overview

Current issues surrounding teaching mathematics to students who require remediation at four-year colleges in this state are similar to issues at the national level. Within the state where this study took place, 23.1% of all incoming freshmen are labeled as Learning Support Program (LSP) or developmental students. These students are labeled LSP students because they are required to take a remedial or introductory Mathematics, Reading and/or English course. Figure 1 shows more clearly the gradual
increase within the state system of colleges of developmental students (hereafter referred to as LSP students). The state’s creation of a newly created taskforce charged with examining issues and recommendations (personal communication, August 2009), coupled with an article entitled “Remedial classes cost colleges millions” in a local newspaper dated November 1, 2010 all attest to the level of concern that this state has regarding its enrollment of developmental students with cost of educating LSP students being the driving factor.

Figure 1. Percentage of incoming recent high school graduates labeled learning support program (LSP) students. Note. Retrieved and adapted from http://www.usg.edu/research/students/ls/lsreqs/srpt850_fall2008.pdf, June 6, 2010.
Specific issues of concern at the institution where this study resides and of the state taskforce are: 1) the methods employed to identify students as learning support developmental mathematics students; 2) the validity of the Computer Adaptive Placement Assessment and Support System test (COMPASS, ACT, 2002) that is currently used to place these students and the appropriate COMPASS scores to be used to signify entry and exit proficiency; 3) discussions of methods of how best to teach these students; and 4) how students are evaluated for readiness for college credit classes.

First, on the issue of identifying students as LSP, debates have been ongoing in the institutions within this state as to what can be deemed a ‘low’ SAT or ACT score. The state’s governing board of colleges, the Board of Regents (BOR), considers higher than 400 on the SATM and higher than 17 on the ACT, acceptable scores for access to credit level mathematics courses, whereas at the institution where this study took place, all students obtaining a SAT score of between 400 and 460 or an ACT score of between 17 and 19 are tested for placement using the COMPASS test. This leads, as stated above, to the second issue, that of the validity of the COMPASS test itself. In a dissertation by John Walter Cotter (2007), on the measure of the COMPASS test to predict success in the first credit level mathematics class, the conclusion was that COMPASS was indeed a poor measure, but Cotter’s dissertation does suggest a score of 40 indicating success in a college credit algebra course. However, no indications were made suggesting a relationship between scores on COMPASS and a developmental class. Also, the arbitrary COMPASS scores of less than 37 and more than 37 which are currently being used as entry and exit scores respectively have been debated and have varied over the last decade (BOR, 2009).
The third issue is that pedagogical practices are related to space issues at the university where this study is housed. Total enrollment increases including a 9.7% increase in developmental mathematics has led to limited classroom space at this institution which in turn has led to the encouragement by upper administration for online and hybrid classes; courses that meet one day on campus and one day online (personal communication, Fall 2009). However, research in developmental education has not supported that the online or hybrid environment is beneficial for developmental students (Jacobson, 2005; Kinney, Stottlemeyer, Hatfield, & Robinson, 2004). This is verified by research showing that developmental students are not self-regulated or motivated (Hall & Ponton, 2005), characteristics required for the online environment. Developmental students also have a need for academic support (Duranczyk, Goff, & Opitz, 2006), and require face to face interactions (Boylan & Bonham, 2007).

Finally, evaluation of LSP students is not only conducted via their grade in their LSP class but also by the student’s success in the next credit level mathematics class. Currently, the percentage of LSP students retained, as of fall 2009, at the university of study is 70%, and of those retained students, 64.6% obtained a successful grade in their next credit level mathematics class (personal communication, 2009). This indicates some measure of success; however the assessment report indicates that only 78% of this university’s developmental college students complete their LSP courses within one academic year. Since retention and progression of students is a BOR policy, this figure is of concern amongst faculty teaching developmental college students at this university.

Utilizing limited resources during a time of budget cuts means many four-year colleges are seriously looking at downsizing if not eliminating learning support or
developmental classes all together. Indeed, current recommendations that were implemented in Fall 2012 by the LSP taskforce in this state are: 1) Allow two and four-year institutions the prerogative to choose open admission or SAT/ACT requirements; 2) Discontinue admission of students who require all three areas (English, Reading, and Mathematics) of LSP classes; 3) Limit the number of attempts LSP classes can be attempted to a maximum of three for Mathematics; 4) Increase the number of college credits earned from 20 to 30 by which time a student with LSP requirements must complete their LSP courses; and 5) Examine and set state-wide COMPASS placement scores (personal communication, October, 2010).

In summary, issues and challenges that four-year colleges face, range from placing students correctly into and out of learning support classes, finding classroom space, providing academic support, to teaching and evaluating students to be ready for college credit mathematics classes, all of which involve cost at a time when colleges are severely under budgeted. While colleges in this state wait for education reform measures at the lower levels (K-12) to take effect, it is clear that students currently testing into the developmental mathematics classes (via the COMPASS test) need different pedagogical practices (beyond the lecture) that will help them be successful. What that teaching and learning context should be is unclear (Hall & Ponton, 2005). With the country’s need for a more educated labor force to compete in the world economy, it seems only prudent to supply opportunity and provide alternative learning environments to those desiring a higher education, including the students who have some deficiencies.

This study focused on exploring how participating in a 4-week summer learning community shaped developmental mathematics college students’ experiences of
mathematical practices. This study investigated a group of four students within a cohort of LSP mathematics students, who were enrolled in a summer learning community, who developed a community of practice, and engaged in mathematical practices. This study used Local Communities of Mathematical Practices and Situated Cognition as its conceptual and methodological frameworks, respectively. It is, therefore important at this stage to define the terms “learning communities”, “communities of practice” and “mathematical practices” as they were used in this study. The conceptual and methodological frameworks will be discussed in the subsequent section.

Discussion of Terms

Learning Communities

Learning Communities (LC) are models of social and academic integration that provide an academic structured social learning environment for students (Terenzini et al., 1996). There are four common models of LCs: 1) paired or clustered courses; 2) cohorts in large courses; 3) team-taught programs; and 4) residence-based programs (Laufgraben & Shaprio, 2004; Shaprio & Levine, 1999). In this study, I adopted the LC definition, that of paired courses in which the same group of students is enrolled in the same two academic courses; in this study a freshman seminar course and the developmental mathematics course.

Summer Learning Communities

Summer learning communities (SLC) are often referred to as pre-freshman summer programs, or summer bridge programs, and have existed since the mid 1970’s, providing proactive, inclusive approaches to meet the social and academic needs of students (Levin, & Calcagno, 2008). They are designed to “enable students to get a head
start on building academic skills, become acquainted with college resources and expectations” (Maggio, White, Jr., Molsatd, & Kher, 2005). Modeled after LC’s, they are often paired courses, typically a study skills class and one from an academic domain as in this study.

Local Communities of Practice

A “community of practice” (CoP) is a term created by Lave and Wenger (1993) that describes the learning that occurs in shared practices within a specific context. The term ‘community of practice’, was coined by Lave and Wenger (1991) describing any group of people who care for something they do and learn how to do it better as they interact regularly. Lave and Wenger, both anthropologists, developed the term after studying the apprenticeship to master cycle in Liberian tailors as a learning model. According to Wenger (1998), these environments provide an intersection of social practice, community, and identity within which learning takes place. In this study, I concurred with Wenger’s (2007c) notion of CoP as having three basic characteristics:

1) The domain. All members of the CoP are committed to the domain and a CoP identity is defined by a shared domain of interest (in this study, mathematics).

2) The community. All members of the CoP are actively engaged through joint activities and discussions in pursuing the domain of interest. They build relationships, encourage one another, and learn from one another.

3) The practice. All members of a CoP are practitioners. They develop shared experiences, memories, stories, tools, vocabulary, documents and processes. They engage in practice which takes time and continued interaction. (p. 1)
Indeed, the common thread that arises within both strands of Tinto’s and Lave’s research and is of importance in this study is that of constructing shared knowledge and shared knowing. It is important to note that this shared experience was engaged and facilitated in and by the faculty member. Indeed, the faculty member was an important component of the learning experience as suggested by both Tinto (1997), and Lave and Wenger (1993).

**Local Communities of Mathematical Practice**

Winbourne and Watson (1998) introduced the notion of *local communities of mathematical practice* (LCMP) as a tool to examine “everyday” school mathematics, stating:

Such communities are local in terms of time as well as space: they are local in terms of people’s lives; in terms of the normal practices of the school and classrooms; in terms of the membership of the practice; they might ‘appear’ in a classroom only for a lesson and much time might elapse before they are reconstituted. (p. 94)

Their notion of LCMP led to six defining characteristics involving people, place, and time and having the following features allowing for the identification of a LCMP within a classroom.

- **C1.** Pupils see themselves as functioning mathematically and, for these pupils, it makes sense for them to see their ‘being mathematical’ as an essential part of who they are within the lesson;
- **C2.** Through the activities and roles assumed there is public [from the participants] recognition of developing competence within the lesson;
- **C3.** Learners see themselves as working purposefully together towards the achievement of a common understanding;
- **C4.** There are shared ways of behaving, language, habits, and tool-use;
C5. The lesson is essentially constituted by the active participation of the students;
C6. Learners and teachers could, for a while, see themselves as engaged in the same activity. (p. 103)

This concept of LCMP allows for the systematic examination of all six characteristics of learning mathematics with respect to the interactions occurring within the classroom.

**Learning Support Programs**

Learning support programs (LSP) are programs that provide remediation in Mathematics, Reading, and English to incoming freshman students who are placed into the programs as discussed earlier. In this study, LSP mathematics students are those needing to review concepts from introductory and intermediate algebra concepts as assessed by their SAT, ACT and COMPASS scores. In many studies and texts these students are also referred to as developmental mathematics students (Boylan & Bonham, 2007).

**Traditionally Aged Developmental Mathematics Students**

Traditionally aged refers, in this study, to students 18 years of age. At the institution where this study took place, traditionally aged refers to students 18 to 22 years of age. “Developmental” defines material that is remedial to a college curriculum. Developmental mathematics for example, defines mathematical content and skill that are pre-requisite to college credit mathematics and science courses. These courses often focus on introductory and intermediate algebra, and most often are taught at community colleges. Many community colleges in the United States have 50% of enrolled students taking a developmental mathematics course (McCabe and Day, 1998).
Problem Solving Tasks

In this study, I have adopted Schoenfeld’s (1992) and Polya’s spirit of problem solving tasks. That is, I provided mathematical problems that allowed students to investigate and question even when methods of finding solutions were only partially mastered. These tasks provided students the opportunity to discuss, create, and evaluate possible solutions.

Mathematical Practices

The National Council of Teachers of Mathematics (NCTM) states that mathematical practices are a set of activities that include mathematical representations, use of mathematical terms, reasoning, and communicating in a specific setting that are actively engaged in by all participants within the classroom (Ball, 2003). In this study, I argue that it is the ways in which students acquire the ability to competently learn and use mathematics, approach, think about, and work with mathematical tools and ideas that are deemed mathematical practice. How people acquire these practices well is what differentiates those who are successful from those who are not. The participants in this study are developmental college students whose mathematical background indicates a deficit in attaining these practices. Students’ acquisition of these practices in cooperation with others within a specific setting creating a community of learners is an idea rooted in situated cognition theory.


**Purpose**

The purpose of this qualitative case study was to explore how participating in a 4-week summer learning community shaped developmental mathematics college students’ experiences of mathematical practices. This study was grounded in situated cognition and was guided by the conceptual paradigm of Winbourne and Watson’s (1998) Local Communities of Mathematical Practice (LCMP). The LCMP framework seeks to address mathematical practices within a specific context, the 4-week learning community in this study. The framework guided the data collection, analysis and interpretation of findings emerged in the study.

The rationale behind using the LCMP framework was to provide a scaffold for examining participation and learning within the mathematics’ classroom utilizing qualitative methods to address questions that afforded a deeper understanding of how learning in a situated context contributed to the academic success of these students. Elaborations of the particulars of the methodology are discussed in the methodology chapter.

**Research Question(s)**

Examining developmental mathematics college students’ mathematical practices within the LCMP framework gave rise to the following main research question:

*How does participating in a 4-week summer learning community shape developmental mathematics college students’ experiences of mathematical practices?*

The LCMP (Winbourne & Watson, 1998) provided the following six sub-questions to help guide this investigation:

1) How do students seem to be acting in relation to attempting problem-solving tasks?
2) What developing mathematical competence is publicly recognized and how?
3) Do learners appear to be working purposefully together towards a shared understanding of problem-solving tasks?
4) What are the shared values and ways of behaving in relation to mathematics: language, habits, tool use?
5) Does active participation of students and teacher in mathematics constitute the lesson on problem-solving tasks?
6) Do students and teacher appear to be engaged in the same mathematical activity? What is the activity?

Rationale

This study on understanding developmental college students’ mathematical practices experiences using the notion of Local Communities of Mathematical Practice (LCMP) (Winbourne & Watson, 1998) within a 4-week learning community was important for several reasons. First, it used the institutionally created Learning Community (LC), that of two paired courses (study skills and developmental mathematics class), and provided this LC as a Pre-Fall summer program. Research in these areas indicated a higher degree of retention for students enrolled in such programs (Levin & Calcagno, 2008). Second, it provided insight into students’ perspectives of mathematical practices in a situated context. Using the LCMP as a framework helped reveal developmental college students’ perceptions of strengths and weakness with mathematical practices. Third, it illuminated for instructors and students the different interactions, mathematical practices, and the teaching/learning moments (Winbourne, 2010) perceived as important in order to develop success in a mathematics class. Understanding these interactions, practices and experiences should help instructors of developmental mathematics college students know which factors within the classroom are of importance, and it helps students better understand the practices that lead to academic success in mathematics. Fourth, this study adds to the existing literature of
developmental education and provides insight into the interactions of a developmental mathematics classroom and provides explanations of developmental college students’ mathematical practices. Fifth, few developmental mathematics research studies have examined students’ mathematical practices experiences using a qualitative approach.

Many studies have been quantitative comparison studies investigating students in college algebra versus developmental mathematics courses (Hall & Ponton, 2005; Young & Ley, 2002). Other studies have focused on comparing students enrolled in computer based instruction versus lecture courses (Kinney, Stottlemeyer, Hatfield & Robinson, 2004). Studies in developmental education using quantitative methodologies, while useful, have not provided the depth or explanation of mathematical practices experiences from developmental students’ perspectives that a qualitative study such as this provides.

The aim of this qualitative case study was to examine students’ learning with respect to mathematical practices experiences using local communities of mathematical practice framework (Winbourne & Watson, 1998).

**Significance**

From a personal perspective, this study was highly significant for me. I have been a 17-year educator of developmental mathematics students. My personal beliefs about learning follow a situated paradigm, believing that learning can be encouraged and supported within the context of the classroom community. I suggest that learning takes place within an academic domain and is enhanced through social interactions. I have taught developmental students who were successful (obtained a 70% or higher on tests) in their LSP classes and went on to be just as successful in college-level mathematics. I also piloted a quantitative study of developmental students in a summer learning
community in Fall 2008. The 2008 study’s findings showed that students enrolled in the
community were successful at a higher rate than those not enrolled. However, the
quantitative study left many questions unanswered, such as *how* and *why* this occurred.
This led me to this qualitative investigation of developmental mathematics students’
perspectives of mathematical practices in a summer learning community. I believe this
study illuminates factors that support students’ success in the situated context of a
developmental mathematics summer learning community.

From a national perspective, the country’s need for an educated workforce has
prompted institutions and organizations to look for methods to help students with
educational deficits graduate. For example, non-governmental organizations (NGO), such
as the Carnegie Foundation, the Bill and Melinda Gates Foundation, the William and
Flora Hewlett Foundation and the Lumina foundation, have funded a $14 million effort
aimed at assisting students complete developmental mathematics classes on the way to
graduation at local community colleges (Carnegie Foundation, 2010). All of the
foundations listed above have expressed a commitment to expand college readiness, and
further students’ retention and graduation rates. They have recognized the need to address
different pedagogy for this group of students and have also recognized that few
instructors at the two-year college level, where most developmental students attend, are
well versed in conducting research. The foundations are currently supporting the
examination of economically viable methods of teaching these students. However, most
of the studies being conducted and supported by these foundations are aimed at providing
material via Computer Assisted Aid (CAA). This study researched the intricacies of the
interactions of the classroom and the effect on the mathematical practices skills of
developmental college students while in a 4-week learning community. It was hoped this study provided an in-depth analysis of the skills necessary for these students to be successful in their mathematics classes.

With enrollment of developmental students at both community colleges and four-year universities increasing (NCES, 2005), it is vital that methods be employed to increase retention, persistence, and graduation of these students. Examining research studies in instructional techniques (Di Muro, 2006; Tanner, 2005) for students requiring remediation within the domain of developmental education, it was noted that results cited are often prescriptive, recommend an algorithm, and imply a teaching plan that if followed, should guide students to success in college mathematics classes (Roueche, & Roueche, 1999; Stratton, 1996). These studies disregard the complexity of learning between individuals and the importance of interactions within the classroom community. It was hoped that by examining the mathematical practices of developmental college students using Local Communities of Mathematical Practice (LCMP), this study illuminated those interactions and clarified the importance of mathematical practices and learning within a classroom context.

**Conceptual and Methodological Frameworks**

This study on developmental college students’ mathematical practices within a 4-week learning community was grounded in situated cognition and used the concept of LCMP as a methodological framework. Below, I briefly give an overview of the frameworks used in this study.
Conceptual Framework: Situated Cognition

Situated cognition has its roots in learning theories born of the social sciences: anthropology, sociology, and cognitive science. It gained recognition in the field of Educational Psychology through the works of Brown, Collins, and Duguid (1989). It was appropriate for this study because situated cognition maintains that learning occurs through collaborative social interaction and the social construction of knowledge (Brown et al., 1989). Lave and Wenger (1991) added experiences from their anthropological study of human behavior to create the term *communities of practice*. They viewed learning not as a transmission of knowledge, from one individual to another, but the building of knowledge through a social process, building through practice, suggesting that learning is situated in a specific context and is embedded within a particular social and physical environment. Lave and Wenger (1991) described communities of practice as participants actively engaged in acquiring beliefs and behaviors, and moving from beginner to expert within the community. Studies in mathematics education have shown that the use of mathematical practices by students is matched by an increase in participation in communities of practice, moving from novice to expert (Franke, Kazemi, & Battey, 2007; Hufferd-Ackles, Fuson, & Sherin, 2004).

In mathematics educational research cognitive studies in learning in a social context were explored by researchers such as Greeno (1998), and Lave (1988). Further research studies in the areas of problem solving, reasoning, proof, representation, and cognition show that students do not engage in mathematical practices alone (Schoenfeld, 1992, 2008; Winbourne & Watson, 1998). Students are involved in the interpretation of mathematics at a social level within the classroom community. Building on Lave and
Wenger’s (1991) ideas of participation in a community and the need to evaluate students’ mathematical practices within the context of the classroom, Winbourne and Watson (1998) introduced the notion of local communities of mathematical practice (LCMP) for everyday school mathematics, using six characteristics discussed below.

**Methodological Framework: Local Communities of Mathematical Practice**

This study used the earlier defined notion of ‘Local Communities of Mathematical Practices’ (LCMP) to explore developmental mathematics college students’ mathematical practice experiences within a 4-week learning community (that of the paired courses defined earlier). This model of LCMP is conceptually appropriate for this study because it is based on the notions of mathematical practices, local communities of practice, and is grounded in situated cognition theory.

Methodologically, using Winbourne and Watson’s (1998) LCMP as a framework to analyze data of the interactions and problem-solving taking place was very appropriate for this study. This framework allowed for the teaching/learning moment to be illuminated, themes of practices to be characterized, and enhanced the view of the learner through those practices. Researchers in mathematics education have employed varying conceptual frameworks that showed impact on cognition in the mathematics classroom. Schoenfeld (1992) writes, “it appears that a consensus emerged with respect to the importance of the following five aspects of cognition in mathematics problem-solving: 1) The knowledge base, 2) Problem-solving strategies, 3) Monitoring and control, 4) Beliefs and affects, and 5) Practices. These categories are important in mathematical cognition because they define how most research in this area is organized” (p. 348).
Winbourne and Watson’s (1998) local communities of mathematical practice (LCMP) framework concurs and addresses these five aspects of cognition in the following way.

Table 1

*Categories of Cognition in Mathematics Problem-Solving*

<table>
<thead>
<tr>
<th>Mathematics Educational Research Cognition Categories</th>
<th>LCMP Framework</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socialization / Beliefs and affects</td>
<td>1. How do students seem to be acting in relation to attempting problem-solving tasks?</td>
</tr>
<tr>
<td>Knowledge Base / Problem-solving strategies</td>
<td>2. What developing mathematical competence is publicly recognized and how?</td>
</tr>
<tr>
<td>Problem-solving strategies</td>
<td>3. Do learners appear to be working purposefully together towards a shared understanding of problem-solving tasks?</td>
</tr>
<tr>
<td>Monitoring and control</td>
<td>4. What are the shared values and ways of behaving in relation to mathematics: language, habits, tool use?</td>
</tr>
<tr>
<td>Practices</td>
<td>5. Does active participation of students and teacher in mathematics constitute the lesson on problem-solving tasks?</td>
</tr>
<tr>
<td>Socialization/Beliefs/Knowledge base/Problem-solving strategies/Practices</td>
<td>6. Do students and teacher appear to be engaged in the same mathematical activity? What is the activity?</td>
</tr>
</tbody>
</table>
Methodologically, other studies (David & Watson, 2008; Frade & Tatsis, 2009) in mathematics education have also used LCMP as a way to obtain the complexities of occurrences within a classroom. Indeed, the power of LCMP is in distinguishing the differences within classrooms based on the six characteristics developed by Winbourne and Watson. Applying the notion of LCMP to this study, answering the questions posed by the LCMP through observation and interviews, and students’ work helped with data collection. These categories also helped me code and identify themes in this qualitative case study and address the research question.

_How does participating in a 4-week summer learning community shape developmental mathematics college students’ experiences of mathematical practices?_

In summary, methodologically, LCMP is appropriate for this study because it is based on the notions of mathematical practices, local communities of practice, and is grounded in Situated Cognition theory. Specifically, LCMP allowed me to look for learning not only in terms of the formal setting of the classroom but also within the informal communities and practices these students established and engaged in during the summer learning community, and in the ‘moments’ where learning is highlighted. Indeed, finding and characterizing those practices helped illuminate these students’ experiences and investigate where those practices originated. It is also important to remember that these students bring with them a sense of self as learner. However, as students in a developmental class, their identity as learners needed to be encouraged and developed in order to impact their future success in college (Winbourne, 2010).
CHAPTER 2
LITERATURE REVIEW

This literature review is comprised of four sections. The first section covers a historical and philosophical overview of how research has impacted and changed epistemological and ontological views of mathematics. It then includes a short historical overview on the nature of mathematical knowledge from a situated cognitive perspective. The second section illustrates the different concepts in a ‘community of practice’, including the Local Communities of Mathematical Practice (LCMP) which is used to frame this study and the institutional Learning Community in which the developmental college students in this study were enrolled. The third part of this literature review covers the impact that Learning Communities have had on illuminating social and mathematical practices in college classroom settings. The fourth section provides an analysis of the characteristics, strengths and weaknesses of the concepts LC and LCMP used in this study.

As this literature review shows, there are few studies that focused on developmental mathematics college students’ mathematical practices. This review showed a need to explore developmental mathematics college students’ experiences with mathematical practices in a situated context. This provided insight and recommendations to instructors and students as to ‘how’ to work with and enhance the academic success for developmental mathematics college students.
Epistemology and Ontology of Mathematics

This section provides a historical and philosophical overview of how research has impacted and changed epistemological and ontological views of mathematics in the late twentieth century. Studies are then highlighted that have investigated and examined the epistemology, and ontology of mathematics (Hoffman, 1989). The proposed study used the Local Communities of Mathematical Practice (LCMP) to investigate experiences of mathematical practices of developmental college students within a situated context, so it is significant, in this review, to study the nature of mathematical knowledge from a situated perspective. Indeed, if we can surmise what students know coupled with how they know, we can hope to provide insight into what works for this group of students. This review shows that there are few studies investigating developmental college mathematics students’ experiences of mathematical practices from a situated perspective.

Historical Overview

Epistemology is a set of beliefs about knowing, and ontology a set of beliefs about what exists or what is real. In mathematics education, epistemological and ontological questions that arise are: 1) How does one know; 2) How does one come to know and; 3) What is mathematics or what is mathematical knowing/knowledge (Hoffmann, 1989)? Epistemological and ontological views of mathematics have had a major influence on the development of school mathematics, curriculum, instruction and research (Dossey, 1992). One’s epistemological and ontological stance provides the foundation of understanding of mathematical thinking. The epistemology that has guided mathematics education, driven by researchers’ paradigms, has primarily focused on conceptual and procedural representation (Hiebert & Carpenter, 1992). This view has
created problems by suggesting that cognitively, representation reflects understanding and is prior to all else. The theory of situated cognition, in which this study is grounded, suggests that “activity and perception are importantly and epistemologically prior” (Brown, Collins, & Duguid, 1989).

Historically, the nature of mathematics has been debated since the time of Plato and Aristotle (Dossey, 1992). The early twentieth century saw three schools of thought—logicism, intuitionism, and formalism—view the contents of mathematics as products. That is, mathematics is a game to be played with set rules, in a given way with definable outcomes. Davis and Hersh (1981) wrote that the formalist views of mathematics still influence the development of mathematics today. Indeed, current studies (Solomon, 2006; Wheeler & Montgomery, 2009) still report that college students’ views of mathematics correspond to the De Corte, Op’t Eynde, and Verschaffel (2002) study that found the following:

Associated with certainty, and with being able to give quickly the correct answer; doing mathematics corresponds to following rules prescribed by the teacher; knowing mathematics means able to recall and use the correct rule when asked by the teacher; and an answer to a mathematical question or problem becomes true when it is approved by the authority of the teacher. (p. 305)

Epistemology and ontology of mathematics have been influenced by the social sciences, sociology, psychology, and anthropology. This shift drew constructivists such as Ernest von Glaserfeld (1991), to look at mathematics as an individually constructed set of knowledge, equating knowing mathematics with doing mathematics. Dossey (1992) further clarified by writing, it is in “the ‘doing – the experimenting, abstracting, generalizing, and specializing – that constitutes mathematics, not a transmission of a well-formed communication” (p. 44). Dossey also quotes Polya (1965) as saying,
“Learning should be active, not merely passive or receptive. The best way to learn anything is to discover it yourself (pp. 44-45). Both Polya and von Glaserfeld promoted an individual construction of mathematical knowledge through doing.

Other researchers, such as Vygotsky (1978) and Dewey (1969), were also proponents of active, situated approaches. Vygotsky’s (1978) theory of social development was based on the idea that social interaction plays a fundamental role in knowledge creation and acquisition. He advocated a Zone of Proximal Development (ZPD) within which there was opportunity for cognitive development. His contribution to education was that children grew to know but not without a teacher’s intervention. Research done by Vygotsky set the stage for social constructivism (Ernest, 1998; Vygotsky, 1978) and social cognitive theories (Bandura, 1986). To social constructivists and cognitive scientists, knowledge is a human product and is socially and culturally constructed (Ernest, 1998). While social constructivism does take into account the social aspect of learning, it centers on the individual coming to know and not on the class as community in knowledge creation. John Dewey (1969) advocated participation as being crucial to the learning process. He believed that the knower is an integral part of the situation where knowledge is to be known. While both Dewey and Vygotsky seem focused on the individual knowing, they did stress the social nature of knowledge construction but were not too concerned with the interactions that gave rise to that construction. Research in learning in practice was conducted by Scribner (1984) and Rogoff and Lave (1984), which led to the current interest in cognition through a set of practices.
So, historically, situated cognition was born from the ideas of Vygotsky, Dewey, and Ernest and derived from the areas of cultural anthropology, sociology, and the cognitive sciences. The exploration in Artificial Intelligence gave rise to a new interest in situated cognition, and gained recognition in the field of Educational Psychology through the works of Brown, Collins, and Duguid (1989). They stated that from a situated perspective, learning is the intersection of activity, concept, and culture (the classroom). They wrote that learning occurs through collaborative social interaction and the social construction of knowledge. Lave and Wenger (1991), added experiences from their anthropological study of human behavior within ‘communities of practice.’ They viewed learning not as a transmission of knowledge from one individual to another but the building of knowledge through a social process suggesting that learning is situated in a specific context and embedded within a particular social and physical environment. The situated perspective focuses on interactive systems and the resulting "trajectories" of individual participation. It borrows research methods and conceptual frameworks from ethnography, discourse analysis, symbolic interactionism, and sociocultural psychology (Lave & Wenger, 1991).

The Nature of Mathematics from a Situated Cognition Perspective

Mathematical knowledge in the situated perspective is understood as being co-constructed in a community within a context. It is within the community that a student learns mathematics. For Lave (1988), the social aspect of learning is a-priori. Lave states, “cognition observed in everyday practice is distributed – stretched over, not divided among mind, activity and culturally organized setting” (p. 1). Studies discussed below, observing the nature of mathematical knowledge from a situated cognition and
community of practice perspective suggest epistemological and ontological views of mathematics are related to actively participating within a community of practice. In investigating developmental mathematics students’ experiences of mathematical practices, it is important to review studies for their impact on such practices. Also impacting epistemic views are an individual’s beliefs about a discipline, the nature of knowledge claims, and their position/identity within the classroom (Boaler & Greeno, 2000; Ernest, 1998; Sierpinska & Lerman, 1996).

For example, Solomon’s (2006) qualitative study based on Wenger’s (1998) communities of practice and situated cognition theory, examined 12 undergraduates’ epistemology of mathematics with proof. These students were enrolled as mathematics majors in a university in England. Students’ “epistemologies of mathematics which assumed certainty, irrelevance, rule-boundedness and lack of creativity” (p. 383) were found to be similar to those stated by Schoenfeld (1987) and his class of college students. Their beliefs about learning mathematics were as static as their view of mathematics itself. Even though students were engaged in mathematical practices, this belief prevented their movement from the periphery to the center of the community of practice in which they were engaged. Another issue raised was that of transitioning from a comfortable community (high school) to an uncomfortable community (university) in which they felt disconnected. Solomon, in interviews, found learners describing themselves as powerless, and lecturers as authority figures. Students had no view of themselves as mathematicians and were unconnected to the larger mathematical community their professors belonged to. The results of the study state that there was little evidence of co-construction of knowledge within the community. In fact, students
contributed little in discussions and in conjecture of mathematical practices. They believed the faculty member would impart his knowledge to them. This study does not discuss the epistemological outlook of the faculty member teaching the course. From a situated and community of practice perspective, all participants play a part in community and knowledge building. This suggests that the instructor needs to be aware of his/her own epistemic views and ethical responsibilities to the group as a whole. Ethical consideration would equate with empowerment and in a situated context empowerment needs to be in the hands of the community (Ernest, 2002).

For this group of students to express views of powerlessness implies a lack of confidence in their abilities to use and create mathematics, a fault that cannot be placed solely on students’ shoulders, given the situated perspective of this study. Solomon's study, like Muis’s (2008) research discussed below, shows the importance of gathering the epistemological view of mathematics of the students entering the community and working together to enhance and/or change that view. It is to be noted that Solomon’s study examines mathematics majors at the undergraduate level and not developmental college mathematics students as the current study examined.

Muis (2008) examined epistemic profiles (rational or empirical) and self-regulated learning of 268 students in college statistics and mathematics courses at two universities in the United States. This quantitative study used a self reporting survey to identify 24 students (mathematics majors) who then participated in two problem solving sessions with a follow up interview, all of which were coded and analyzed using statistical methods. Results of Muis’ study showed a relationship between the epistemic views of mathematics and problem solving approaches. Specifically, students profiled as
predominantly rational had the highest mean performance compared to individuals profiled as both rational and empirical and those profiled as predominantly empirical (Garofalo & Lester, 1985; Schoenfeld, 1987).

Interestingly Muis’ study, indirectly, revealed a process of teaching students, at the two different universities, to be very rational in nature, focusing on conceptual and procedural processes of mathematics (Hiebert & Carpenter, 1992). This study again observed mathematics majors who may, or may not already be involved in a community of mathematical practices although that was not the focus of Muis’s research. Suggestions were made to investigate relationships between epistemic profiles of developmental college students and mathematical practice approaches. This suggestion makes an interesting statement, one that the current study takes into consideration. While the focus of this study was not on investigating the epistemic nature of developmental college mathematics students, a valid research question arising from the literature review to add would be: What are the epistemic views of mathematics of developmental mathematics college students and can epistemic views be influenced as students progress within a LCMP?

The only study that was found to research epistemological beliefs with developmental college students as participants was one conducted by Wheeler and Montgomery (2009). They used a method called Q methodology in which qualitative comments were prioritized by 74 students enrolled in developmental mathematics courses at two campuses of a Midwestern community college. Although their study was not grounded in situated cognition, it is included in this review because of its reference to developmental mathematics college students. The research conducted expressed three
distinct types of learners found within a developmental mathematics college course; active, skeptic, and confident learners. The main outcome of this research showed that developmental college students who had had experiences in which they succeeded were more likely to be confident in their ability and beliefs about mathematics. This study also suggested that developmental college mathematics students were interested in ‘why’ something works than in memorizing formulae. A limitation of the study was researchers’ self-construction of the qualitative statements used. There was no discussion of reliability or validity of the study. However, the issue of the instructor/student relationship being of significance suggests to this researcher that the students viewed the instructor as a figure in authority.

The role of the classroom is another factor influencing cognition from a situated perspective, one to which instructors and teachers of mathematics should pay close attention. Studies such as Boaler (1999) and Schoenfeld (1985), describe the culture of the classroom as one that is easily overlooked but important to note. Indeed, Jo Boaler’s (1998) longitudinal study on students learning mathematics in two English schools revealed the significance of the culture of the classroom on knowledge. The two schools in her study had adopted different pedagogies to teach mathematics; one implemented a traditional textbook approach and the other a project based approach. Her initial analysis of data did not focus or place any value on the context. However, her re-evaluation of data collected, looking at social interactions and cognitive change, revealed that the students “development of mathematical content knowledge could not be separated from their engagement with the common practices of the school mathematics classroom” (p. 114).
Another example, of mathematics being taught in a situated context is
Schoenfeld’s (1987) research on teaching problem solving and students’ experiences to a
class of college mathematics students. Schoenfeld discovered that while students initially
viewed mathematics in an object orientated way, by the end of the semester students were
accustomed to the culture of the classroom, engaged in discussion, analytic in their
responses, involved in mathematical practices, and more open to seeing mathematics with
a more creative, constructivist view.

In summary, the examples provided above show that the views of mathematics for
some students and teachers remain in the formalist camp. Some of the studies discussed
above focus on the epistemological views of college students (Muis, 2008; Solomon,
2006) and some on grade school (K-12) students. Only one study examined
developmental college mathematics students (Wheeler & Montgomery, 2009). While the
studies discussed above examined epistemic views of the nature of mathematics, only one
had a situated perspective (Solomon, 2006). The views of mathematics in these studies
were still found to be formalist in nature, static, uncreative, and rule bound. As we move
forward in examining mathematical practices for developmental college students from a
situated perspective, it is important to remember as Schoenfeld (1992) points out, “what
one thinks mathematics is will shape the kinds of mathematics environments one creates,
and thus the kinds of mathematics one understands, and what mathematics one’s students
will develop” (p. 344).

So, mathematics from a situated perspective is described in varying ways. For
example, Winbourne and Watson (1998), whose local communities of mathematical
practice (LCMP) framework is grounded in situated cognition theory, mathematics is the
interactions of and intersections between student, instructor, and environment with an emphasis placed on the social interchanges taking place, and the practices that encompass learning. Mathematics is the interwoven complexity of social actions with respect to mathematical practices, developing mathematical competencies, shared understanding of tasks, and common use of language, tools, and habits, and active participation of all members of the community as well as the practices students bring with them into the classroom (Winbourne, 2010).

Morrison and Collin (1996) state that a student’s success in a subject is often a function of his/her awareness of the rules of engagement. That is, a student’s success is dependent on how well they are able to participate, without issues of reprisal, in the community of mathematical practice. The difference in the student who is a novice and one who is an expert is being able to share common values, assumptions, purposes, rules, and communication of the community. However, as discussed above (Wheeler & Montgomery, 2009) developmental college students often bring learned notions about the nature of mathematics and their role in interacting with the domain. Indeed, in the words of Greeno (1997) in his remarks to Anderson in support of situated cognition:

The situated perspective does not say that group learning will always be productive, regardless of how it is organized, or that individual practice cannot contribute to a person's becoming a more successful participant in social practices. It does call for more varied learning situations. For mathematics, this means more than collective watching and listening, doing exercises individually, and displaying individual knowledge on tests. Students need opportunities to
participate actively by formulating and evaluating problems, questions, conjectures, conclusions, arguments, and examples (pp. 5-17).

Finally, as the above suggests, my study needed to attempt to identify epistemic views of developmental college students, make clear the rules of engagement within the community of mathematical practice, and be aware of prior views that students bring with them to the classroom.

**Concepts of Communities of Practice**

Educational researchers and policymakers in the past decade have placed an increased emphasis on the processes of problem solving, reasoning, and communication within the classroom (NCTM, 1989, 2000). Reform efforts have centered on the teaching and learning of mathematical practices (Ball, 2003). The RAND group and the National Council for Teachers of Mathematics (NCTM) suggest that students need to not only understand and construct conceptual knowledge but also have ways in which to build mathematical practices. Current research grounded in situated cognition maintains that building practices is inherently social, requiring the participation of all members of the community. Mathematics teaching and learning involving the processes of problem solving, development of social interactions, increased communication within the classroom, and involvement in mathematical practices requires a classroom community of practice (CoP) that involves all participants.

As discussed earlier, CoP’s can form anywhere humans are engaged in a joint effort to gain knowledge of a particular subject through discussion, interaction, and practice. Communities of practice can be found in many domains. For example, CoP’s can exist in organizations, in government, in education, in the social sector, in
international development, and within technologies. This study is mainly concerned with CoP’s in education, specifically in mathematics education. In mathematics education research the term ‘communities of practice’ (CoP) is utilized and customized by researchers to derive notions such as:

1) Classroom practices (CP) (Boaler, 1998; Rogoff, Goodman, Turkanis, & Bartlett, 2001)

2) Communities of inquiry (CI) (Goos, 2004)

3) Local communities of mathematical practice (LCMP) (Winbourne & Watson, 1998)

4) Learning communities (LC) (Tinto, 1998)

Studies in the area of communities of practice have focused on identifying learning within a community of practice (Boaler, 1998), to pedagogy creating communities of inquiry (Hunter, 2008), to what defines a mathematical community of practice (Winbourne & Watson, 1998). The model of learning communities (LC), another notion of CoP, is not within the domain of mathematics education; however, it is an important concept that provides institutional structure to this study and must be included in this section as a CoP.

While much has been written in the area of communities of practice at the K-12 level, few studies deal with this topic at the university level and none that examine communities of practice for developmental mathematics college students. In the area of institutional learning communities, which traditionally give attention to the retention and progression of college students via the act of co-scheduling courses to promote socialization (Tinto, 1998), this review shows that few studies focus on mathematical
practices within these communities and fewer still to the mathematical practices of developmental mathematics college students.

**Classroom Practices (CP)**

Jo Boaler (1998) undertook a 3-year study researching students’ mathematical experiences and understanding in traditional and non-traditional settings in two schools in England. One school used the traditional ‘learning from a textbook’ technique, and the other used ‘project based’ techniques. Conducting qualitative ethnographic case studies of the two schools, Boaler looked at the relationships between students’ experiences in the classroom and their understandings of mathematics. As a researcher participator, through observations, and interviews, she found that in the textbook taught school students found mathematics boring, static, cue based, and believed mathematics to be a set of rules to be memorized that could only be applied in the classroom. In contrast at the project based school, results showed students found mathematics to be interesting because they had to explain the problem and discuss the ‘why’ and ‘how’ behind their results. Boaler (1998) found that students in the traditional approach school developed an “inert, procedural knowledge that was of limited use” (p. 59). Students in the project based approach school had been introduced to concepts through activities that resembled an apprenticeship, applying a situated activity. These students were able to use mathematical concepts as tools to be applied in different situations. She writes, “traditional textbook approach that emphasizes computation, rules, and procedures, at the expense of depth of understanding, is disadvantageous to students, primarily because it encourages learning that is inflexible, school-bound, and of limited use” (p. 60). This is exactly the approach that many developmental mathematics college students have been
accustomed to and, in my opinion, why many of them fail to do well on the COMPASS test and end up in developmental mathematics courses at the university level. An important idea from this study is the ability to transfer mathematical knowledge to unseen questions in unfamiliar circumstances-- for example, negotiating future credit level mathematics courses.

A limitation or weakness of Boaler’s (1998) study is that of a researcher bias to favor nontraditional settings. Students in both sets of classrooms were still involved in a community, but each community had defined different sets of rules. To say that students learned little in one school over the other is a premature judgment of the researcher.

Students gain mathematical knowledge in a myriad of ways. Also, as researchers, we should not forget that there are students whose preference for learning is to study unaided. However, a longitudinal ethnographic study such as this can obtain a holistic picture of students’ experiences and understanding (Lincoln & Guba, 1985).

Another example of situated learning in a CP is the study of Barbara Rogoff and her colleagues (2001) who with Jean Lave, worked with two teachers at a school in Salt Lake City. They investigated and co-wrote with the community about the work of the teachers and students who implemented ‘learning as a community’ approach to teaching. Adults and children were involved in meaningful activities that came from their environment. Rogoff (2001) suggests that one should prioritize “instruction that builds on children’s needs in a collaborative way” (p. 3). This community of learners in a situated context revealed that children can excel given opportunities and support.
Communities of Inquiry (CI)

Examining another concept of CoP is that of communities of inquiry (CI). Creating a culture of inquiry, providing scaffolding by the teacher are not uncommon topics of study in mathematics education (Schoenfeld, 1987). Studies within socio-cultural, constructivist, and situated cognition theories all support the notion of socialization, scaffolding, and practices (Forman, 2003; Lave and Wenger, 1991; Sfard, Forman, & Kieran, 2001). Studies investigating teachers as a community of inquiry highlighted the need to develop pedagogy for communities of practice (Goos, 2004; Hunter, 2008). Since communities involve all participants with students in an apprenticeship role, it is vital that instructors be aware of the necessary characteristics involved in creating such a community. Studies such as Goos (2004) and Hunter (2008) both focused on how teachers can implement a community of inquiry. While Goos (2004) does not use situated cognition as her theoretical foundation, this study is included in this literature review for her use of ‘community of inquiry’ which is a CoP. Goos (2004) uses Vygotsky and the Zone of Proximal Development (ZPD) as the framework for analyzing how a teacher, in Australia, develops a community of learners of high school students over a two-year period. She does mention the notion of communities of inquiries as reform classrooms. The teacher she participated with had had prior experience in inquiry oriented pedagogy. Data were collected via video and audio tape observations of teacher-to-student and students-to-student interactions. Interviews verifying the videotaped discussions were conducted with both teacher and students. Using a naturalistic inquiry approach (Lincoln & Guba, 1985), the data were analyzed and reviewed constantly. Results showed the teacher provided scaffolding by enacting his expectations regarding
sense-making, justification, ownership, and self-regulation. He gradually removed his support and provided only occasional comments. Students emulated his strategies and independently became peer tutors to weaker students in the class.

This longitudinal study clearly shows the affordances, constraints, and attunements suggested by David and Watson (2008), although Goos (2004) does not name the interactions as such. This study also evokes a sense of situated cognition theory with the students in an apprenticeship role. They clearly moved from the periphery of the community to the center as they engaged with the teacher and became experts in their own right.

Hunter’s (2008) study investigated if a group of teachers in New Zealand could use a participatory tool designed to enhance communities of inquiry in middle school classrooms. This study, using socio-cultural theory, involved four teachers and 120 middle grade children of Maori and Pasifika ethnic groups. This was an interesting study because implementing a community of practice means flexibility on the part of the teacher and to think of using a matrix to guide a social enterprise seems contradictory. However, the study does comment that the teachers collectively prepared each phase of the framework to be used. Results showed that with higher teacher participation there was a corresponding increase in student reasoning and more defined use of mathematical terms. Teachers adopted and adapted the framework to account for personal interests and needs. However, the study does indicate further research is needed to validate the tool being used. This is one of the weaknesses of this study, implementing a tool that has been designed in house without validation.
A research review, written by Siegrist (2009), focused on the merits of a community of mathematical inquiry at a high school. His investigation was on identifying the characteristics of a community of inquiry. His contention was that a community of inquiry may not necessarily form; a lot depends on the participants of the community itself and the strategies they use to problem solve. While his emphasis was on the understanding of mathematics through dialogue, the characteristics he noticed were not unlike those of Winbourne and Watson’s (1998) LCMP. He noted seven characteristics within a classroom that promoted mathematical understanding. First, dialogue is required; if students are not discussing, explaining, reflecting, then they do not understand. Collaborative learning is also a necessary component of learning (Johnson & Johnson, 1986; Vygotsky, 1978) to help enhance processes, become apprentices in the situated model. He stated a requirement for a community of inquiry to be self-regulating. Are students cognitively aware of mathematical meaning, and if so, was correction taking place when a process was in error? Another characteristic was students taking risks. Do they attempt mathematical processes they initially felt were difficult? His fifth characteristic is that “students consider, propose, and build on alternate approaches to problem solving” (p. 54). He stated that students should be able to inquire into the processes at hand. Finally, the community should support doing mathematics as mathematicians. He cites several researchers (Cobb, Wood, Yackel, & Perlwitz, 1992; Schoenfeld, 1987; Vygotsky, 1978) to support his ideas and based his conclusions on current literature. This is not an empirical study but a theoretical paper, from which is missing research based on Winbourne and Watson’s LCMP. Studies using LCMP are discussed next.
Local Communities of Mathematical Practice

There are very few empirical studies that used the notion of communities of mathematical practice. Frade and Tatsis (2009) and David and Watson (2008) are two studies that have used LCMP as a framework with which to investigate learning, participation, and mathematical practices. Frade and Tatsis (2009) researched students learning in terms of participation in collective mathematical discussions in a class of 7th graders in Brazil. Data on students’ examination of area measurement was collected via a questionnaire, video, and audio tape of two sequential activities. Winbourne and Watson’s LCMP was used as a framework to see if a community of practice had been formed. Transcriptions of and subsequent coding of the tapes were labeled with respect to the LCMP characteristics. The results showed that ‘‘signs’ of learning and ‘local’ changes of participation’ was evident. This study did not indicate if participation equated to understanding or if mathematical practices were apparent. The only comment made as to the significance of this study was of the teacher’s role being vital in scaffolding students’ thinking.

David and Watson’s (2008) inquiry of three teachers of mathematics in a K-12 school in England also used Winbourne and Watson’s LCMP. Their study analyzed the differences in classroom practices established as a result of pedagogy. They noted that after only viewing a few lessons conducted by the teachers, they could not definitively say that a LCMP was evident. They concluded that while the LCMP “helped us to analyze practices by laying them out to be compared, it was the concepts of affordances (opportunities for interaction), constraints (if – then situations), and attunements (individuals patterns of participating)” (p. 55) that helped differentiate the classes. David
and Watson did cite limitations as only observing a few lessons which gave them limited views. This study focused, as the above studies have, on K-12 children and provided an insight into the complexities of the classroom. David and Watson did not participate as Boaler (1998) did, but observed. This could have affected outcomes of student participations, but they too noted the importance of the teacher’s role in this community.

**Learning Communities**

School, and/or university culture must be included in community of practices studies because of its impact on the socialization of students in and out of the classroom (Solomon, 2006). Therefore, the literature review would be incomplete without looking at Learning Communities whose focus is on providing institutionally structured communities of learners.

According to Barbara Oertel’s (2001) research study, LC’s can be modeled in different ways, but the majority has the following five common characteristics.

1. The curriculum is integrated and interdisciplinary, cutting across departmental lines and divisions.
2. There is a high level of faculty collaboration and participation in all facets of the learning community program.
3. Learning is collaborative and active – students are actively engaged in the learning process.
4. There is on-going assessment and communication about student learning outcomes and program results.
5. The learning community program fits within its institution’s mission, structures, processes, culture and climate. (p. 108)
Tinto (1997) describes learning communities as paired courses, typically a study skills class and one from an academic domain. The same college students register for two or more courses, forming a study team. For example, as in this study a pairing of developmental mathematics and a freshman seminar course. He advocated using learning communities as a tool for the retention and academic success for incoming freshman students.

Learning Communities (LC) are an institutionally driven tool to enhance education they attempt to provide students with a “community of learners” (COL) (Tinto, 1997). In LC’s faculty members are encouraged to actively promote shared knowing by employing collaborative or cooperative pedagogies within and between the linked courses. These pedagogies require students to take an active role in the construction of knowledge and do so in ways which require them to learn together as connected learners. By enrolling in several classes together, students not only share a body of knowledge, they also share the experience of trying to know or learn the material of the shared courses.

Like learning communities, pre-freshman summer programs have also gained in popularity. Pre-freshman summer programs have existed since the mid 1970’s. For example, a well-known study is that of Dr. Triesman’s research on African American males enrolled at the University of California at Berkeley in a summer calculus program (Triesman, 1990). These programs provide proactive, inclusive, contextual approaches to meet the social and academic needs of students (Levin & Calcagno, 2008). They are designed to “enable students to get a head start on building academic skills, become acquainted with college resources and expectations” (Maggio, White, Molsatd, & Kher,
2005, p.32). Characteristics of these programs also vary, with emphases on institutional preferences. Lauridsen and Meyers (1982) surmised that differences in these programs can shape the success or failure of enrolled students.

While these programs have existed, few research studies exist on factors contributing to their effectiveness and fewer still with respect to a pre-freshman summer developmental mathematics course paired with a study skills class (Santa Rita & Bacote, 1997). With enrollment of developmental students at both community colleges and 4-year universities increasing, and a national debate raging about the cost of educating these students, it is vital that methods be employed to increase retention, persistence, and graduation of these students. Given the pervasiveness of developmental education in the United States, it is surprising that there is so much uncertainty about the most effective ways to work with students who have weak academic skills (Grubb, 2001).

This study on developmental students in a SLC used a paired course model, which connected individually taught courses. This type of LC typically enrolls between 20 and 30 students and links a basic course, writing or reading, with a core social science course. In paired courses, faculty attempt to make curricula connections between classes to enhance understanding of core concepts. For example, pairing calculus with general chemistry promotes scientific discovery and quantitative reasoning skills (Laufgraben & Shaprio, 2004). In a paired course, faculty might combine a class meeting, schedule an off campus field trip, or integrate a service learning component into the common curriculum. In this study, off campus field trips were used to enhance connections between faculty and students (Shapiro & Levine, 1999). This study paired a developmental mathematics course with a study skills course in order to promote study
skills necessary for success in academia. While studies in the LC area have focused on social interactions, collected data on the impact of LC’s on grades and retention, none have focused on the impact of LC’s on mathematical practices.

**Strengths and Weaknesses Identified by Previous Studies**

Strengths of CoP’s observed in the prior studies were: 1) They all had an engagement and interest in the common domain of interest (mathematics); 2) A community was developed; Supportive relationships were built within the community, students relied on each other as well as the teacher for support and, 3) All were involved in developing practices. It is clear from the studies above that the internal workings of a CoP in the form of discussion, explanation, and interactions clarify complexities of classroom interactions, content understanding and mathematical practices.

Weaknesses of the concept of communities of practice as a whole and especially in the Frade & Tatsis study include: 1) Very little discussion on the effectiveness of the students within the community. Were they involved in mathematical practices, and if so, did that translate to academic success as defined by passing a state exam for example? To say that a community of practice exists does not convey meaning for educators. It lacks purpose. 2) While David and Watson (2008) and Goos (2004), both mention that there were non-participating students in the classroom there was no indication of what efforts were made to include these students. Jo Boaler does state in her study that while some students were not willing participants, on a state exam given to all 16-year-olds in England, students in the project based classroom outperformed those in the traditional textbook using school. (Not that using a textbook is a bad thing; how one uses lessons from a textbook could be the key.) Any non-participating member of a community,
including the teacher, is going to disrupt the group as a whole. 3) If the teacher fails to participate, a CoP may not exist at all.

Another weakness cited in the literature related to the communities of practice concept is that no study cited above accounts for prior knowledge of students entering the classroom/community. Prior knowledge should be evaluated to help group the novices and experts and implement a smoother transition into a community of practice. Finally, only in the study examining the epistemology of college students (Solomon, 2006) was there mention of the impact that an institution provides in structuring the community in and out of the classroom. Solomon states that the students did not feel an external connection to the university or an internal connection within the course itself.

In summary, all of the above studies (Boaler, 1998; David & Watson, 2008; Frade & Tatsis, 2009; Goos, 2004; Hunter, 2008) used a community of practice as defined by Wenger (1998). Awareness of strengths and weaknesses as discussed above helped in investigating developmental mathematics college students’ problem solving experiences. First, the issue of epistemological beliefs of students and instructor needs to be noted. Second, forming and communicating rules of engagement as a community are vital for discussion. Third, allowing for a shift in thinking is necessary as students in this proposed study are transitioning from one community (high school) to another (college). Finally, focusing on both social and mathematical practices will allow the community to focus on mathematics in a different but successful way.
Impact of Learning Communities on Social and Mathematical Practices

This study utilizes local communities of mathematical practice (LCMP) to examine the experiences of developmental college students with mathematical practices enrolled in a 4-week Learning Community (LC), (Tinto, 1997; Winbourne & Watson, 1998). So, this following section of the literature review comments on both social and mathematical practices of local communities of practice as defined by Wenger (1998) and learning communities as defined by Tinto (1997). This section begins with research conducted at the institutional level and then graduates to the classroom level by commenting on research with communities of practice perspective.

Both types of communities are structured to impact learning through socialization, interactions, and practice. Institutional LC research have been shown to have an impact on the positive outcomes of social practices in classroom settings, but little is known about the impact of these types of LC’s on mathematical practices in classroom settings. While extensive research exists on the social impact of Learning Communities (LC) on retention, progression, and graduation, little exists on Learning Communities that include a developmental mathematics courses alone. As this section of the literature review shows, there are few studies that examine the effect of LC’s on mathematical practices in a developmental mathematics class. From a situated perspective (Wenger, 1998), few studies show the impact that a learning community has on social or mathematical practices. Indeed, studies that have investigated mathematical practices have mainly focused on K-12 children (David & Watson, 2008; Frade & Tatsis, 2009; Goos, 2004).
Impact of Institutional Learning Communities on Social Practices

Because developmental mathematics classes are mainly taught in community colleges, it is prudent to examine the existing Learning Community (LC) research at these institutions. In a longitudinal unpublished study by Engstrom and Tinto (2007), the effects of being in a learning community were investigated with respect to student persistence and student behavior (Retention and progression issues). This study used a random design to assess learning communities from 13 community colleges and 6 four-year universities. Data from the community colleges and universities were not separated out; results were collectively addressed. Findings on the impact of LC’s indicated that students had a more positive view of both their classmates and instructors (connection with peers and faculty), had stronger perceptions of the support and encouragement experienced on campus (connection with the institution), were more likely to spend time with other students not only socially but for academic purposes, and were more likely to feel that their coursework emphasized higher-order thinking skills. Indeed, the primary focus of this study was on program review and student persistence rates. The study indicated that students in LC’s persisted at a rate five percent higher than those not in LC’s. The social factor was not isolated but gathered from comments students made in open-ended questions in a survey. This study did not differentiate between LCs that included a developmental mathematics class and also did not focus on mathematical practices within the classroom.

Scrivener, et al., (2008) investigated a program evaluation of 40 learning communities at Kingsborough Community College, where 1,500 students were randomly assigned into learning communities (that contained a developmental English course not a
developmental mathematics class), or a control group (in which students registered in unlinked courses). The study found that students who were enrolled in learning communities were more satisfied with their overall college experience, experienced a stronger sense of belonging to the college community, and were more engaged in learning. Researchers report that students moved more quickly through English courses that were required for graduation. However, positive impacts on course completion and credits earned diminished after the semester in which students were enrolled in the learning communities, and no impacts were found on degree attainment. Results on persistence were mixed: No difference was observed in the percentages of students in the program and control groups who enrolled in the next semester or the semester thereafter. However, as in the Engstrom and Tinto (2007) unpublished study, students in learning communities at Kingsborough were 5 percentage points more likely to be enrolled three semesters later. This study did not examine practices within the classroom and used quantitative data collection methods to analyze the effect of LCs.

Maher (2005) found in his study of 13 graduate students involved in a three-semester learning community that a sense of shared peer academic responsibility emerged. This study involves graduate students who, in this researcher’s opinion, are more likely to continue to hold academic goals as a priority. Additional support for cohort membership comes from a long-term qualitative study conducted by Eteläpelto, Littleton, Lahti, and Wirtanen (2005) in which highly involved cohort members viewed other members of the group as motivators for maintaining good study habits and pursuing their academic goals. While this study does not involve developmental mathematics
students or concentrate on classroom practices, it does illuminate the fact that cognitive factors are enhanced through the participation of a learning community.

In an unpublished dissertation, a qualitative study conducted by Russo (1995), interviewing 70 students, revealed three issues that learning communities can target: 1) students struggles to attend college; 2) students learning to participate in the classroom; 3) students understanding the different paradigms that support knowledge construction. Russo’s study found that being in a learning community helped address students concerns from a social and academic level. This study concurs with the other studies in this section that there is an impact on empowering students through social practices in institutionally structured learning communities. As seen above, studies exist on impacts of social practices, but little is really investigated as to the social practices themselves. What social practices are being employed? What interactions are deemed important or of value? An even smaller number of studies investigate mathematical practices.

Critical thinking, learning strategies, and mathematical practices are important components of a mathematics class (Schoenfeld, 1985). However, there are limited studies that examine mathematical practices in an institutional learning community environment. Some studies (Stefanou & Salisbury-Glennon, 2002) offer evidence that learning communities improve critical and problem-solving skills, sometimes referred to as higher-order thinking. In their quantitative study of the relationship between first-year students’ participation in learning communities and their motivation and cognitive learning strategies, they found that there was a significant change in students’ cognitive strategies, including critical thinking and rehearsal, after participating in a learning community. It is to be noted that their study of six LCs of paired courses did not include a
developmental mathematics class, did not look at content or problem solving skills in a particular domain, but only collected pre and post test data using the Motivated Strategies for Learning Questionnaire (MSLQ), (Pintrich, Smith, Garcia, & McKeachie, 1991).

Indeed, Stefanou and Salisbury-Glennon (2002) supports this current study by indicating that a qualitative study examining student learning and practices is needed. These results however, do support the findings of Tinto’s (1997) study, whose participants, members of a Coordinated Studies Program, spoke of the relationships between their participation in this program and their increased ability to explore and practice concepts that they learned in class. This study again did not involve developmental mathematics courses. While the focus of much research in the LC environment is on retention, progression, and graduation and learning is an assumed byproduct, this dissertation study’s focus is on problem solving experiences that focus on learning in a community. Many studies on college students cited below do not directly investigate the impact of learning communities’ social and mathematical practices so, indirect suppositions will be made.

**Impact on Social and Mathematical Practices from a Situated Perspective**

Social and mathematical practices from a situated perspective are often intertwined. Mike Askew’s (2008) study of seven-year-olds, the emergence of social identities as learners of mathematics was examined. While his study did not involve college students it raises some leading issues in the investigation of mathematical experiences of developmental college students. He argues for the inclusion of relationships as being social and situated and affecting learning. Indeed, Askew (2008) states, “the ‘social’ in terms of relations tends to be a given; if good social relations exist, these are in the background of accounts of mathematical teaching and learning” (p. 77).
He suggests bringing this issue of relations to the foreground and examining the impact on student learning. While ‘relations’ is not an explicit factor this is the case with the following studies: Solomon, 2006; Wheeler & Montgomery, 2009. Both of these studies investigated college students’ epistemological beliefs and yet in interviews, students commented on the significance of the social relationship with the teacher. Whether that relationship had an effect on mathematical practices is a question still to be answered.

In a qualitative study by Solomon (2006), on 12 (mathematics majors), reviewed in a previous section of this literature review, Solomon (2006) found that issues arose of student perceptions of transitioning from one community (high school) in which they felt comfortable to another community (university) where they felt disconnected. While the study did not specifically address the impact of those perceptions on the mathematical practices within the classroom, it is clear that the relationship between students and faculty and institution shaped students’ epistemological beliefs in their abilities and in mathematics. Learning communities address these relationships by engaging in social activities outside of the content area. Solomon also found learners describing themselves as powerless, and lecturers as authority figures. While these students were not developmental college students, it is clear from this study that the relationship between students and faculty was understated and lack thereof led to an undermining of the community of mathematical practices that should have been in place in a proofs course.

In Wheeler and Montgomery’s (2009) research on developmental mathematics students’ beliefs using Q methodology, the social aspect of learning was highly prioritized. This relationship was found to influence students’ mathematical practices. Several students report, “That a teacher’s encouragement had kept them going” (p. 302).
From this study and others examined above, social relationships are significant but social practices as a factor of research are not clear or defined.

In summary, the social practices that students engage in are an indirect outcome of the studies cited above. The impact of social practices plays a significant role in students’ epistemological and ontological views of mathematics (Solomon, 2006). Studies in the LC area conclude that relationships between student and college are important, but the relationship between student and instructor--that is of significance.

**Characteristics of Communities of Practice**

This study integrated two concepts of ‘community of practice.’ The first concept is situated in the domain of mathematics education, and uses a notion known as local communities of mathematical practice (LCMP). The second is the institutionally driven learning community’s concept (LC). This study used local communities of mathematical practice to explore developmental mathematics students’ experiences mathematical practices within a 4-week summer learning community; therefore, it is important to understand the similarities, differences, strengths and weakness of each concept in order to understand the impact on developmental college students’ experiences of mathematical practices.

Table 2 shows how learning communities (LC) and communities of practice (CoP) are almost identical, with the exception that CoP are domain driven and LC’s are structured to cross domains. For example, in a LC, a science course may be paired with a mathematics course, giving students the opportunity to apply mathematical applications in their science course. This enhances mathematical practices but does not mean a local community of mathematical practice is formed within the mathematics course itself.
Also, the community is created in CoP’s within the classroom and in LC’s within the institution. Learning Communities, because they are a facet of the institution, need to collect data on the effectiveness of these initiatives. Most data collected refer to retention and progression figures, and little is qualitative in design. Still in the studies discussed in the prior section of this literature review, data collected showed higher rates of retention for students enrolled in LC’s than students not enrolled in a LC. This illustrates an external connection between students and the institution, but says little about the domain practices that students are engaged in internally or within the classroom or if the external connection impacts students within the course.

Table 2

*Characteristics of Communities of Practice and Learning Communities*

<table>
<thead>
<tr>
<th>Communities of Practice Characteristics (Wenger, 1998)</th>
<th>Learning Communities Characteristics (Tinto, 1997; Oertel, 2001)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Domain</td>
<td>The curriculum is integrated and interdisciplinary, cutting across departmental lines and divisions.</td>
</tr>
<tr>
<td>All members are committed to domain</td>
<td>There is a high level of faculty collaboration and participation in all facets of the learning community program.</td>
</tr>
<tr>
<td>The Community</td>
<td>The learning community program fits within its institution’s mission, structures, processes, culture and climate.</td>
</tr>
<tr>
<td>Actively engaged through joint activities, building relationships.</td>
<td>Learning is collaborative and active – students are actively engaged in the learning process.</td>
</tr>
<tr>
<td>The Practice</td>
<td></td>
</tr>
<tr>
<td>Develop shared practices, experiences, use of language and tools.</td>
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</tbody>
</table>
Strengths and Weaknesses of the Integrated Learning Community Model

Learning Communities have several strengths 1) They are an institutionally driven tool designed to enhance education. 2) They attempt to provide students with a “community of learners” (COL). 3) In LC’s faculty members are encouraged to actively promote shared knowledge by employing collaborative or cooperative pedagogies within and between the linked courses. 4) These pedagogies require students to take an active role in the construction of knowledge and do so in ways which require them to learn together as connected learners. 5) By enrolling in several classes together, this cohort of students not only shares a body of knowledge, they also share the experience of trying to know or learn the material of the shared courses.

Their weaknesses lie in the fact that 1) Getting approval for LC’s or CoP’s from institutions, parents and students alike (Boaler, 1998) is sometimes difficult. 2) Students can choose not to participate. 3) Administrative issues arise in scheduling paired courses. 4) Challenges are presented when contacting faculty who will work together creating a joint curriculum or finding faculty willing to share topics during the semester, or finding faculty who are knowledgeable about LC’s. Despite these weaknesses, research in the field of Learning Communities has reason to promote the effectiveness of these institutional initiatives (Tinto, 1998). Table 3 summarizes the strengths and weaknesses for the two concepts employed in this study.
Table 3

*Strengths and Weaknesses of Learning Communities and Local Communities of Practice.*

<table>
<thead>
<tr>
<th></th>
<th>Institutional Learning Communities</th>
<th>Local Communities of Mathematical Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strengths</strong></td>
<td>Faculty supported</td>
<td>Teacher supported</td>
</tr>
<tr>
<td>Socialization/Discussion</td>
<td>Type of apprenticeship/Scaffolding</td>
<td></td>
</tr>
<tr>
<td>Co-construction of knowledge</td>
<td>Socialization/Discussion/Justification</td>
<td></td>
</tr>
<tr>
<td>Building peer relationships</td>
<td>Co-construction of knowledge</td>
<td>Building peer relationships</td>
</tr>
<tr>
<td><strong>Weaknesses</strong></td>
<td>Faculty may not share institutional vision</td>
<td>Teacher may not be well versed in techniques required for a CoP</td>
</tr>
<tr>
<td></td>
<td>Not all may participate</td>
<td>Not all may participate</td>
</tr>
</tbody>
</table>

In summary, in the area of learning communities of both kinds (institutional and classroom), it is clear that more rigorous studies of learning communities are badly needed, particularly of impacts on the outcomes that affect not only community colleges, but also four-year universities that offer developmental courses. The progress from developmental to college-level coursework and overall persistence for at-risk groups is a necessary component of academic success for these students. However, there is a shortage of trustworthy studies on the effectiveness of learning communities from a social and mathematical practices view. The lack of such studies may be attributed to the lack of focus on studies investigating cognitive components of learning that are clearly missing from these studies.

While learning communities are an orchestrated attempt at providing students with an environment conducive to learning and mastering material, a “community of
practice” describes the learning that occurs in shared practices within a specific context (Lave & Wenger, 1991). Indeed, the common thread that arises within both strands of Tinto’s and Lave’s research is that of constructing shared knowledge and shared knowing. It is important to note that this shared experience is engaged and facilitated in and by the faculty member. Indeed, the faculty member is an important component of the learning experience as suggested by both Tinto (1998) and Lave and Wenger (1991).

It is the collaborative learning, student and faculty relationships that build a sense of belonging that drives the increase in student’s efforts to succeed. It is the effort and engagement in learning processes that drives student’s knowledge acquisition and the development of relevant academic skills (Tinto, 1997). According to Wenger (1998), these environments provide an intersection of social practice, community, and identity within which learning takes place. Wenger contends that engagement in social practice is the fundamental process by which we learn and so become who we are. For students in developmental mathematics classes, it may be the social process provided by learning communities that is so vital to these students’ success.
CHAPTER 3
METHODOLOGY

In this chapter, I address the methodology used to conduct my study. I begin with the purpose and research question(s) of my study. Then I explain qualitative case study research methodology and the study design that I used to conduct my study. I describe participant selections, and the research setting. I discuss the research protocol/procedures, data collection, and data management. Additionally, I address the data analysis and data interpretation process. This chapter also covers my role as researcher, which includes confidentiality and ethics concerns. Finally, I address issues regarding validity and reliability. I conclude this chapter with a summary of my methodological approach. I examine my findings and interpretations of data in chapter five.

**Purpose and Research Question**

The purpose of my study was to investigate traditionally aged (as defined earlier) developmental mathematics college students’ experiences of mathematical practices in a 4-week summer learning community. Combining the theories mentioned above and using Winbourne and Watson’s (1998) Local Communities of Mathematical Practice (LCMP) as a methodological framework, I explored these students’ ways of approaching, thinking, discussing, and working with mathematics all of which defines mathematical practices.

The main research question which drove this qualitative case study was:

*How does participating in a 4-week summer learning community shape developmental mathematics college students’ experiences of mathematical practices?*
Qualitative Research and the Study Design

The intent of this study was to delve into students’ experiences of mathematical practices. Due to the interpretive nature of this investigation qualitative case study design was chosen. Denzin and Lincoln (2000) state “qualitative researchers study things in their natural settings, attempting to make sense of or interpret phenomenon in terms of the meanings people bring to them” (p. 3). As is fitting for a study that pursues understanding and interpretation of local communities and mathematical practices within the classroom, I selected explanatory case study as the methodology of choice (Yin, 2009).

Case studies are used for examining a characteristic or behavior within a social context in an attempt to understand a real-life phenomenon. They are used to examine contemporary events over which the researcher has little or no control, collecting multiple sources of evidence. Yin (2009) describes specific types of case studies as being exploratory, explanatory and descriptive. This study is explanatory and attempts to answer ‘how’ and ‘why’ questions about the learning community and mathematical experiences of the participants. Additionally, the goal of case study research is not to generalize but to gather any knowledge from, as in this investigation, a single case.

Cases can be defined in different ways. For example, for this study I implemented a single case (embedded) design (Yin, 2009). A single case would be defined as the entire class of 27 students. Since collecting data on the entire class would have been impractical, having an embedded design gave me the option of using a single group of four students within the class as my unit of analysis. (I describe the population, the sample, and selection of this unit later in this chapter.) This unit provided the focus for data collection within the context of the summer learning community (SLC) (figure 2).
In this investigation, the case study methodology allowed me to examine if participating in a 4-week learning community shaped the mathematical practices of developmental mathematics college students. Focusing on mathematical practices within a classroom and allowing instances of learning and themes to emerge is not unusual when investigating LCMP’s (David & Watson, 2010).

Figure 2. Basic Design for Case Study
Propositions

Using propositions to help direct attention to the data being collected and analyzed is entirely appropriate in qualitative research (Yin, 2009). As stated earlier the propositions of this case study were suggested by the LCMP model and defined in chapter one (Winbourne and Watson, 1998). Since this case study was explanatory and answers ‘how’ questions it was important, while collecting data, to remain focused on the criteria suggested by the LCMP (see chapter one).

The Research Setting

This study took place at a four-year, mid-sized, liberal arts, public state university in a state, located northwest of a large metropolitan city. This university has seen a steady growth in student applications and has been recognized by U.S. News & World Report for the past two years as an “Up-and-Coming Masters University,” ranking among the top ten (8th) in the 2010 issue of “America’s Best Colleges.” The university’s First-Year Experience program has been named an “Academic Program to Look For” by U.S. News for ten consecutive years and was named one of 12 founding institutions in a project called “Foundations of Excellence in the First Year of College” of which learning communities played a major role. In the Fall of 2010, university enrollment was at 23,452 students of which 41% were males and 59% females with more than 3,000 students living on campus. Full-time undergraduates numbered 14,806 or 74% of the student body. There were 5,054 total freshman with 2,893 categorized as new first-time freshmen, with approximately 400 students being categorized as needing some type of remediation especially in mathematics. The students enrolled in SLC met Monday
through Thursday in a technology equipped classroom that I describe in detail in chapter four.

Participants

Population

The population (see Table 4) for this study comprised all incoming traditional freshman who applied for admission to the 4-year public university in the Southeast, who required a developmental mathematics college course in Fall of 2011. Students in the population were identified as “developmental” mathematics students (those students needing remediation) in the following two ways: 1) students who made between a 400 and 460 on the mathematics portion of the SAT, or 17 to 19 on the mathematics portion of the ACT and then 2) students who scored below a 37 on the COMPASS test (ACT, 2000). These indicators, set by the University, identified individuals requiring remediation in Algebra I and Algebra II topics. These students (295) were mailed a brochure describing the summer learning community inviting them to consider applying.
### Table 4

**Population Demographics (2011)**

<table>
<thead>
<tr>
<th>Gender Breakdown</th>
<th>Classification of Students</th>
<th>Ethnicity Breakdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males 41%</td>
<td>First-Time Freshman 2,749</td>
<td>American Indian or</td>
</tr>
<tr>
<td></td>
<td>Requiring developmental course 859</td>
<td>Alaskan Native 87 or &lt;1%</td>
</tr>
<tr>
<td>Females 59%</td>
<td>Requiring developmental mathematics - 480</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Freshman - 4,749</td>
<td>Asian or Pacific Islander</td>
</tr>
<tr>
<td></td>
<td>Sophomores 4,778</td>
<td>Black, Non-Hispanic Origin</td>
</tr>
<tr>
<td></td>
<td>Juniors 4,614</td>
<td>3,101 or 14%</td>
</tr>
<tr>
<td></td>
<td>Seniors 5,971</td>
<td>Hispanic 1,223 or 5%</td>
</tr>
<tr>
<td></td>
<td>Graduates 2,085</td>
<td>Multi-Racial 472 or 2%</td>
</tr>
<tr>
<td></td>
<td>Other 192</td>
<td>Pacific Islander/Hawaiian</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35 or &lt;1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Undeclared 1,049 or 5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>White, 15,587 or 70%</td>
</tr>
</tbody>
</table>

### Sample

The study sample comprised of students in the population group identified as requiring a developmental class by virtue of a 37 or lower COMPASS score, as described earlier, and who responded to the invitation to participate in the specially designed 19 week program\(^1\) that began with a 4-week summer session termed the “Summer Learning Community” (SLC). There were 75 applications received from the population, and 26 students that voluntarily accepted the invitation to participate. These 26 students attended the mandatory informational session and were enrolled in the institutionally created

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\(^1\) The 19 week program began with the 4-week summer learning community which introduced students to topics from introductory algebra or Algebra I. The next 15 weeks were spent exploring topics from intermediate algebra or Algebra II.
learning community that consisted of the developmental mathematics class and the freshman seminar class.

In addition to the 26 students who were enrolled, two tutors were hired to provide an in-class support system and (by request) out-of-class support. These tutors were students who had enrolled in SLC in prior semesters and had been very successful. Both tutors were beginning their junior year; one tutor was a science major and the other a business major. The SLC coordinator and I interviewed both tutors in the spring semester, prior to the summer program. The tutors had also participated in the informational SLC sessions.

Based on the sample selection of 26 students, five groups of four students and two groups of three students were selected based on results of a diagnostic/pre-test (see Appendix F) given on the first day. All test scores on the first diagnostic/pre-test for the class were below a 73%. So, each of the six groups was comprised of four students; one who had scored a very high score (69-73), one a high score (65-68), one a medium (60-64), and one a low score (below 60). The two groups of three students were similarly assigned. This ensured that the groups would have at least one person who could be considered the “expert” to give the group a “leader” to initiate discussion on problem solving exercises (Brown, Collins, & Duguid, 1988; Lave & Wenger, 1991). I purposefully chose one group of four students to represent the “critical unit of analysis” of a local community of learners for which data were collected (Yin, 2009). The criteria I used to select the group: 1) They created a cohesive group quickly. 2) They established rapport with me. 3) They were on task. I knew I had four weeks within which to collect data and would need participants willing to be interviewed later. In choosing one group, I
could focus data collection on that unit and examine their interactions in detail. I describe this group fully in chapter four.

In keeping with the methodological framework of LCMP, these students remained in their ‘local’ communities for the entire semester, working together on various problems and tasks and employing various strategies to develop identities as mathematical learners. While the program itself continued for an additional 15 weeks after the initial summer bridge portion, this study focused on collecting data during the initial four weeks beginning in July. In qualitative research, it is entirely appropriate to set time boundaries to collect data to help maintain focus and provide direction (Yin, 2009).

**Case Study Protocol / Procedure**

**Timeline**

The students on enrolling in the SLC had signed a contract with the coordinator to attend class from Monday through Thursday, from 9:30am to 11:30am for the period July 12, 2011 to August 4, 2011. They were required to participate in ice-breakers, work during lab time, and ask their tutors for help when needed. During the four weeks of the summer program, they were engaged in the following timeline described in Table 5.
Table 5

*Timeline for study*

<table>
<thead>
<tr>
<th>First Day</th>
<th>Second Day and through July 12 – August 4, 2011</th>
<th>Fall Semester 2011 And Spring 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice-breakers held before class</td>
<td>Seven groups created based on pre-test results</td>
<td>Interviews with students from researcher selected group</td>
</tr>
<tr>
<td>Students asked permission to use student work / data by CAGANO faculty member</td>
<td>Short lecture given Group tasks assigned</td>
<td>Video and audio tape analysis</td>
</tr>
<tr>
<td>Consent forms collected</td>
<td>Parallel calculation chains, Solver and recorder, Clue problems, (Askew, 2008)</td>
<td></td>
</tr>
<tr>
<td>Pre-test given</td>
<td>Observations, classroom video and individual group audios recorded</td>
<td></td>
</tr>
<tr>
<td>Strategies / Group work discussed</td>
<td>Prompts given on class web-site for students to reflect on lesson</td>
<td>Observations taken during class and field notes and reflections were written after class</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Researcher began analysis of data collected as a normal part of class</td>
</tr>
</tbody>
</table>
Procedure

On the first day at 8:30am, the entire class of students participated in ice-breakers with their peers, their tutors, and faculty. In these ice-breakers they learned interesting facts about each other as well as each other’s names. Then, as a class, they strolled into the mathematics classroom at 9:15 a.m. Some students were busy talking; some were a little reserved. While I waited in my office, the students in the sample were informed by a faculty member that they had an opportunity to engage in research, be observed, have work collected, be video-taped and that their non-participation would in no way affect their grade or the manner in which they were treated. They were reminded that all work assigned in class was mandatory, whether they participated in the research or not. They were informed that only students agreeing to be a part of the research would have their work analyzed. They were asked to sign the approved Institutional Review Board (IRB) consent form that signified their permission to participate (see Appendix C). They were assigned a pseudonym to ensure anonymity. All the groups were given audio tapes to tape their interactions so as not to distinguish the ‘critical case’. They were also given a short lecture on mathematical strategies, what they are, how to use them, and were provided with the rules of community engagement.

A class of developmental algebra students at any four-year university enters with varying mathematical abilities, depending on what and when their last mathematics class was taken in high school, the geographical area they come from, and the high school they graduated from. In order to familiarize themselves with each other, they participated in ice-breakers held before class with peer leaders and two assigned tutors. Also, due to the short time of 4-weeks of the study, I gave a pre-test on the first day to facilitate group
formation. These pre-tests allowed me to assess the concepts they were weak in or had little knowledge of. This also helped me in building a lesson plan for each week. Every day I began class with a short overview of concepts. Then the class broke up into their groups and began work. As they worked in class, I observed their mathematical practices by using the LCMP model of categories to check off on a pre-printed template. This worked well in the pilot study in 2008; however, I resorted to watching the videotapes after class to verify my observations since I was pulled in many different directions during class time.

Since much of the work done in this 4-week summer learning community was collaborative (Johnson & Johnson, 1993) and focused towards identity and knowledge building (Lave & Wenger, 1993), the students stayed in these groups for the entire four weeks. However, as stated earlier, only one group of four students was selected as the ‘critical case’ from the learning community. Care was taken not to distinguish this group from any other in the classroom.

As the researcher participant, instructor and classroom observer, I made reflective notes immediately following a class period to make certain to keep track of my own experiences. I also used my reflections as an important supplement for interviews since in these notes I recorded sights, sounds, smells, and expressions. Field notes also helped to keep track of the development of the study (Bogdan & Biklen, 2007). At the end of each day, I also examined the observations and videos and listened to the audio tapes. In this case study observing, interviewing, and interpreting on a daily basis allowed for changes to be made to study strategies and lesson plans, always keeping in mind the goal of substantiating the research question (Hays, 2004; Miles & Huberman, 1994). I
transcribed video and audio recordings during the fall of 2011, and then contacted students to be interviewed during the spring 2012 semester to provide further insights and to provide member checking (Merriam, 2009).

Data

Data Collection

Yin (2009) states that a case study researcher should use three principals of data collection: 1) Use multiple sources, 2) Create a case study database, and 3) Maintain a chain of evidence – which describes the data that is to be collected to support the research question. I used multiple sources of data: 1) videotape, and audiotape of classroom interactions; 2) my own classroom observations (scaffolded on Winbourne and Watson’s [1998] LCMP model); 3) two individual interviews with each participant; 4) Student artifacts; 5) Researcher’s and students’ reflections; and 6) Diagnostic pre-test. These multiple sources of data came from the entire four weeks with a special focus on three specific days; one day during the first week, one day during the third week, and one day during the last week of the SLC program. I chose these days with respect to the mathematical concepts and practices that were being explored on those days; 1) order of operations, 2) linear equations, and 3) systems of equations.

As stated above, I also conducted two open-ended individual student interviews, which ranged from 30 minutes to 1 hour, with the four participants in the chosen group in the spring of 2012. The first open-ended interview allowed me to focus on the participants’ perspectives of their overall summer experiences as well as their thoughts about each of the specific days. I had the videotape on hand to remind them of their experiences. The second interview was used for member checking in the triangulation
process of qualitative data (Merriam, 1998; Yin, 2009). Student work that had been collected was used to help participants recall events during their interview sessions. Yin (1994) states that, “interviews should be considered verbal reports only, as such, they are subject to the common problems of bias, poor recall, and poor or inaccurate articulation” (p.85). So, using videos, field notes, and work collected helped the participants recall their experiences in SLC. I listed the data I collected in Table 6 linked to the propositions in LCMP, as Yin states is appropriate in qualitative research.

Table 6

*Data Collection Linked To LCMP Model*

<table>
<thead>
<tr>
<th>LCMP Category</th>
<th>Data/Evidence Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Being Mathematical</td>
<td>Observation</td>
</tr>
<tr>
<td>- Using Strategies</td>
<td>Student work/Reflections</td>
</tr>
<tr>
<td>- Reading the problem</td>
<td>Interview</td>
</tr>
<tr>
<td>- Using deductive reasoning</td>
<td></td>
</tr>
<tr>
<td>- Drawing a picture/</td>
<td></td>
</tr>
<tr>
<td>- Writing down known information</td>
<td></td>
</tr>
<tr>
<td>- Using an Algorithm</td>
<td></td>
</tr>
<tr>
<td>- Using Formulas</td>
<td></td>
</tr>
<tr>
<td>2) Public Recognition</td>
<td>Observation</td>
</tr>
<tr>
<td>- Positive reinforcement</td>
<td>Videotape</td>
</tr>
<tr>
<td>- Kind gestures</td>
<td>Interview/Reflections</td>
</tr>
<tr>
<td>3) Purposeful collaboration</td>
<td>Observation</td>
</tr>
<tr>
<td>- Coming to a consensus</td>
<td>Videotape</td>
</tr>
<tr>
<td>- Having direction/rules</td>
<td>Interview/Reflections</td>
</tr>
<tr>
<td>4) Shared ways of behaving and tool usage</td>
<td>Observation</td>
</tr>
<tr>
<td>- Calculator uses</td>
<td>Videotape</td>
</tr>
<tr>
<td>5) Students and teacher participation</td>
<td>Videotape</td>
</tr>
<tr>
<td>- Questioning</td>
<td></td>
</tr>
<tr>
<td>6) Students and teacher immersed in activity</td>
<td>Videotape</td>
</tr>
</tbody>
</table>
Data Management

All collected data related to my study was kept in various forms. Digital collections of transcribed classroom video, and audiotapes were kept as Word 2007/2010 files. Student interviews were recorded on a digital recorder and were also transcribed, as were student reflections. Digital files were kept on a password protected computer in my office at work. Paper copies consisting of IRB consent forms, observations made using the LCMP propositions, and completed student work were kept in manila folders in my locked cabinet in my office. All folders were kept using pseudonyms to ensure anonymity (Bogdan & Biklan, 2007).

All data pertaining to my chosen group was sorted and put aside as I went through the data on a daily basis. Yin (2009) states that qualitative researchers who manage data and write field notes/reflections as they proceed through the study can retain greater detail about the study; this certainly was the case for me.

Data Analysis / Analytic Procedures

In qualitative research, analysis of evidence collected involves working with, organizing, coding, and developing themes and patterns. The goal is to identify, describe, and explain themes from the participants’ perspectives, and to find meaning (Creswell, 2003). This investigation is a qualitative explanatory case study and presumes to explain how or why something occurred or happened. In such research cases, Yin (2009) recommends several techniques as suitable for data analysis. I provide in this chapter an overview of the techniques and how I applied them to this study. These are summarized in Table 7. I provide the details of my findings in chapter five.
Table 7

**Techniques Used for Data Analysis**

<table>
<thead>
<tr>
<th>Technique</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pattern Matching</td>
<td>Iterative Nature: Observations, student work, interviews, and other data collected were matched with the categories of the LCMP framework. Pattern matching meant the sources of data supported the same fact/occurrence and the categories of the LCMP. Pattern matching indicates an increase in construct validity.</td>
</tr>
<tr>
<td>Explanation Building</td>
<td>Iterative Nature: An explanation of what is occurring in terms of identity outcome and the effect of the LCMP on student work will be built.</td>
</tr>
<tr>
<td></td>
<td>1) Make initial theoretical statement. Is a LCMP in place?</td>
</tr>
<tr>
<td></td>
<td>Do the LCMP categories lead to a deeper analysis of data offering other categories and themes?</td>
</tr>
<tr>
<td></td>
<td>2) Compare findings against statement</td>
</tr>
<tr>
<td></td>
<td>3) Revise statement</td>
</tr>
<tr>
<td></td>
<td>4) Compare findings again</td>
</tr>
<tr>
<td>Time-Series Analysis</td>
<td>The students were observed daily and identities and characteristics were examined over the four weeks. Explanations based on identity change and LCMP were made.</td>
</tr>
<tr>
<td>Cross-Case Synthesis</td>
<td>Each participant was interviewed to provide a within group analysis and increase reliability</td>
</tr>
</tbody>
</table>

As suggested in studies in the situated cognition and communities of practice domain (Boaler, 1999; David & Watson, 2008; Solomon, 2006), my analysis of data was conducted by first transcribing video and audio recordings, coding both classroom observations and video transcriptions by using the characteristics/categories described by the LCMP (Winbourne & Watson, 1998). Then, transcribed students interviews were coded. I then tried to identify any patterns and themes that developed in relation to the research question. Specifically, I had a two-step process, which I describe below. First, as
stated above, Winbourne and Watson’s (1998) LCMP model was used to scaffold all observations, which allowed me to sort data. I used a Word document with the LCMP characteristics/categories into which I began to sort my data using Yin’s pattern matching technique. There were LCMP sub questions/categories that overlapped. For example, sub question/category 3 asks “Do learners appear to be working purposefully together towards a shared understanding of problem-solving tasks?” While sub question/category 4 asks, “What are the shared values and ways of behaving in relation to mathematics: language, habits, tool use?” I found that in the participants’ interviews I could not separate ‘working together’ and ‘shared ways of behaving’ which I further discuss in chapter five.

So, I tried hard to focus on participants’ perspectives rather than force a particular comment or moment into a specific category. I also discussed collecting and analyzing data with the other faculty member who was listed on the IRB. For example, I discussed which LCMP categories I should put my comments regarding participant work, and I discussed unexpected themes. I did this because in the study on epistemic views of developmental mathematics students by Wheeler and Montgomery (2009) the impact of the instructor on knowledge views was unexpected. I discuss emergent themes and make interpretations in chapter five.

Second, on the advice of my committee Chair, I re-examined my data to see if any themes emerged. I was, as stated in the table above, building explanations so I went back to my literature review chapter and began to make connections from my emergent themes to existing research. Using the time series analysis technique, I examined if over time there were changes in perspectives or identities in the participants.
Since daily observations were conducted, initial coding began to reveal themes that I paid attention to in future data collection sessions (Miles & Huberman, 1994). For example, audiotape comments such as, “I don’t know how to do this” or “I’m not sure what this is asking”, was coded as a lack of self-confidence and I addressed it during class by encouraging students to persist and try. During the personal interviews I asked students for their prior mathematics histories and this theme of lacking confidence in their ability arose again and I speak of it in the findings chapter under the theme of identity. The emerging themes and categories were written up using a rich, thick description as is typical in qualitative research and were shared with the participants during their second interview to help guarantee reliability and rigor of findings and to represent students voices accurately in the findings chapter (Merriam, 1998).

Hays (2004) states that in qualitative research it is important for the researcher to maintain focus on substantiating the research question and this is what I tried to do. While there was a lot of data collected, I remained focused on answering the research question: How does participating in a 4-week summer learning community shape developmental mathematics college students’ mathematical experiences? Merriam (1998) states that analyzing data should be done simultaneously with collecting data. This, she says, enables the researcher to interpret findings and be flexible enough to switch strategies if necessary. In this case study, I found that observing, interviewing, and interpreting on a daily basis allowed for this change (Miles & Huberman, 1994).
Interpreting Findings

I present my findings and interpretations in chapter five concurring with Bogdan and Biklen (2007) who stated that, “Analysis involves working with the data, organizing them, breaking them into manageable units, coding them, synthesizing them, and searching for patterns. Interpretation involves explaining and framing your ideas in relation to theory, other scholarship, and action, as well as showing why your findings are important” (p. 159). I also concur with Merriam (1998) in saying that while it is easily defined, it was not so easy to break analysis and interpretation into two separate tasks when engaged in qualitative research. Indeed, for me as the participant researcher, I found that I wove these two tasks together and only by reflecting was I able to acknowledge my biases. For a qualitative researcher, providing explanations requires an eye on one’s own biases, reflective queries and a concern for participant perspectives. So, interpretation for this study meant I stay focused on the research question and the participants’ perspectives. Using daily observations, reflective notes, and interview data that were collected, coded, and interpreted, it was important for me to stay focused on themes that supported the question, narrowed the study, and linked to theoretical issues (Bogdan & Biklen, 2007).

Researcher Role

I have been teaching developmental mathematics college students for 17 years, beginning initially at a community college and then at my present location at a 4-year university in the Southeast. Teaching developmental mathematics college students has given me an interest in employing different pedagogy and observing informally techniques having impact on mathematical skills. As a teacher of developmental
mathematics college students, over the years I have developed my own theories of why these students failed the COMPASS test and why I now see them in my classes. It is here that I now speak to those biases and theories that encompass my own preconceived notions of developmental mathematics students.

As a teacher of developmental students, I have a preconceived notion that the majority of these students have no concept or self-confidence of themselves as mathematicians. Many of them have been affected by a ‘bad’ mathematical experience in the past, meaning that they were told they were not good at mathematics and have always thought they were not good, think they have test anxiety, think their mathematics teacher was to blame for their failure, or did not think they needed mathematics since it was not their major. I have found that these students need encouragement, need to know that there are other students in the same position, and are able to share their experiences. However, as a researcher, I was mindful of my opinions and aware of my informal assumptions and theories, so I went into this study with a flexible outlook, without notions of answers, with a firm grasp of the issues being studied, and with a view to answering questions that arose (Bogdan & Biklen, 2007; Yin, 2009).

My personal beliefs about learning follow a situated paradigm. My belief is that learning takes place within a certain context that of the classroom or in this case a summer learning community. I think that an instructor who believes that learning is enhanced through social interactions will attempt to create a learning community where both students and instructor are engaged. Through my experiences with these students, it is my belief that focusing on mathematical practices using the LCMP framework helps
illuminate important factors from students’ perspectives in completing any mathematical task.

My primary goal was to interpret the data as it was being collected (Yin, 2009). While collecting data I had to be mindful of my dual roles of both researcher and participant. As the teacher/researcher, I have a responsibility to both the participants and the study. I also asked questions during the data collection to see that it upheld the propositions of the study. As advocated by case study research I had to be aware of the need to make changes to the research protocol as data were collected, but it was equally important for me to keep the original purpose of the study in mind and not get distracted by my observations and my participation that might lead the study in a different direction.

Confidentiality and Ethics

As Creswell (2003) states, “Researchers also need to anticipate the possibility of harmful information being disclosed during the data collection process….the ethical code for researchers is to protect the privacy of the participants and to convey this protection to all individuals involved in the study” (p. 65). As the researcher, I took steps to obtain IRB permission to study this class of students at both the university where the study took place and where I teach, and at the institution where I am a graduate student. Obtaining IRB approval means that I am aware of the ethical implications of studying a group of students. This included not coercing students into participating in the study and not marginalizing them if they did not participate. I informed students as to the nature and the duration of the study, and the methods used to collect data via a consent form (see Appendix C). The participants understood the anonymity of their involvement in the study. They knew that pseudonyms would be used to protect their identities.
Strategies for Establishing Validity, Reliability, and Credibility

In qualitative research, it is important to discuss how valid, reliable, and credible the study will be (Lincoln & Gruba, 1985). The data collected from classroom observations, video tapes, student interviews, and students’ work, all helped to address the main research question and helped triangulate the data (see Table 8). Triangulation of data supplied verification of facts through different data sources and strengthened the construct validity of the study. Student interviews provided a review of my observations and also provided a deeper understanding of events videotaped in the classroom known as member checking (Merriam, 2009). When I interviewed participants individually, they reviewed their work and reflections, and made their own comments about occurrences in the classroom on viewing the videotape. In this way, member checking was restricted to each student reviewing his/her own work, his/her own reflections, and addressing questions to observations I had made in the classroom. This increased the reliability of the study (Yin, 2009).

Strategies for achieving trustworthiness/credibility involved the following: 1) Daily observations of the participants; 2) Triangulation, which was discussed above; 3) Member checking also discussed above; 3) Employing a rich thick description to reflect the complexities that arise in the study; 4) Self-reflective student postings and teacher journal. Table 8 that follows provides a summary of data collected and how it was used to support construct validity and reliability.
<table>
<thead>
<tr>
<th>Data/Evidence Collected</th>
<th>Used For</th>
</tr>
</thead>
</table>
| 1) Student Work         | Records ways of being mathematical:  
                        | a) Show all work and justify all steps taken in completing any task assigned in class.  
                        | b) Work helps to document the accounts of progress in the classroom.  
                        | c) Conveys understanding.  
                        | d) Documents progress of identity as mathematical learner.  
| 2) Audiotapes in classroom | Records interactions of group to:  
                        | a) Indicate purposeful collaboration  
                        | b) Indicate public recognition  
                        | c) Indicate shared ways of behaving  
                        | d) Indicates progress of members over time  
                        | e) Helps identify identity change over time  
| 3) Classroom Observations | Records researcher observations of students:  
                        | a) Being mathematical – specifically strategy use  
                        | b) Public recognition – given by students to each other as well as instructor to students  
                        | c) Purposeful collaboration  
                        | d) Shared ways of behaving and tool usage  
| 4) Videotape            | Records classroom in action  
                        | a) Students and teacher participation  
                        | b) Students and teacher immersed in activity  
                        | c) Verification of classroom observations  
| 5) Student interviews    | Member checking to increase reliability  
                        | a) Verification of student work collected  
                        | b) Verification of audiotapes  
                        | c) Verification of classroom observation  
| 6) Student reflections   | Member checking to increase reliability  
                        | (Answering daily prompts)  
                        | (Formative Assessment)  
                        | a) Provides verification of student work  
                        | b) Provides insight to cognition  
                        | c) Provides student interview prompts  

Summary

In summary, this chapter focused on using case study methodology to explore developmental college students’ mathematical experiences in a local community of mathematical practice. Using case study enabled me to provide an in-depth understanding of a phenomenon or behavior (Yin, 1993) and was appropriate for investigations on social interactions and mathematical practices. It was bounded by 1) the research question, *How does participating in a 4-week summer learning community shape developmental mathematics college students’ mathematical experiences?* 2) the group of four students being observed, as well as 3) the time of the study, 4-weeks.

This qualitative case study used field notes, observations, students’ work, researcher observations, video, audio, and interviews to reveal developmental college students experiences. All data collected were transcribed into Word documents, which were housed on a password protected computer. Analysis of the data involved coding using the scaffold provided by the categories of the LCMP suggested by Winbourne and Watson (1998), and highlighting common themes and patterns from students’ interviews, as well as experiences of mathematical practices from students’ perspectives. I am aware that interpretations are my sole responsibility with verification of data collected checked by the participants. As the researcher, I note here that I have a goal to add to knowledge and not to pass judgment in my interpretations of data that are described in the chapter 5. Before I discuss the findings, I now include a chapter four that provides a rich description of the daily events of the day for the participants enrolled in SLC. This is appropriate in qualitative research and provides the reader the context in which I conducted this study.
CHAPTER 4

THIS STUDY’S STORY

The purpose of this study was to explore how participating in a 4-week summer learning community shaped developmental mathematics college students’ experiences of mathematical practices using Local Communities of Mathematical Practice, and employing a qualitative case study methodology (Yin, 2010). This chapter presents the ‘story’ of the study in order to provide a rich description as is appropriate in qualitative studies, and to give the reader an overview of the daily occurrences within the classroom. I will begin with 1) a description of the classroom setting and the daily occurrence within the class, 2) my role as participant/researcher, 3) the students within the class, and 4) a description of the four participants. I discuss findings in chapter five.

Classroom Setting

The mathematics classroom, in which the entire SLC and the four participants spent most of their time, was a rectangular ‘presentation technology classroom’ meaning that it was equipped with an instructor’s computer, DVD system, and document viewer. All of these instruments were connected to an overhead projection system allowing for instructors or students to make whole class presentations. The classroom also contained 24 computers placed around the perimeter of the room. The classroom was also equipped with a large whiteboard spanning the length of one entire wall, and one projection screen. This allowed me to employ any visual techniques that might be required to enhance academic content. For example, I demonstrated graphing concepts such as linear equations or introduced systems of equations or described solutions and other graphing concepts using the calculator, the computer, and written examples on the white board at
the same time. While the classroom was equipped with technology, the classroom walls were bare; there were no pictures on these white walls.

The classroom seating arrangement had long tables that were normally placed side by side in four rows all facing the whiteboard. Each table sat two people on one side. These tables, for SLC, were separated and reorganized to face each other to create a square table that could accommodate four people, two on each side facing one another in a group setting creating community. “Community/Group” work was an essential part of how I wanted to conduct class for these developmental students.

Also, for the duration of the study (4-weeks), two digital cameras were set up at either side of the room in order to capture a visual representation of the classroom and the groups at work. Each group received a numbered digital voice recorder so as to record group interactions. These recording provided data used in chapter five. The recording from both video and audio were saved each day after the class had met on a password protected computer in my locked office.

As stated earlier, my class was part of the summer learning community (SLC), which included the developmental mathematics class and a seminar class focused on study skills and transitioning to college life. Considered a learning community, these students would begin each day with daily ice-breakers, so consequently they would enter the classroom talking and laughing about something else they had learned about their fellow classmates and their peer tutors. I did not need to take attendance because these students were required to attend each day of the program and had signed a contract stating they would do so. As they entered the classroom, they would sit in their assigned
groups at the same table each day. However, during the 4-weeks, my students would engage in discussions with students at other tables.

First, daily interactions with my students began with me stating goals for the day. These goals were derived from the pre-test I had given them on the first day of every week of the 4-week program. The pre-tests allowed me to analyze which concepts needed review and which needed to be enhanced through additional problem solving. My main goal with this group of students was to help remind them that they too could “do math.”

In class reflections, many students had indicated how inadequate they felt in their high school mathematics classes, unable to ask questions because of feeling “dumb,” of “trying to be ignored” because they did not know the answer, of being “very quiet in math class” because they did not want the class to laugh at them. Second, I needed to go over concepts they had learned in prior grades, and according to pretest results did not remember, and introduce them to concepts they did not know without doing too much lecturing. Third, I wanted to allow the community (the class, the tutors and myself included) to provide support and guidance to each other. As a developmental mathematics teacher for over 17 years, I was personally aware of previous students’ lack of self-confidence and self-awareness, and I hoped that group/community work would supply the support this class would need to implement their mathematical practices.

In chapter three I discussed how the class was sorted into groups. From conversations with my class and later from interviews with my purposefully chosen group, I knew that group work was something these students were unaccustomed to. Most of them would say “they preferred to work alone,” or “they never did group work in high school.” They were unaware of the connection between the discussion of and
learning of mathematics in the mathematics classroom (Schoenfeld, 2008). So, on the first day, I discussed group work techniques such as think-pair-share, parallel calculation chains, solver and recorder, and clue problems (Askew, 2008). I wrote and posted these techniques on the wall.

Creating a comfortable environment is an important goal for some teachers (Palmer, 2009). It is a goal I strive for because it allows me to create a working relationship with my students. I wanted them to feel as if they could ask me any question; even if they thought it was a “dumb” question So, I would begin class on most days interacting with my students discussing any topic they raised, before beginning to review mathematical topics, based on their pre-test scores, with which I knew my students were familiar. This way my students could feel a connection to a concept they knew before progressing onto new concepts. For example, on graphing linear equations, the class had discussed the coordinate plane, what an ordered pair was, what it meant, and the correct mathematical notation of an ordered pair before moving forward with either more discussion or a lecture on linear equations.

As is important in a community of practice, the instructor is not always the person who answers the questions asked by students. Group members would lean over and whisper an answer or a student from another group would pipe up. What was important to me was to entice from them what they knew so they could build a connection to another concept. Employing active teaching and learning methods, such as leading and guiding by questioning, helps students retain material (McKeachie, 2006). I knew from pre-test results these students knew some concepts but were missing pieces of concepts which lead to failure where mathematics was concerned. Daily concepts, questions, exercises,
and processes were also posed for the students to discuss in groups. As the groups discussed their questions, I would walk around making notes, examining work, guiding, and questioning; being part of the group when a group needed me. Also, lectures were often driven by class discussions. Since we had just investigated systems of linear equations (see Appendix E), I asked the groups to graph six equations, asking them to write down what they noticed, what information could be gleaned from their graphs. The entire lecture on systems of equations was done by students in their groups, with me facilitating as needed in this manner.

Each group then shared with the class their discoveries. Some notes on material were the same, and some were expressed in a different way. For example, some groups expressed their findings visually by drawing a graph and others used words. Some students in a few groups remembered that intersection points indicate solutions to systems, and parallel lines have no solution. These groups put words to what their graphs were showing them. At the end of the lecture, I would ask a student in one of the groups to summarize the class’s discoveries. I felt we always ran out of time. I discuss these findings and others further in chapter five.

While all the groups in the classroom were in the study and three out of the seven groups included young men, I purposefully chose a group of four young women as the unit of analysis, the participants. They represented 60% of the class that was women, and represented the majority of students on the university campus where this study was conducted. As stated in chapter three, this group also interacted well with each other, with me, and with the class as a whole. I felt they would be willing to divulge their
perspectives with me without reservation on the interviews I needed to conduct because of our relationships. I will describe the participants next.

Participants

_Tasha._ Tasha is an African American female who wanted to be a theology major until she found out that the university did not offer it, and resorted to being undeclared when she applied to the university. She has since then decided to declare her major as Spanish/Applied business. A tall, calm individual, she attended a performing arts high school where she began as a vocal major, starting her own gospel choir there, but ended her high school career as a drama major. She did well in her mathematics classes, never making “below a 90” and “enjoyed” her mathematics teacher, who she had for three consecutive years. Tasha comes from a conservative family; her parents are pastors and she wants to go into that field herself. She is currently a youth pastor at her church and says she enjoys helping other people. She chose the Spanish major specifically so she could be a more effective minister by reaching out to those outside of her race. So she is more than excited about what she is pursuing now in college.

When applying to college, Tasha had heard that the COMPASS test she had to take was “hard” and was not surprised when she failed to make the score that would allow her to continue on to college algebra, the freshman general education mathematics course. With that failure, the idea of mathematics in college became a lot scarier to her. A very composed, mature young lady, Tasha thought the idea of SLC sounded very interesting but was used to working alone. She initiated contact with the university by completing the card that came with the original flyer about the program. From there she
obtained admission into the program and says she loved the opportunity to participate in SLC.

Sharon. Sharon is an East Indian female whose family came from Ghana. Like most Indians, Sharon is about five feet tall with long dark brown hair, but unlike most Indians, she has a hyper personality. She had lived in America her whole life and was “really mad” (because she had received high C’s in mathematics in high school), that she failed the COMPASS test and had to take learning support classes. She attended a regular high school which she states, “was a really good high school, but math was just like Chinese to me.” She “sometimes got it, sometimes I didn’t.” Sharon reported in her reflections that she often “slept in class.” She had a bad attitude towards mathematics which she developed in middle school. Sharon wanted to major in English education but often was at odds with her Indian parents who felt she should be a business major who could “earn a lot of money.” Sharon, a very social talkative individual, did not want to spend four weeks of her summer in a classroom thinking it was a ruse on part of the university to make more money. However, her parents chose SLC for her first college experience, which she ended up enjoying. She was definitely irritable at first because she felt that it was not fair that her parents were forcing her to “waste” her senior summer after high school and before freshman year of college to drive an hour every day to “some stupid math program.” But as the days went on, Sharon found that she fell in love with Cagano State and its faculty. For the first time ever, math wasn’t like Chinese. It was like English, which so happened to be the subject that Sharon was majoring in to eventually teach one day. She was so engaged in the LSP math class that her confidence hit the roof once she began to understand that if she actually put her mind to it and didn’t use the
excuse of “I’m bad at math anyways because I’m more of a words person,” that she could actually make a grade she would be proud to take home to her parents. She ended up passing the majority of the tests with flying colors. She never thought that she would be able to say that about a math class. She definitely didn’t think that she would be able to be the one tutoring her peers in math class either. And Sharon eventually realized that the one hour commute to and from Cagano every day was worth it. She made two great friends through her SLC math class that she remained friends with into the school year because of it.

Anna. Anna is a Caucasian female with long hair who is one of the least talkative in her group. An elementary education major, she attended a local high school and felt she was never good at mathematics. She had been placed in Algebra III in what she refers to as “informal and remedial math.” She states that “they did the basics and got out”; “we didn’t do anything special.” She did not enjoy her mathematics classes in high school and was not surprised when she did not pass the COMPASS test. She also admitted that “she would prefer to work alone.” Amongst the members of the group, Anna had the second strongest skill set when it came to mathematics, even though she did not think so. She volunteered very little information unless she was asked but did communicate with her group. That is, Tasha and Anna would consult each other often. When Anna heard about SLC, she was not enthusiastic, but she knew her algebra skills were weak based on her COMPASS score so decided to give the SLC a try.

Andrea. Andrea is an African American female who is from another state, with an interest in nursing. She knew she had to get good grades in all her classes in order to be accepted to the nursing program. She also knew she needed to review her mathematics,
an area in which she felt she was weak. She had applied to the university and had to take
the COMPASS test. When she did not get a passing grade for the COMPASS test, she
knew that joining SLC would be a good way to review her mathematics, get to know
other students, the campus, and get settled in before the Fall semester began. Andrea is
another very quiet student who hated her mathematics classes in high school and
confessed that, “The only thing keeping me afloat in those classes were my extra credit
assignments.” She also admitted to “goofing off” in high school when she did not
understand the material and talking with her friends.

These four individuals had never associated with one another until they were
enrolled in the SLC program. During ice-breakers at the beginning of the day, they
became familiar with one another. It was in the developmental mathematics class that
they found themselves in a group working together. None of the four had worked in
groups in a high school mathematics class, so the concept was strange to them. In fact, on
student reflections when asked about their feeling on group work, one quoted, “Before
SLC, I HATED group work. I absolutely DESPISED it and had the nastiest attitude about
it.” When asked about this statement later she confessed that group work seemed
unproductive to her in high school because there was only one person doing the work and
everyone else copied the answers. Also, interesting was the fact that they would not have
chosen to be in a group with each other; however, one participant in the group observed
that, “It was cool. People are completely people I would never talk to, I did.” was a
comment that reflected how cool it was to get to know people different than themselves.
Indeed, “in SLC, my peers were all just as bad as me at math.” This comment reflected
the camaraderie that was created in the SLC when the students discovered they had all
received a score of 37 or less on the COMPASS score, thus placing them in the LSP course. This knowledge, facilitated with assigning groups in this developmental mathematics class of students provided a comfortable safe learning environment.

Over time, this group grew to depend on each other, share information with each other, and appreciate each other for what each bought to the table. They knew they each needed to understand the material for tests but were able to lean on one another inside and outside of the classroom. In the next chapter I will report on the findings and discuss the group’s growth as individuals and as a community and address the research question.
CHAPTER 5
FINDINGS AND DISCUSSION

The purpose of this qualitative case study was to address the research question:

*How does participating in a 4-week summer learning community shape developmental mathematics college students’ experiences of mathematical practices?*

This chapter examines the situated experiences of the “critical” unit of analysis: a single group of four students and the findings/themes that arose. Utilizing Yin (2009) and Creswell’s (2003) advice on analyzing case study research, and employing Winbourne and Watson’s (1998) Local Communities of Mathematical Practice (LCMP) as the methodological framework for my data, I provide in Chapter five: 1) a summary of the process of data sorting, organization and analysis; 2) the findings of that analysis with respect to the categories/sub questions provided by the LCMP propositions; 3) a discussion of the emerging themes that represent the collective perspectives of the participants and finally; 4) a summary of the perspectives and growth of the individuals in the group as they were shaped by the 4-week learning community. I remind the reader here that the situated perspective does not state that group interactions and learning will always be productive for the participant. It did provide, however, in this study, varied learning situations for the participants. It offered them the opportunity to participate actively in class by discussing, evaluating, questioning, and presenting conclusions (Winbourne, 2010).
Summary of Data Analysis

The developmental mathematics college students enrolled in the summer learning community (SLC) were reviewing concepts from introductory algebra. While these students had experienced the concepts in high school, the pretest indicated errors in execution of problems. The problem solving tasks that the SLC was engaged in, and from which I collected data, came from the concept areas of 1) order of operations, 2) linear equations, and 3) systems of equations (see Appendix E).

The findings discussed in this chapter came from data used from three specific days of classroom video tapes (taken from the first, second and last week of the program) and was comprised of classroom (video, audio and researcher) observations, individual student interviews, and student and instructor reflections. I paid much attention to participants’ interviews and conversations with each other and me in class. The data were transcribed and coded using the categories of the LCMP. In order to sort data I created a table in Word containing the LCMP categories. As I went through each transcription, I sorted relevant data into each category. As stated earlier in chapter three, categories in the LCMP were filled with information from all relevant data sources although not all collected data contributed to each category. Data that gave rise to these themes which developed from the LCMP categories are listed in Table 6 in chapter three.

As explained in chapter three, the analysis came from examining the Word table to identify underlying meaning and themes from within the categories that would address the research question above. I then condensed them into the following major themes that shaped the students’ experiences of mathematical practices. Based on communities of practice literature and the methodological framework LCMP, my investigation gave rise
to the following emergent themes that shaped the participants mathematical practices; 1) Identity (through practice), 2) Social structure, 3) Purpose, 4) Shared repertoire, 5) Joint enterprise, 6) Mutual engagement. Table 9 below displays the relationship between the LCMP categories with the emergent themes generated by this study and the related mathematical practices.
Table 9

*LCMP Categories with Emergent Themes and Related Mathematical Practices*

<table>
<thead>
<tr>
<th>LCMP Framework</th>
<th>Emergent Themes</th>
<th>Mathematical Practices</th>
</tr>
</thead>
</table>
| 1. How do students seem to be acting in relation to attempting problem-solving tasks? (Being mathematical) | Identity | Using strategies  
Reading the problem  
Using deductive reasoning  
Drawing a picture/  
Writing known info  
Using an algorithm or formula |
| 2. What developing mathematical competence is publicly recognized and how? (Public recognition) | Participation | Positive reinforcement  
Getting feedback from group  
Knowing an incorrect process and how to correct |
| 3. a) Do learners appear to be working purposefully together towards a shared understanding of problem-solving tasks? (Purposeful collaboration) | Collaboration With Purpose | Coming to a consensus  
Having direction and rules |
| 4. b) What are the shared values and ways of behaving in relation to mathematics: language, habits, tool use? | Shared Repertoire | Coming to a consensus  
Tool/Calculator use  
Using correct terminology |
| 5. Does active participation of students and teacher in mathematics constitute the lesson on problem-solving tasks? | Mutual Engagement | Questioning  
Creating  
Discussing |
| 6. Do students and teacher appear to be engaged in the same mathematical activity? | Joint Enterprise | Questioning  
Creating  
Discussing |
Findings Addressing Categories of the LCMP Framework

The local community of mathematical practice framework (Winbourne & Watson, 1998) identifies the features of a community of practice in a mathematics classroom if the community has the six following characteristics:

C1. Pupils see themselves as functioning mathematically and, for these pupils, it makes sense for them to see their ‘being mathematical’ as an essential part of who they are within the lesson;
C2. Through the activities and roles assumed there is public [from the participants] recognition of developing competence within the lesson;
C3. Learners see themselves as working purposefully together towards the achievement of a common understanding;
C4. There are shared ways of behaving, language, habits, and tool-use;
C5. The lesson is essentially constituted by the active participation of the students;
C6. Learners and teachers could, for a while, see themselves as engaged in the same activity. (p. 103)

Using the LCMP as a methodological framework helped in identifying how developmental mathematics college students’ mathematical practices were shaped by the summer learning community. Below, I discuss the data gathered under each category and addressing each sub-question posed by the category.

Findings Addressing Category One

Category one of the LCMP addresses the following question. *How do students seem to be acting in relation to attempting problem-solving tasks?*

This category reflects concepts from communities of practice (Wenger, 1998) of finding identity through practice. Winbourne (2010) also discusses learning mathematics as a function of the student’s sense of her or himself as a learner. This feature of identity as a learner is also discussed by Schoenfeld (1992) who reflected that how a student perceives themselves with respect to mathematics defines the kind of mathematics that
students will develop. For the participants, their sense of self as a learner with respect to mathematics was pessimistic. This pessimism was due to their prior experiences with mathematics. One classroom conversation on the audio tape revealed that Anna and Andrea had shared similar prior experiences. For example,

Anna spoke of being in a “remedial math class, where we didn’t do anything,”

Andrea stated, “Math classes in high (school) really made me dislike mathematics even more than I had in previous grades. If we were in class and started not to understand a topic or the teacher started going too fast, we would just start talking to each other and goofing off, which didn’t help very much either.”

Tasha and Sharon, however, both expressed positive experiences with mathematics in high school but lacked self confidence in their mathematical abilities. In their interviews with me, on the audio tapes with each other, and in the classroom Tasha and Sharon spoke of “how bad I am at math,” and “I was always bad at math, so I knew I was going to fail the COMPASS test,” or “I was always in a low level math class all through high school,” and “I’m bad at math anyways because I’m more of a words person.” This sense of identity with respect to mathematics was illuminated as the LSP students worked with each other and as they tackled the assignments. It permeated their attempts in using strategies, reading the problem, using deductive reasoning, drawing a picture, writing known info, and/or using an algorithm or formula. For example, from the videos, I observed that when tackling tasks, there was a reluctance to begin, knowing which strategy to use or algorithm to proceed with, or to even put pen to paper. Interestingly enough when discussing the order of operations with the class many of them were able to recite PEMDAS (the acronym used to remember which operations to use first). However, when working with the order of operations assignment and to begin
discussion I asked them to write down what they remembered. Audio recordings revealed
comments such as:

Andrea: Do you know what we’re supposed to do?
Tasha: Let me think.
Sharon: I can remember bits and pieces of it, but just the overall concept I can’t remember.
Anna: I get confused when something’s on the outside of a parenthesis.

Student work reflected those comments. For example, when asked to evaluate a) (X)^2 and
b) (-X)^2 and c) -(X)^2 when X = - 2 Anna expressed her answers as - 4 for all choices,
Andrea wrote 4 as her choice, only Tasha were able to execute the problem correctly.
When asked to explain why the answer was - 4, Anna looked confused. In her interview
with me she again suggested that, “When there’s something outside of the parenthesis
and stuff and that like multiply, I don’t know, just the outside the parenthesis, I pretty
much knew the concept, but just bits and pieces I didn’t know.” Anna was not the only
participant who did not understand the difference in notations of the examples given.
Sharon and Andrea were seen leaning over Tasha’s paper examining the differences in
their answers, before raising their hands and asking if what the group had was correct.

In terms of identity it was clear that Anna, Sharon, and Andrea had established an
identity of being ‘bad’ at mathematics, whereas Tasha clearly had a more positive sense
of identity with respect to mathematics. Her decision to, “Let me think,” and then share
her work reflected her interview comments when she stated that, “We covered it a long
time in high school, so I remember pretty much all of it.”

Each assignment revealed different strengths in the participants. As the
participants began work on linear equations, Sharon became the leader because she
recalled working on the graphing calculator, while Anna had never used a graphing
calculator. Classroom observations showed Sharon, Tasha and Andrea helping Anna understand linear equations through graphing on the calculator.

Identity in this study shaped the mathematical practices of the participants in the study. In the order of operations lesson Anna, Sharon, and Andrea were considered as being on the periphery of the community (Wenger, 1998). They asked Tasha for help, and needed confirmation of their answers from me or the tutors (the experts). However, each participant became a “master” within the LCMP with respect to the topics being assigned. As they gained experience within the community through the lessons of linear equations and systems of equations, all the participants moved towards mastery.

**Findings Addressing Category Two**

Category two addressed the following sub question, *what developing mathematical competence is publicly recognized and how?* Recognizing mathematical competencies for the participants were difficult. Recognition involved positive reinforcement, getting feedback from group, knowing an incorrect process and how to correct an incorrect answer. Individual conversations with participants had indicated that they had not felt it was their responsibility to recognize their knowledge but their teachers’. The participants would often ask me, “Is this the right answer?” and would be perturbed when I asked, “What do you think? Can you explain why it is the right answer to me?” Yet, during the 4-week summer learning community, they began to discuss and recognize their group’s efforts towards understanding. For example, Sharon reported, ..this one time we were doing a graph of something and I can’t think, that’s how I started talking to Andrea because I don’t know, something in the graph looked like something she had seen back home, wherever she’s home, and then she started talking about it.
Within the local community that comprised of the four participants there evolved a social structure that was used to publically recognize a developing mathematical competency. This allowed the participants to interact on an apprentice/master scale as is common in a community of practice (Lave and Wenger, 1998). Tasha was often referred to as the ‘master’ as Sharon reflected, “I don’t know why Tasha was in the SLC because she knew how to do most things.” So, in recognizing a developing mathematical competency, the group would lean towards Tasha for confirmation of correct solutions and terminology. For example, when working with order of operations examples, I asked the group if they had questions. Anna stated, “No, we were really just trying to make sure that our solution was correct.” And Sharon commented, “Tasha usually gets the right answer first and Anna and I tend to make careless errors. She definitely helps point them out to us so we can correct them for next time. If Andrea doesn’t understand something, I usually help her do it, which reinforces the concept in my head as well.”

Graphing also presented its ups and downs for the participants. For example, while Andrea wrote down, “Rise over run, y = mx + b,” without understanding what was meant by rise over run, her connection to slope was unclear. When asked to define a solution to a linear equation, she responded, “We used both a calculator and drew a table to help us along in the process,” indicating a connection to prior knowledge, use of the calculator but not a clear indication of the concept of solution. Exploring solution for the group meant finding what X was equal to. Anna commented, “I remember I never did like a lot of linear in high school stuff and never graphed on a calculator before your class.” The group, however, collaborated in helping Anna with the calculator, analyzing the linear equations I gave them and came to an understanding that was recognized
mathematically by the group, the tutors and myself. Tasha also voiced, “At times, yeah. I think when you went over it more; we started using the words you were using. But probably in the beginning not so much.”

**Findings Addressing Category Three and Category Four**

I placed these two categories together because it was difficult to separate data specifically into each category. Category three of the LCMP asks, *do learners appear to be working purposefully together towards a shared understanding of problem-solving tasks?* Category four asks *what are the shared values and ways of behaving in relation to mathematics: language, habits, tool use?* Category three reflects the idea that the community has a purpose; it comes to a consensus and has direction and rules, whereas category four proposes the community as having a shared repertoire, coming to a consensus, applying tool/calculator use and using correct terminology. Data showed that the participants would be working purposefully together on assignments while coming to a consensus through discussion and shared repertoire.

The data collected for this category came mainly from observations and student responses from reflections and interviews. From video observations, it was clear that the group began to rely on each other. The participants spoke of working and coming to an understanding of the respective tasks they were assigned. For example, when working on the systems of equations assignments in their group, they had come to a consensus about how this was to occur.

Tasha: Let’s work this out first and see what we get
Sharon: Ok. I think I can do this on my calculator.
Anna: I never used a calculator in my high school.
Andrea: (silent)
Eventually, they shared their solutions on evaluating if a given ordered pair is a solution to a given linear equation and describing why it is a solution.

Sharon: Is this right? I don’t know if I’m right? I don’t why it’s a solution. Anyone help?
Tasha: That’s what I got. I don’t know why either. We can ask her.
Anna: How did you do that in the calculator?
(Andrea and the others helping Anna)

In personal interviews they each spoke of the collective purpose of understanding.

Tasha: The one that may have helped me the most was Sharon because we just talked through math, and Anna because I was like she’s getting good grades, I’m getting good grades, so somebody needs to have better grades. And that was Anna.

Sharon: Everyone had different problems in math. Like Tasha, for instance, understood math really, really well. I don’t even know why she was there because she was so smart. But then things that she didn’t get, I maybe would get or things that I wouldn’t get, she would get, and we were two completely different people, two completely different skills in a certain subject. We got along so well trying to put the puzzle together. It was pretty cool.

Anna: If we all got together, if one person got it wrong we would all kind of figure out why and that way we wouldn’t make the same mistake as well.

Andrea: We helped each other slow down and work through each problem carefully. They can be tricky even though the process is fairly easy. As we each gained a better understanding of the lesson, we were able to get better and better at helping each other. Even if we were grasping at different paces.

Of using correct terminology, this was almost non-existent until we all discussed correct terminology in class. Tasha reflected, “At times, yeah. I think when you went over it more; we started using the words you were using. But probably in the beginning not so much.”

The community’s purpose was in executing assignments correctly, while they were able to come to a consensus about what was a solution to a linear equation, they
could not explain why it was so. However, on asking for direction or hearing concepts explained in class, participant understanding of the concepts was improved.

**Findings Addressing Category Five**

Category five examined the underlying sub question of, *Does active participation of students and teacher in mathematics constitute the lesson on problem-solving tasks?*

This category examines the joint enterprise of knowledge creation. In reviewing prior literature on learning in mathematics classrooms (Schoenfeld, 1992; Boaler & Greeno, 2000), it is the idea of combined cooperation that motivates students to be successful. The participants, the SLC, and I shared thoughts and ideas that created the lesson for the day.

When discussing order of operation for example,

Professor: But, somebody tell me what’s a good way to stop from messing up all of those negatives?
Student 1: Put them in parenthesis
Professor: Put them in parenthesis. Okay student 1, tell me, put what in parenthesis?
Student 1: Uh, -5.
Professor: Okay. Alright.
Student 1: And -6.
Professor: Okay, so are you saying this, like that? Can you help me?
Student 2: Yea and then put the square on the outside
(Student coming up to the board to show me and the class)
Professor: Okay put the square on the outside. What about this negative?
Student 2: Leave it
Professor: Leave it, okay, alright. And this one?
Student 3: Put the negative 6 in parenthesis and leave the square out.

Discussing, questioning, and community are all important attributes of a mathematics classroom and even more so in a developmental mathematics college class (Winbourne & Watson, 1998). Indeed, it is often not until there is active participation of the entire community (students and instructor) involved that how much and what is
understood becomes apparent. For example, in discussing with the participants, during class time, about systems of equations which they graphed and written known facts.

Professor: Tasha, did everyone understand how to tell why the lines were parallel and why the lines were perpendicular?
Tasha: Yeah. They did.
Professor: And was that before or after the class discussion?
Tasha: After.
Professor: After the class discussion. So it was a concept that wasn’t immediately –
Tasha: Readily learned.

Findings Addressing Category Six

Category six of the LCMP asks, *do students and teacher appear to be engaged in the same mathematical activity? What is the activity?* Jo Boaler and James Greeno (2000) argued that part of being successful, for students, in a mathematics classroom is the connection to and identification with the instructor. This shared engagement is an important aspect of teaching and especially in a developmental mathematics classroom (Wheeler & Montgomery, 2009).

In examining linear equations and their attributes, there was mutual engagement in discussing terminology used in the linear equations topic; ordered pairs, coordinates, and solutions to linear equations. The goal was for the entire class as well as the group of participants to understand the concept thoroughly and the activity was in understanding the relationship of calculator illustrations to the concept.

Professor: How did you know which was x and which was y?
Sharon: In here? (pointing to calculator)
Professor: Do you know what they are called?
Anna: Coordinates.
Professor: They’re coordinates good. What order do we write the variables in coordinates?
Tasha: They’re an ordered pair and we always put x first and y next?
Sharon: That’s about it. I just plugged it into the equation and B wasn’t a solution. (Talking about her written work where she substituted an ordered pair and found that it was not a solution.)

Professor: B was not a solution, how do you know?
Sharon: One side didn’t equal the other.

Professor: Good, go ahead and plot B on your graph Tasha, just show us where B would have ended up. Okay, what do you notice about B guys?

Andrea: It’s not on the line.

Professor: It’s not on the line. We can’t run a line through B can we? What does that tell us about solutions of linear equations? Andrea said they make a line, that’s correct. What else do we know about solutions for linear equations? How many are there? Well there’s how many for question 5?

Anna: Three.  
(Speaking of the three ordered pairs that held the equation true.)

Professor: But how many could there be?
Andrea: Infinity

Professor: It could be infinitely many. Yes. Why
Tasha: Because there’s a lot of points on the line.
Professor: Yes.

Here the goals of the community coincided, where the students and I were engaged in exploring mathematical concepts together. These practices occurred often and are common in LCMP’s (Winbourne & Watson). The students were also engaged in developing mathematical knowledge. In their interviews with me, they stated:

Tasha: And if there was a collective mistake, then you went and asked Chelsea or you asked me for that help. Pay a lot of attention to the process, and I like that a lot.

Anna: Well, either you would come to help me or a tutor would come just to explain something. And sometimes even somebody in another group, like Stephen. We were also talking between groups.

Sharon: Professor Naidu-by making me feel comfortable enough to raise my hand and ask questions, I’d never experienced that before in a mathematics classroom. It wasn’t like, in high school, I kind of felt pressured, if you don’t do this, you’re not going to pass, you’re not going to graduate, you’re not going to get into college. It was kind of like, hey, what’s wrong? What don’t you get about this? Let’s work on it. You just would watch us work it out, and then where we made the mistake, you would question us not just tell us. That helps me a lot. Like go
back and look at this section here, what do you see that’s wrong? You would actually make me focus and look, oh; I see what I did there. And then it helps for me to pay attention because that’s the part that I mess up on. If I would see three problems, that’s the same part I’d mess up on all three, then that helps me to see that that’s the part where I need to focus, that’s where I mess up.

Andrea: A tutor came to help, she looked at our work and our process and told us that we were either correct or she would try and show us where we went wrong and how we could come to the correct answer.

This collaboration was of immense value to my students. They valued the tutors, myself and each other.

**Discussion of Themes**

I have presented above the findings to the propositions presented by answering the sub-questions to the LCMP categories. I now present a discussion of those findings and consequently the underlying themes (see Table 9).

**Identity**

Linking identity and practice is part of communities of practice theories (Wenger, 1998) and is a common theme in LCMP (Winbourne & Watson, 1998). It explains why some developmental mathematics college students succeed and some do not. Studies in communities of practice do suggest that students can develop positive identities by working together and can have positive relationships to mathematics through their interactions with everyone in the community (Boaler & Greeno, 2000). From the findings above, it was clear that the participants had negative relationships with mathematics prior to the SLC stating for example, “I was never good at math.” This is not an unusual finding in LSP students. They perceive their placement in an LSP mathematics class in college as failure on the COMPASS exam, yet the COMPASS exam is truly a placement test (ACT, 2002).
This study also confirms literature in the areas of developmental mathematics such as Young and Ley’s (2002) investigation that developmental students have low mathematical problem-solving self-efficacy (the belief of being able to complete a mathematical task) and low mathematical problem-solving performance. While this study did not measure self-efficacy, interviews and video observations do indicate this low expectation that the participants had of themselves. For example, from Tasha’s personal interview reflecting on a graphing exercise, confirmed by the observations:

Professor: What was going on in your group?
Student: Probably a whole bunch of nothing. Because I remember when you gave us those big papers, we kind of all just sat there looking at the paper.

This negative identity image with respect to mathematics was indicative of the participants’ behavior at the beginning of the SLC and shaped their mathematical practices as indicated by the pre-test scores. When this category was observed at the end of the four weeks, during the systems of equations lecture, observations showed that while there was still some reluctance to begin a mathematical exercise, the findings suggest there was a marked increase in the group leaning on each other for support and direction.

**Participation**

This category within the LCMP framework addressed public recognition of developing mathematical competencies. From a situated cognitive perspective, communities of practice requires some form of participation to be in place for developing competencies to be recognized and to be constructive (Goos et.al, 1999). Participation within the social structure was formulated by the SLC participants in their individual
communities and involved receiving positive reinforcement, getting feedback from the group, knowing an incorrect process and how to correct a mathematical algorithm. For example, why were signs so important, which linear systems were consistent, non-consistent and dependent, and why an ordered pair was a solution, along with why solving was different from evaluating, were concepts that were discussed and recognized constantly.

It is important to discuss that for these LSP students in a mathematics class recognizing a mathematical competence was equivalent to deriving a correct answer not understanding per se, as can be seen in the findings when discussing systems of equations. I concur with Hiebert and Carpenter’s (1992) research that signifies using correct mathematical terms is an indication of knowledge progress; connecting terminology and process shows understanding. Individual interviews had indicated that the participants had not felt it was their responsibility to provide positive feedback or give recognition to one another of their knowledge but their teacher’s. Yet, in the 4-week SLC, they began to discuss and recognize their group’s efforts towards understanding mathematical concepts.

Collaboration with Purpose

A community must have purpose; the members must come to a consensus, have direction and rules. For this to happen they must collaborate in a meaningful way (Lave & Wenger, 1991). The SLC was provided rules for engagement, but how they came to work together, come to a consensus and discuss direction was negotiated by each group. For the participants, their consensus on how to work (individually at first), their direction
(giving each other feedback), before addressing the ‘expert’ (either Tasha or a tutor or me) was one that was discussed and negotiated within the group.

Tasha, Anna, Sharon, and Andrea had commented that they had not had the opportunity to engage in group work in a mathematics class before and were used to working alone. Both Andrea and Sharon had commented that they did not like group work. However, comments from participants’ interviews and reflections below signify the importance of collaborating on mathematical tasks and exercises.

Tasha: Our group from the very beginning formed a bond to help each other. We are working very smoothly together, and for the most part I would say that our test scores reflect that. We communicate well and share the knowledge we have gained in a combined effort to help the rest. I am no longer afraid to ask questions to the teacher or anyone else because now I know that we are in this together to reach a common goal.

Sharon: They definitely help me with math. Whenever we are assigned a problem, we automatically work it out ourselves and then compare answers. If it's something we have no idea on how to do, we help each other from start to finish. Tasha usually gets the right answer first and Anna and I tend to make careless errors. She definitely helps point them out to us so we can correct them for next time. If Andrea doesn't understand something, I usually help her do it, which reinforces the concept in my head as well.

Andrea: I think that my group communicates well in class. If one of us is having trouble with a problem, we ask each other and usually understand better. They are really great about helping me if I have questions during class. I honestly don't have anything that I need more of from my group, just for everyone to keep up the great work.

Anna: I think my group is working well together and communicating well because we know not to shout out the answer we wait until everyone is done then we find out if we all got the same answer and if someone got it wrong we help that person find their mistake or talk them through the steps.
In fact, prior research indicates that collaboration or cooperative learning (Johnson, & Johnson, 1986) is an effective model of learning that provides students the opportunity to discuss mathematics and become apprentices in this community of inquiry (Hunter, 2008). As Moschkovich (2002) states, from a situated cognition perspective, it is important to allow students to “construct knowledge, negotiate meanings, and participate in mathematical communication (p. 190).” Also, research in the “millennium student” area indicates that the millennium student enjoys a variety of active learning opportunities and that interaction with others gives academia a social perspective which they enjoy (Crone & MacKay, 2007).

I would like to address here the fact that the participants were women working in a group. I believe that these women interacted and performed well for several reasons. First, a study from MIT states that a high level of social sensitivity and willingness, known as the c-factor, to let everyone talk equally, plays a large part in the success of a group of women (Woolley, Chabris, Pentland, Hashmi, & Malone, 2010). As comments from the participants show, there was camaraderie amongst the group and willingness to listen to each other. Second, from research concerning the millennium student, they are “team-oriented,” seeing the good of the group as paramount along with a notion that they really don’t care for group work. As Anna commented, “I don’t really like working in groups,” but she still thrived academically while in her group. Finally, while diversity (men and women) in groups has been shown to increase productivity, the more women there are in a group increases the overall intelligence of the group itself and overall group performance on a given task (Woolley et al., 2010).
The MIT study also upholds and concurs with my study on the effect of learning in social groups on mathematical practices (Woolley et al., 2010). Indeed, Sharon and Anna indicated,

Sharon: Everyone had different problems in math, then things that she didn’t get, I maybe would get or things that I wouldn’t get, she would get, and we were two completely different people, two completely different skills in a certain subject. We got along so well trying to put the puzzle together. It was pretty cool.

Anna: If we all got together, if one person got it wrong we would all kind of figure out why and that way we wouldn’t make the same mistake as well.

This purposeful collaboration and progression from being used to working alone in high school to working together as a group reflected a change of behavior from the beginning of the 4-week SLC to the end of the four weeks; they began to rely on each other for strategy use, for algorithm use and drew pictures if needed. The participants had begun to understand the differences between high school and college activities and their responsibilities in and out of the classroom.

**Shared Repertoire**

The LCMP category that reflected the fourth theme called ‘Shared Repertoire’ was, “what are the shared values and ways of behaving in relation to mathematics.” As stated earlier in the findings section of this chapter, I found that this theme, while focused on shared values is very much related to theme three of collaboration with purpose, because collaboration gives rise to shared repertoire. Shared values signify a community of practice (Lave & Wenger, 1991) in which participants actively engage in acquiring behaviors and begin moving from beginner to expert.

The findings do indicate that the social structure of the participants’ community placed Tasha, the tutors, and me as the experts within the community from which Sharon,
Anna, and Andrea (apprentices) received feedback and positive reinforcement. However, as the findings also suggest the social structure (that of expert and apprentice) was fluid. Sharon became the expert once graphing was being explored, and Tasha relied on Anna to discuss mathematical tasks.

First, I speak of the group’s shared values and ways of behaving. The group’s process consisted of them individually tackling a task and then coming together to evaluate, discuss and re-evaluate if needed. This group process and progress became more and more evident as the four weeks progressed. Comments suggested that the students were actively engaged in building knowledge together, for example,

Sharon: But then things that she didn’t get, I maybe would get or things that I wouldn’t get, she would get, and we were two completely different people, two completely different skills in a certain subject.

Andrea: We helped each other slow down and work through each problem carefully. They can be tricky even though the process is fairly easy. As we each gained a better understanding of the lesson, we were able to get better and better at helping each other. Even if we were grasping at different paces. It gave me a sense of security and helped me not feel so bad if I were to get an answer wrong, because I didn’t get it wrong by myself.

Mutual Engagement

This category emphasizes the questioning, creating, and discussing that is important and ongoing in a mathematics classroom (Schoenfeld, 1998). It is the mutual engagement in practices, between all the participants of a community, of constituting a lesson on problem solving that is a precondition for a community of practice (Wenger, 1998). The findings suggest that the students in the SLC and the participants on whom data were collected had not experienced this mutuality in high school. They saw the
teacher as a discreet entity, not one involved with them as part of the community.

Comments such as these are revealing:

Sharon: It wasn’t like, in high school, I kind of felt pressured, if you don’t do this, you’re not going to pass, you’re not going to graduate, you’re not going to get into college. It was kind of like, hey, what’s wrong? What don’t you get about this? Let’s work on it.

Andrea: That helps me a lot. Like go back and look at this section here, what do you see that’s wrong? You would actually make me focus and look, oh; I see what I did there. And then it helps for me to pay attention because that’s the part that I mess up on. If I would see three problems, that’s the same part I’d mess up on all three, then that helps me to see that that’s the part where I need to focus, that’s where I mess up.

Anna: Professor Naidu you make me feel comfortable enough to raise my hand and ask questions, I’d never experienced that before in a mathematics classroom.

Research indicates that for LSP students’ collaboration, discussion, and questioning helps to motivate them and helps to build positive experiences with mathematics (Wheeler & Montgomery, 2009). The research on millennium students and on academic learning communities (Price, 2009; Tinto, 1991) also suggests that these students work harder academically if they obtain a connection to faculty. Price cites five strategies for working with and teaching millennium students. These strategies are 1) Active learning methods, 2) Relevance, 3) Rationale, 4) Relaxed, and 5) Rapport. In a recent online seminar (Magna, November, 2011) Price reports that “Rapport” is the most important factor for these students, “Students are going to be more likely to work toward achieving their learning outcomes if they have a positive rapport with us… You don’t have to be their best friend. You just have to be perceived as being on their side.”
In communities of practice, the instructor is part of the community, has rapport with the students because he/she is part of the ongoing work that is being done in the classroom (Winbourne, 2010).

**Joint Enterprise**

Tinto (1997) emphasized the importance of a ‘Joint Enterprise’, an academic learning community encompassing faculty and students. Making connections to the university, the class, and to faculty are important parts of students’ growth as college freshman (Solomon, 2006). Boaler (1999) and Schoenfeld (1985) also found that a regular interaction between students and teacher was another factor that influenced cognition from a situated perspective. The culture of the classroom was based on supporting learning communities from Tinto’s perspective (connection to faculty and each other), from Lave and Wenger’s (1991) community of learners’ perspective. From initial comments from the participants, I gathered this was a factor in situated learning for them.

Sharon: But it actually helped me so much, like interacting with the peer tutors, with you, there was all the – I used to stay up here with Suzy and Jessica all the time.

Tasha: And if there was a collective mistake, then you went and asked Denise or you asked me for that help.

Anna: Pay a lot of attention to the process, and I like that a lot.

The comment from Sharon reflects the creation of a learning community that was occurring inside the classroom, and unknown to me, an extension of that community created with other students in SLC outside the classroom. Tasha had a couple of people she asked for help or she helped her peers. Anna learned to focus on the process and her
group and her time in class helped her do this. These comments concur with a study by Siegrist (2009) in which he states that mathematical practices are occurring and evolving within a classroom community if students are discussing, explaining, reflecting, and then understanding the mathematics in which they are immersed.

An aspect of communities of practice is that members of the community are not only learning to do but are also part of the doing. The community itself was a joint enterprise of a SLC of students who had self-selected for this experience and the faculty immersed in facilitating them. In interviews and reflections participants spoke of the SLC being a community in greater part because they were in a comfortable environment in which they could ask questions, and the community extended to outside the classroom walls. This community allowed for the growth and the transition of these individuals from being high school students to becoming successful college students. I choose here to provide the reader with additional comments that the participants made about the SLC program they were engaged in.

**Additional Participant Comments**

Tasha commented, “Yeah, like I don’t know, if I would have just came in, because me and Lisa and the rest of us, we talk about it all the time, if we would have just came into college without SLC, we would have been screwed. We wouldn’t have known anybody. It would have been horrible. I felt right at home with the teacher because her very detailed teaching style reminded me of my high school teacher. My idea of college math has been reversed.”

Sharon reported, “That through SLC I have learned my way around campus for one. I understand what, “Go to UC 225 at 1:30 p.m.” means. Most freshmen will not have
that. I even saw a bunch of them posting on Facebook about how scared they were about getting lost on campus. I won’t have that problem! I also learned how to not be afraid of math anymore! It is still my weak spot but I feel a lot more confident in it than I did when I was sleeping through every math class in high school. And I just got it. It just like kind of clicked, and I was like super happy because for once, I didn’t feel like I was ripping my hair out to do a math problem. I didn’t think my teacher was crazy trying to put letters in math.” Although she is not presently at Cagano, Sharon says “I definitely recommend the SLC program to anyone who is able to take it. Not only did it help me academically in a tremendous manner, I met friends that are wonderful people and it facilitated the process of being an on campus resident once the school year began. It’s definitely one of the best moves I made so far in college.”

Finally, Andrea says, in coming to SLC, I’ve done just that. I’ve never made so many B’s in math, ever! I’m still not a big fan of math, but it no longer annoys me as much as it used to, especially in high school. Professor Naidu is a wonderful teacher. I’ve never had a good math teacher, so it was a change for me to see her teach math with such passion and actually care about her students.

**Summary**

In summarizing this chapter, I presented the situated experiences of the participants’ Tasha, Sharon, Andrea, and Anna using the LCMP framework. The findings addressed the research question revealed several themes: 1) Identity, 2) Participation, 3) Collaboration with Purpose, 4) Shared Repertoire, 5) Mutual Engagement, and 6) Joint Enterprise. The findings reflected themes that, while not wholly unexpected, confirm findings in research literature from situated cognition

First, the participants’ identity with respect to mathematics shaped their progress academically. As suggested by communities of practice theories (Lave & Wenger, 1991; Wenger, 1998), the participants, were hesitant, unwilling to try until given support and encouragement from their group and community. While all the participants spoke of this hesitation as a common theme, Tasha and Sharon were more willing to tackle a specific topic by asking each other and the group for their participation. Anna and Andrea quietly absorbed the discussion and became successful in their own way.

Next, the group’s participation evolved during the four weeks of SLC. Wenger suggests that participation must be legitimized by the teacher (existing practitioner) and based on the findings in this study, the participants recognized and understood that contributing to group discussion and evaluation of mathematical concepts helped them become more aware of their learning. Learning new concepts also reinforced their relationship to mathematics and, consequently, their identities within that domain. Tasha and Anna were able to recognize and make the connections to their prior knowledge and understand new concepts quickly. Sharon and Andrea had the weakest knowledge base in the group but enjoyed the group discussions that allowed them to move forward.

Third, as discussed, collaboration with purpose became an important tool for learning for these women participants. Indeed, they developed relationships and connections with other members of their class getting support both in and out of class. This support continued in future semesters and was not limited to just mathematics classes. Fourth, sharing new knowledge, and working together all supported the theme of
shared repertoire. The effort of being social, working in groups, impacted the shared values of the participants mathematically. They were not as hesitant when completing an in class assignment, and more willing to share and discuss concepts for understanding than just a correct answer. Fifth, mutual engagement as explored in the literature review chapter and as cited in many studies (Price, 2009; Tinto, 1998; Wheeler & Montgomery, 2009) and as findings in this chapter shows is an important motivating factor in developmental mathematics students’ academic success. Finally, I discussed the importance of the joint enterprise as expressed by the participants. They enjoyed the SLC and felt they could ask any question of everyone in the community. They relied on each other for support both in and out of the class.

It is clear that the summer learning community shaped the participants mathematical practices in the following ways. 1) By working as a community both as part of the classroom and within the individual groups they were able to discuss concepts, process, and terminology. Discussing helped reinforce their mathematical practices. 2) The participants were able to evaluate different strategies that each had used to complete a problem, and were able to understand concepts more thoroughly than if they were working on exercises alone. 3) The idea of community that included the instructor was at first a strange one but, during the 4-week SLC they grew accustomed to questioning, creating, processing, and teaching each other with the instructor’s guidance. 4) The effect of the SLC on mathematical practices was illuminated quantitatively by the difference in the pre and post test scores (Appendix G) and by the participants overall test scores at the end of the 4-weeks in which they examined topics and concepts from introductory algebra. 5) The participants began to see themselves as learners who were capable of
engaging in mathematical practices as was evidenced by their passing future mathematics courses at the university.

Indeed, Morrison and Collin (1996) state that a student’s success in a subject is often a function of his/her awareness of the rules of engagement. That is, a student’s success is dependent on how well they are able to participate, without issues of reprisal, in the community of mathematical practice. The difference in the student who is a novice and one who is an expert is being able to share common values, assumptions, purposes, rules, and communication of the community. These participants understood the rules of community engagement and were able to contribute successfully.
CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

I conclude this study of developmental mathematics students in this final chapter by summarizing the purpose of the study, the research questions, the methodological approach, and the conceptual framework. I include in chapter 6 the practical and theoretical significance of this study and how it informs the field of research. I make recommendations for those devoted to the mathematics education of developmental students. I then discuss the limitations of the study and the implications for research, policy, and practice. Additionally, I offer suggestions for future research. I conclude with participants sharing how these experiences shaped the “rest of their stories” in college.

Summary of Study

Developmental mathematics courses have become synonymous with barriers to education. The NCES (2012) reports that Basic Algebra has the highest failure and withdrawal rate for post-secondary courses. Yet, in spite of these dire reports, over the past 17 years, I have watched developmental mathematics students succeed when given the right support. So, this study was primarily driven by my own interests and desire to further research for this group of students. Secondarily, this study is driven by an increase in national interest in providing an education for all fueled by reports such as the above, and funded by organizations such as the Carnegie Foundation, the Bill and Melinda Gates Foundation, the William and Flora Hewlett Foundation and the Lumina foundation (Carnegie Foundation, 2010).

The purpose of this qualitative case study was to examine traditionally aged developmental mathematics college students’ experiences of mathematical practices, in a
4-week summer learning community, using a methodological qualitative case study approach (Yin, 2009). This study also used the framework of Local Communities of Mathematical Practices (Winbourne & Watson, 1998) to help sort and analyze data, and the conceptual theories of situated cognition (Brown & Duguid, 1988). These theories along with research in the areas of communities of practice (Lave & Wenger, 1991), and learning communities (Tinto, 1997), provided a foundation of theory that based the underpinnings of this study. The goals of the study were to inform instructors and administrators as to the contextual factors that provide more opportunities for developmental mathematics college students to be academically successful as evidenced by their mathematical practices (Ball, 2003; National Council of Teachers of Mathematics, 2000).

The main research question for this qualitative, explanatory case study (Yin, 2009) is;

*How does participating in a 4-week summer learning community shape developmental mathematics college students’ experiences of mathematical practices?*

The LCMP methodological framework gave rise to the following sub-questions and propositions:

1) How do students seem to be acting in relation to attempting problem-solving tasks?
2) What developing mathematical competence is publicly recognized and how?
3) Do learners appear to be working purposefully together towards a shared understanding of problem-solving tasks?
4) What are the shared values and ways of behaving in relation to mathematics: language, habits, tool use?
5) Does active participation of students and teacher in mathematics constitute the lesson on problem-solving tasks?
6) Do students and teacher appear to be engaged in the same mathematical activity? What is the activity?
This investigation used a qualitative explanatory case study methodology, intent on examining a characteristic or behavior within a social context (Yin, 2009). I utilized daily classroom observations and videotapes, student interviews, and student reflections. As researcher, participant, and instructor, I was also privy to classroom discussion and conversations. Three days of classroom videotapes were transcribed over a period of 6 months. Videos were used from a day in the first week, a day during the second week, and a day in the last week of the 4-week study. I then scheduled interviews with each participant over the following spring semester. Transcriptions of classroom observations, videotapes and student interviews were used to triangulate collected data. I did meet with the participants a second time during the spring semester in order to verify my understanding of comments made during the interviews. Student reflections were collected that had been assigned online and member checking was utilized to establish reliability. I utilized the LCMP framework as a scaffold for examining participation and learning within the mathematics’ classroom. The LCMP framework also helped me to focus on data of the interactions, occurrences, and problem-solving taking place. This allowed me to examine at a deeper level of how learning in a situated context contributes to the academic success of these students. These findings were reported and discussed in chapter five.

Along with a case study methodological approach, I employed a situated cognition conceptual framework to investigate developmental mathematics students’ experiences in a 4-week learning community. Situated cognition is appropriate for this study because it maintains that learning occurs through collaborative social interaction and the social construction of knowledge (Brown, Collins, & Duguid, 1989). Utilizing
situated cognition theory allowed me to explore the impact of communities of practice, learning communities, and classroom practices on the experiences of the participants. Situated cognition also aligned with qualitative case study because I wanted to explore the participants’ experiences within a specific context.

In this study, four participants provided rich thick descriptions of their experiences within the summer learning community (SLC) and their related experiences to mathematics. They spoke of their experiences in high school and learning to transition to college, their negative beliefs towards their ability to do mathematics, their reluctance towards group work, the holes in their mathematical knowledge, and their overall acceptance of the skills they gained through the SLC learning community. They identified how reliance on group members helped them acquire the ability to competently learn and use mathematics, approach, think about, and work with mathematical tools. These developmental mathematics students were engaged in mathematical practices as defined in chapter one (Ball, 2003).

This study increases the knowledge of the faculty engaged in teaching, and administrators of developmental mathematics regarding the experiences of one group of four individuals in the SLC program. This study attempted to show that developmental mathematics students can be successful when provided the right environment in which they can thrive. A 4-week summer learning community can provide the connections to their peers, their institution, and the faculty which allow them to successfully pass developmental mathematics and thrive in credit bearing mathematics courses. I continue now with recommendations for instructors, and administrators.
**Practical Significance of the Study**

The practical significance of this study was to illuminate the interactions of faculty and students engaged in exploring developmental mathematics in a 4-week SLC. This investigation showed that students benefitted from viewing the instructor and other students as a support system and team. It revealed that developmental students while lacking in skill and identity (with respect to mathematics) could regain those skills through group activities in the classroom. This study discovered that developmental mathematics students could also retain and use those skills in future mathematics and other college courses. It also showed that being in a learning community helped address students concerns from a social and academic level. This study concurs with the notion of empowering students through social practices in institutionally structured learning communities. Specific recommendations for educators follow in this chapter.

**Theoretical Significance of the Study**

This study adds to the scholarly literature by supporting the categories and propositions of the LCMP by revealing a LCMP was in place as defined by Winbourne and Watson (1998). These categories suggested themes of identity, participation, collaboration, mutual engagement, shared repertoire, and joint enterprise common in communities of practice. This study also confirms that the intersections of learning are the intersection of activity, concept, and culture (the classroom). Brown, Collins, and Duguid, (1988) wrote that learning occurs through collaborative social interaction and the social construction of knowledge and this was confirmed by the participants perspectives of their engagement in mathematical practices.
Recommendations of the Study

For Instructors

As I conclude this study and reflect on the data I have collected, I realize that there many issues facing developmental students that I as an instructor/researcher have been privy to. This study I hope sheds some light on the needs of developmental students, but is by no means the answer to all. I agree with organizations such as the Carnegie Foundation, The Lumina Foundation, and The Bill and Melinda Gates Foundation that we cannot deny a college degree to those whose weak academic area is mathematics. Investigating developmental mathematics students within a 4-week learning community has allowed me the opportunity to share with others recommendations to help further these students’ education.

As a result of this study, I would like to offer five recommendations on how to begin working with developmental mathematics students. While these suggestions worked for the students in this study, I do not begin to assume that they would work for all. I am, however, arguing that these recommendations might assist in the mathematical achievement of developmental students in our colleges and universities. I propose that instructors reflect on how these suggestions might be revised and implemented in their own classrooms with their population of students.

Recommendation #1: Create Community through Participation

In keeping with this study’s conceptual perspective of situated cognition (Brown, et al., 1989), and with the findings from chapter five, I recommend that this idea of “community through participation” be at the forefront of issues dealing with the teaching and learning of developmental students. Creating community is not a new idea. Lave and
Wenger (1991) researched communities of practice which have been implemented in education. Tinto (1997) also confirmed the relationship between academic success and institutional connections that empowers students to become learners. Seigrist (2009), and Price (2009) all speak of community within the classroom as an essential component of academic success. With research supporting the establishment of communities, faculty and administrators should consider learning community initiatives. When students collaborate, participate in a variety of learning activities, such as group work, and build a supportive community, this raises their academic performance (Barkely, Cross, & Major, 2005). Communities also increase faculty to student connections and studies have shown these connections are very important to college students (Seigrist, 2009; Tinto, 1997; Wheeler & Montgomery, 2009).

Providing a comfortable environment in which students can contribute was important to the students. Ice breakers, while time consuming, can help in creating a cohesive group. The participants in the SLC all learned the rules of engagement within the community, to ask questions, not be afraid to ask and to communicate with each other. They often remarked about gaining help from their peers, helping each other inside and outside of the classroom. They spoke of supporting one another in the developmental mathematics class, and two of the members forged a new supportive community (with others from SLC) in the next two credit bearing college mathematics courses. So, I advise instructors of developmental mathematics students to create a community that includes both students and instructor. This encompasses the admonition of Bryk and Triesman (2010) to, “strengthen the connections of students to successful peers, to their institutions, and to pathways to occupations and education” (p. 20).
Recommendation # 2: Engage Students in the Classroom

A natural continuance of creating a community within the classroom is that of engaging students in mathematical discussions. As was reported in chapter five, the participants had mentioned that they would never have asked questions in high school, they would try not to participate because they felt ‘dumb’. Tasha was one who said, “I am no longer afraid to ask questions to the teacher or anyone else because now I know that we are in this together to reach a common goal”. Engaging students through discussion, making them feel a part of a community to reach a common goal, helps motivate and enhances understanding of mathematical concepts (Seigrist, 2009).

Recommendation # 3: Be Aware of Affective Factors

My third recommendation proposes that faculty working with developmental mathematics students should consider affective factors with respect to mathematics. Often forgotten in the area of academic success is the affective domain. Research from Schoenfeld (1983) to Bandura (1997) has expressed the importance of the relationship between affective and cognitive factors, and I challenge instructors of developmental students to be aware of this relationship as they work with their students.

This study like others (Bates, 2007; Hall & Ponton, 2005) has shown that developmental mathematics students bring with them negative mathematical identities, anxiety, and low self-confidence. Instructors should attempt to build affirmative interactions through activities for students learning mathematics to build positive identities. In the affective domain Wheeler and Montgomery (2009) also found that a surprising outcome of their study was of faculty ‘caring’ about their students and provided motivation for developmental students to do well. Indeed, Andrea said, “I’ve
never had a good math teacher, so it was a change for me to see her teach math with such passion and actually care about her students.” I believe this was because I was part of the local mathematical community of practice.

**Recommendation # 4: Provide Academic and Social Support**

The participants’ stories indicated a lack of self-confidence. As acknowledged in chapter five, all of them reported a lack of belief in their ability to do mathematics. These deficits led to poor performance in mathematics, but with support the students succeeded. The participants shared stories of failure, of being ignored, of ignoring teachers, and of being labeled ‘remedial’ in mathematics. Yet, all of the participants successfully navigated the developmental mathematics curriculum and went on to successfully pass credit level mathematics courses. The students in this study were provided access to tutoring and peer support both on campus and in the dorms. So, sharing study strategies, modeling mathematical practices and providing support systems, such as tutoring, should be an important part of the developmental mathematics classroom (Nolting, 2002).

**Recommendation # 5: Facilitate not Lecture**

While it is a struggle sometimes to complete the required curriculum in a set period of time, I ask faculty who teach developmental students to facilitate more and lecture less. These students bring with them some knowledge of mathematical concepts (as is evidenced by low pre-test scores), and correcting and extending that knowledge should be achieved by facilitating and mutual engagement, not lecturing. This study used the conceptual framework of social cognition and the methodological framework of LCMP focusing on creating knowledge through group and class interactions. I submit
that developmental students can employ group strategies and learn to support one another, as the findings in chapter five illustrate. While some students were reluctant to engage in group work, the majority found it motivating, interesting, and worthwhile. For example, Sharon expressed,

Over at SLC over the summer, we did a lot of group work and I was like I don’t want to work with these people Pinder what are you doing? I don’t know the people. I want to do my own work, get in here and get out. But it actually helped me so much, like interacting with the peer tutors, with you, there was all the – I used to stay up here with Cori and Heather all the time, like there was always, even like Sam at nighttime was available to help us. (Interview 1)

Research also suggests that millennials prefer a variety of active learning methods (Price, 2009). When they are not interested in something, their attention quickly shifts elsewhere. Interestingly, many of the components of their ideal learning environment – less lecture, use of multimedia, collaborating with peers has been well established by researchers such as Boaler (2000), Cobb et al., (1992), and more recently in Price’s November, 2011 online seminar.

**For Administrators**

This study showed that bringing students to campus four weeks early and allowing them to transition shaped their mathematical experiences. Many administrators would state that cost is incurred, but I would argue that these students made connections to each other, to the institution, to the faculty, which in turn led to retention and, hopefully, graduation. Retention at a time when educating developmental students is a national debate makes the SLC a program worth examining.
For Policy Makers

The major implications of this study for policy makers are given here: 1) Eliminating developmental education is eliminating an opportunity for some groups of students to remediate. 2) Enrolling under-prepared students in gatekeeper courses as co-requisites is currently seen by policy makers as an “opportunity” for these students. However, this study shows these students needed remediation in order to feel competent about their mathematics skills. 3) This study shows that these students benefitted from the option to remediate and that option should continue to be provided. 4) Policy makers suggest that the high failure rate of developmental students correlates with the idea that developmental education does not work. Correlation was never meant to suggest causality and policy makers should “read between the numbers,” (Goudas & Boylan, 2012).

Limitations

First, my biggest limitation was being the researcher, the instructor and the participant in my own study. My ability to remain objective was at times challenged, and I had to remain vigilant in obtaining observations while I was teaching. I relied heavily on the classroom videotapes to record observations I might have missed. Second, the time factor of four weeks was limiting. Socialization did occur via the ice-breakers, as did the relationship between the participants and myself in my chosen group. However, what was unclear was the effect of community on mathematical practices. For example, Tasha noticed that when given linear equations to explore her group was doing, “Probably a whole bunch of nothing.” I would surmise that in some instances there were moments when the effect was noticeable. For example, when the students were examining systems...
A longer time period could also have given me a clearer view of the participants’ change in perspectives about mathematics. Third, while qualitative research methodology supports the use of four participants in a study, I cannot make generalizations about developmental students from this small a sample size. Fourth, since this was a qualitative case study, I was aware of the need to attend to reliability, credibility, and validity. I did use classroom observations, videos and personal interviews to validate statements. For reliability, I could only conduct member checking with one student at a time. Sharing another student’s work would have been inappropriate. So, while the results recorded in this work was of a group consensus, member checking was made by individuals alone.

**Implications for Research, Policy, and Practice**

This study on developmental mathematics students has implications for research, policy, and practice. With respect to research in the area of developmental mathematics education, more investigations using qualitative methodologies should be undertaken. Sharing these students’ stories would reveal the complicated issues that they bring with them to college. Issues ranging from family, friends, finances, transportation, food, to housing all combine to make obtaining an education very difficult. I had thought that it was only the adult learners that dealt with issues of this magnitude, but the stories that the participants shared with me led me to believe that we cannot address solutions to educating developmental students without addressing the problems they face. For example, Sharon revealed that, “I wasn’t used to, I mean, I was commuting a lot, so the attendance kind of like drove me crazy, like with SLC...” While issues such as these were not a part of my investigation, they did make me speculate their affect on students’
academic success. Research addressing topics such as these may find some solutions in the area of on campus learning communities of which policy makers can take note.

I propose that policy makers move towards the conceptual framework of situated cognition with respect to traditional aged developmental mathematics students. I suggest that providing learning communities on campus provides a situated environment that enhances their learning experiences, and provides a much needed support system within academia. Research supports learning communities as a viable tool for transitioning students, and this study has shown it to be a viable option as a support mechanism for students.

I also suggest that policy makers do not view developmental mathematics students using a cost/benefit analysis. Bahr’s (2008) research suggests that educating developmental mathematics students costs too much and few students are retained. However, viewing the data I have kept of the pilot study I conducted in 2008 shows that SLC students have been retained at a higher rate than developmental students not in a learning community.

Implications for developmental mathematics practitioners are to recognize the mathematical potential in developmental students, and to research active teaching practices that enhance mathematical practices (Boylan, 2002). In the case of Tasha, who the other participants felt did not belong in a developmental class, she believed that she was not good at mathematics and viewed herself as an underachiever. She needed to believe in her abilities, and her leadership role in the group activities confirmed her knowledge and elevated her self-esteem. Indeed, Tasha did very well and completed all her mathematics credit level mathematics classes as well. So, an implication of this study
is for practitioners to implement researched teaching activities (McKeachie, 2006), employ group activities (Barkley, Cross, & Major, 2005), and become part of the community (Tinto, 1997). These things drive academic success for developmental mathematics students.

**Suggestions for Future Study**

This study addressed developmental students’ experiences of mathematical practices in SLC over four weeks. I have several suggestions for future study. First, depth would have been added to the study if it had been conducted as a longitudinal study. Extra data would have allowed for additional themes to emerge. While four weeks was sufficient time to observe some changes in students transitioning from high school students to college students, change was not as apparent for their attitudes or beliefs about their mathematical practices. I concur with Parjares (2008) and Bandura (1984) who report that shaping beliefs of individuals in an academic setting can be done but does take time. A longitudinal study would also reveal if all or any of the SLC students’ experiences affected their success in credit level mathematics classes (the group that was studied did pass both college algebra and statistics – their next required credit bearing courses) and their eventual graduation.

Second, this study would have been more objective if the research had been done using another instructor’s class. Researching in one’s own backyard (Bogdan & Biklen, 2010) is both an advantage and a disadvantage. It is an advantage to have access to research participants, and conducting a LCMP study needed to include the instructor of the class creating a “whole” community. The disadvantage was in being both the instructor and researcher; I felt there might have been important learning instances that I
missed because I was focused on both teaching and researching at the same time. This meant the videotapes were crucial to the research process and reviewing them after class was both time consuming and exhausting.

Third, this study was conducted at a four-year university. In my opinion as I see admission criteria increase, cut off scores boosted, and other restrictions placed on developmental students, entrance to a four-year university will become more difficult to achieve. These students will be encouraged to go to a community college to complete mathematical deficits. Community colleges may have different demographics so a recommendation is to replicate this study at a community college to see if results remain the same or differ.

Fourth, this study could also be replicated with freshman college algebra students. Allowing an SLC for college algebra students may elevate college algebra pass rates at this university (currently at 50-60%), and perhaps allow an avenue for high achieving developmental students to pass a credit bearing mathematics course instead of spending time in non-credit bearing courses at a four-year university as suggested in the implications section.

Fifth, as stated above in the implications section I do advocate further qualitative studies to be undertaken to investigate the impact of outside factors on the education of traditional aged developmental mathematics students. While studies of this nature are found in adult educational literature (Tolbert, 2005) very little is covered in the area of developmental education.
“The Rest of the Story”

In summarizing this study it is important to note that all of the participants successfully passed the introductory algebra course (Appendix G) in which they were enrolled. In the following semesters Tasha and Anna effectively navigated college algebra and statistics the two general education mathematics courses required at this university with two different teachers, making well above average grades in both classes. Tasha says she owes her mathematics success to the confidence she gained from her SLC mathematics teacher and because of the foundational SLC mathematics class. Tasha now looks forward to graduating in four-years to become a pastor, while Anna has been accepted into the College of Education to become an elementary school teacher. Both of these participants reported that their community of practice expanded to include two different group members of the SLC. The ‘new’ community formed a support system that moved these participants successfully through college.

Andrea, who was out of state, chose to return back home and is currently a successful college student at a university in her state. She is at present enrolled in a Statistics class in addition to four other courses that are necessary for her nursing major. She states that her goals are to make A’s and B’s in her classes and to increase her GPA in order to get into nursing school in spring 2014. Improving her math skills was something that aided Andrea in reaching her ultimate goal. Sharon also chose to attend another college close by due to financial reasons where she remains successful.
References


http://www.carnegiefoundation.org/statway/invitation-join-the-joyful-conspiracy


Data from the Pell institute for the study of opportunity in higher education. (June, 2008). *Chronicle of Higher Education*.


Staying the course: Factors influencing enrollment and persistence in adult education.


Winbourne and Watson’s (1998)

Local Communities of Mathematical Framework

Catgeories/Group Observation Form

<table>
<thead>
<tr>
<th>Category</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupils see themselves as functioning mathematically and, for these pupils, it makes sense for them to see their ‘being mathematical’ as an essential part of who they are within the lesson.</td>
<td></td>
</tr>
<tr>
<td>Through the activities and roles assumed there is public [from the participants] recognition of developing competence within the lesson.</td>
<td></td>
</tr>
<tr>
<td>Learners see themselves as working purposefully together towards the achievement of a common understanding.</td>
<td></td>
</tr>
<tr>
<td>There are shared ways of behaving, language, habits, and tool-use.</td>
<td></td>
</tr>
<tr>
<td>The lesson is essentially constituted by the active participation of the students.</td>
<td></td>
</tr>
<tr>
<td>Learners and teachers could, for a while, see themselves as engaged in the same activity.</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX B

Entry and Exit Surveys

Entry Survey

Name: _____________________________________ Date: ____________

Answer each of the questions below:

1. What was the last mathematics class you took?

2. When and where did you take it? What was your grade?

3. Briefly describe an experience (positive or negative) in a mathematics class that stands out in your memory?

4. In your opinion what is the best way for you to learn mathematics?

5. What do you think mathematics is?

6. Do you think of yourself as a mathematician?
Exit Survey

Name: _____________________________________ Date: ____________

Answer each of the questions below:

1. Briefly describe an experience (positive or negative) in a mathematics class that stands out in your memory?

2. In your opinion what is the best way for you to learn mathematics?

3. When working on a mathematics problem did you prefer to work alone or in a group?

4. Did working in a group help you? How did it help you?

5. What do you think mathematics is?

6. Do you think of yourself as a mathematician?
APPENDIX C

Consent Form For Cagano State University
Summer learning community

I agree to participate in the research project conducted at Cagano State University titled: Examining Developmental Mathematics College Students’ Experiences of Mathematical Practices within a 4-Week Summer Learning Community Using Local Communities of Mathematical Practice (LCMP).

This research is being conducted by Ms. Bhupinder Naidu, graduate student at Georgia State University and instructor of this class. I understand that this participation is voluntary; I can withdraw my consent at any time and have the results of the participation returned to me, removed from the experimental records, or destroyed. Benefits are none.

The following points have been explained to me by Mr. Mike Keleher:

1. The reason for the research is to show the impact of local communities of mathematical practice (LCMP) on students’ mathematical experiences within a 4-week summer learning community.

2. Definitions of the above are: A local community is this classroom, mathematical practices are looking at the doing how and doing what of mathematics as a community together in the four weeks in the summer.

3. The procedures are as follows: Procedures for doing individual and group work will be distributed and followed throughout the four weeks in the summer. All students in the class will do the same work whether you choose to participate in the study or not. Participants work done in class will be observed and collected. You, as a student of the class, will not know who is participating or who is not participating. Interviews with participating students will be held in the Fall semester discussing the work done in class, and to verify if the observations collected by Ms. Naidu were accurate. Work will be observed daily for 4-weeks.

4. The discomforts or stresses that may be faced during this research are: None

5. Participation entails the following risks: There are no risks in participating or not participating in the study. The instructor will not get upset if anyone chooses not to participate. Grades will not be affected.
6. The teacher will collect the data and not use it for research until after the class has been completed and grading is complete.

7. The results of this participation will be confidential; an alias for all students participating will be used and will not be released in any individually identifiable form without the prior consent of the participant unless required by law. We will use an alias or your CAGANO number rather than your name on study records. Only Bhupinder Naidu will have access to the information you provide. It will be stored in a locked file cabinet with the key in Ms. Naidu’s possession at all times. The alias key will be stored on a password protected computer in Ms. Naidu office at CAGANO. This key will be destroyed when the study is completed. Your name and other facts that might point to you will not appear when we present this study or publish its results.

Your signature below indicates that you are willing to participate in this study.

__________________________________________________
Signature of Investigator, Date

__________________________________________________
Print Name, Date

__________________________________________________
Signature of Participant [or authorized representative], Date

__________________________________________________
Print Name, Date

PLEASE SIGN BOTH COPIES, KEEP ONE AND RETURN THE OTHER TO THE INVESTIGATOR

Research at Cagano State University that involves human participants is carried out under the oversight of an Institutional Review Board. Questions or problems regarding these activities should be addressed to Institutional Review Board, Cagano State University, 1000 Chastain Road, #2202, Cagano, GA 30144-5591, (678) 797-2268.
APPENDIX D

Consent Form For Georgia State University

Georgia State University
Department of Middle-Secondary and Instructional Technology

Informed Consent

Title: DEVELOPMENTAL MATHEMATICS COLLEGE STUDENTS’ EXPERIENCES OF MATHEMATICAL PRACTICES IN A 4-WEEK SUMMER LEARNING COMMUNITY USING LOCAL COMMUNITIES OF MATHEMATICAL PRACTICES

Principal Investigator: Faculty Advisor, Dr. Christine Thomas
Student Investigator: Doctoral Student, Ms. Bhupinder Naidu

I. Purpose:

You are invited to take part in a research study. Participating in the study is voluntary. The purpose of the study is to look into how and what developmental mathematics college students’ work with mathematics while in a 4-week summer learning community.

You are invited to take part because you are enrolled in the developmental mathematics course within the Summer learning community (SLC) which is a summer learning community at Cagano State University. You are included because you are eighteen years of age or older and taking part in the 4-week SLC learning community.

A maximum of 4 students will be signed up for this study. Taking part will require no more of your time than the time spent in class between the hours of 9:30am to 11:30am, Monday through Thursday, over a period of July 11th to August 4th. If you are one of 4 students chosen to take part then you may also be interviewed in the Fall semester of 2011 to discuss your time in class. You will not know who has chosen to join in the study.

II. Procedures:

If you decide to take part, you will not be treated any differently than those who did not take part. The whole class will fill out surveys, be video-taped during in-class assignments, be audio-taped while working alone and in groups, have work collected and graded, and be assigned tests.

Only those participating will have their surveys, video-tapes, audio-tapes, and class work analyzed. Only those participating will be interviewed by Ms. B. Naidu in the Fall semester. The study will be done everyday beginning on the second day, July 12th to August 4th.
All of the work will be done in the classroom, during the four weeks in the summer, from July 11th to August 4th. No extra time will be required. There will be no reward given to take part in the study. There will be no extra credit given to participate in the study. All students in the class will be treated equally and grades will be based on tests and online homework assigned in class only. The instructor will not treat any student differently.

III. Risks:

In this study, you will not have any more risks than you would in a normal day of life.

IV. Benefits:

Taking part in this study may not benefit you personally. Overall, we hope to gain information about the affect of community on developmental mathematics college students’ mathematical practices which include; writing in correct mathematical ways, using mathematical terms, thinking, and talking about mathematics in the classroom with everyone in the classroom. In other words the doing ‘how’ and doing ‘what’ of mathematics.

V. Voluntary Taking Part and Dropping Out of the Study:

Taking part in research is voluntary. You do not have to be in this study. If you decide to be in the study and change your mind, you have the right to drop out at any time. You will not be treated differently if you decide to drop out of the study. You will be taught the same material as any other student enrolled in the class and who chose not to participate.

You may not stop involving yourself in class at any time because you’re taking part in class, work on tests, and on homework is part of the normal class for which you are enrolled and for which you will earn a grade. Whatever you decide, you will not lose any benefits to which you are otherwise entitled.

VI. Confidentiality:

We will keep your records private to the extent allowed by law. Dr. Thomas and Ms. Naidu will have access to the information you provide. Information may also be shared with those who make sure the study is done correctly (GSU Institutional Review Board, the Office for Human Research Protection (OHRP) and/or the Food and Drug Administration (FDA), and the sponsor). We will use your CAGANO number rather than your name on study records. All information collected will be kept in Ms. Naidu’s office which is locked at all times. The information you provide on surveys, and class work will be stored in Ms. Naidu’s office in a locked drawer. Any audio files will be stored in a password protected computer in Ms. Naidu’s office. The video-tapes and
audio-tapes will be locked in a cabinet in Ms. Naidu’s office. The video-tapes and audio-tapes will be destroyed one year after Ms. Naidu’s dissertation is completed.

The code key (CAGANO number) that identifies you will be stored as a word document on the password protected computer in Ms. Naidu’s office. No one other than Ms. Naidu will know who is participating in the study. Your name and other facts that might point to you will not appear when we present this study or publish its results. The findings will be summarized and reported in group form. You will not be identified personally.

In order to maintain confidentiality you should not talk about anything discussed in the interviews. All interviews will be transcribed into word documents and kept on Ms. Naidu’s password protected computer in her locked office. All interview audio-tapes will be kept in a locked drawer in a cabinet in Ms. Naidu’s office and will be destroyed one year after her dissertation is complete.

VII. Contact Persons:

Contact Dr. Christine Thomas via email at cthomas11@gsu.edu or via phone at 404-413-8065 or Bhupinder Naidu via email at pnaidu@Cagano.edu or via phone at 770-499-3456 if you have questions about this study. If you have questions or concerns about your rights as a participant in this research study, you may contact Susan Vogtner in the Office of Research Integrity at 404-413-3513 or svogtner1@gsu.edu.

VIII. Copy of Consent Form to Subject:

We will give you a copy of this consent form to keep.

If you are willing to volunteer for this research, and be willing to be video-taped and audio-taped please sign below.

________________________________________________________________________
Participant ________________________________ Date

________________________________________________________________________
Principal Investigator or Researcher Obtaining Consent __________________________ Date
APPENDIX E

Problem Solving Exercises

Based on the pretest information the following exercises from introductory algebra topics were assigned and data were collected.

Order of Operations

1) Each group was asked to discuss the difference between
   a) $-X^2$ethod of
   b) $( - X )^2$ and c) $(X)^2$

2) Now evaluate each of the above terms for $X = -2$

3) Discuss the differences in your answers (if any).

Linear Equations

Each group was given a 21 inch by 48 inch sheet of paper. They were asked to define and discuss in their groups what was meant by the following:

1) A coordinate plane

2) An ordered pair

3) What is a solution of a linear equation? What does this mean?

4) What are the quadrants of a coordinate plane?

5) Given $2X + Y = 5$ which of the following are solutions to the given linear equation?
   a) $(-2, 0)$
   b) $(2, 3)$
   c) $(0, -4)$
   d) $(-1, -2)$
Systems of Equations

Each group was given a 21 inch by 48 inch sheet of paper and asked to discuss the following:

1) Given the following two linear equations, \( Y_1 = -X - 1 \) and \( Y_2 = 2X - 7 \)
   a) Graph them on the same coordinate plane.
   b) Discuss what is occurring.
   c) How many solutions does this system have?

2) Given the following two linear equations, \( 2Y = X - 1 \), and \( Y = (1/2)X + 3 \)
   a) Graph the equations.
   b) Discuss what is occurring.
   c) What do you notice about the equations?
   d) How many solutions does this system have?

3) Given the following pair of linear equations \( 2Y - 2 = 4X \), and \( Y = 2X + 1 \)
   a) Graph the equations.
   b) Discuss what the graph is showing you.
   c) How many solutions does this system have?
## APPENDIX F

### Diagnostic Test

1. Write an expression to represent the following: "3 kilometers less than \( \frac{2}{5} \) the distance, \( d \)"

   Answer: 

2. A collection of nickels and dimes is worth $1.85. There are 26 coins in all.

   How many dimes are there?
   - dimes

   How many nickels are there?
   - nickels

3. Solve: \(-4(-3 + 6x) + 6 = -3\)

   Answer: 

4. Divide: \(-\frac{8}{0}\)

   - A. 8
   - B. \(-8\)
   - C. Undefined
   - D. 0
   - E. None of these

5. The sum of two numbers is 7. One of the numbers is 3 times the other number. What is one of the numbers?

   - A. 2
   - B. \(\frac{7}{3}\)
   - C. \(\frac{7}{4}\)
   - D. None of these
   - E. 1
6. If \( f(x) = 10x^2 - 9x - 9 \), what is \( f(-2) \)?

\[ f(-2) = \square \]

7. Draw the graph of \(-4x - 3y \leq 7\)

- [ ] A.
- [ ] B.
- [ ] C.
- [ ] D.

8. Solve \( PV = nRT \) for \( V \).

- [ ] A. \( PnRT \)
- [ ] B. \( nRT - P \)
- [ ] C. None of these
- [ ] D. \( \frac{P}{nRT} \)
- [ ] E. \( \frac{nR}{PT} \)
9. Solve: \(9x + \frac{9}{4} = 9 + \frac{13}{12}x\)

A. None of these
B. \(\frac{5}{2}\)
C. \(\frac{144}{31}\)
D. \(\frac{61}{54}\)
E. \(\frac{72}{5}\)

10. Solve: \(-7 + x + 10x = -1x - 9\)

A. \(\frac{1}{6}\)
B. \(\frac{1}{5}\)
C. \(\frac{5}{1}\)
D. \(\frac{6}{1}\)
E. None of these

11. A collection of nickels and dimes is worth \(\$0.60\). There are 8 coins in all. If \(n\) is the number of nickels and \(d\) is the number of dimes, the system of equations that solves the problem is:

A. \(n + d = 8\)
   \(5n + 10d = 0.60\)
B. None of these
C. \(n + d = 8\)
   \(5n + 10d = 60\)
D. \(n + d = 0.60\)
   \(0.05n + 0.10d = 8\)
E. \(0.15nd = 8\)
   \(0.05n + 0.10d = 0.60\)
12. A collection of nickels and dimes is worth $0.70. If the dimes were nickels and the nickels were dimes the value would be $1.10.

How many dimes are there?

☐ A. 10
☐ B. 2
☐ C. None of these

How much are the nickels worth?

☐ A. $0.20
☐ B. $0.50
☐ C. None of these

13. Simplify the absolute value: $|2 - 14|$

Simplified Answer: [ ]

14. Solve: $8 - 10x \geq 33$

☐ A. $x \geq -\frac{43}{10}$
☐ B. $x \geq -\frac{10}{43}$
☐ C. None of these
☐ D. $x \leq 0$
☐ E. $x \leq -\frac{10}{43}$

15. A total of $22100 was invested in two accounts. One account earned 2.7% simple interest and the other earned 2.6% simple interest. At the end of one year the interest income was $582.70.

How much money was original invested at 2.7%?

S [ ]

How much interest did the 2.7% account earn?

S [ ]
16. What is the slope of the line containing the points \((7, 9)\) and \((-5, 4)\)?

- **A.** None of these
- **B.** \(\frac{5}{12}\)
- **C.** \(\frac{12}{5}\)
- **D.** \(\frac{5}{12}\)
- **E.** \(\frac{12}{5}\)

17. 268 tickets were sold for a play. Student tickets cost $8 and non-student tickets cost $9. The total box office receipts were $2265.

- How many student tickets were sold? \(\square\) tickets
- What were the receipts from non-student tickets? $\square$

18. Brand X, worth $5.70 per pound, is to be mixed with brand Y, worth $9.70 per pound. The result is to be a 300 pound mix worth $8.10 per pound.

- How many pounds of brand X are needed? \(\square\) lbs
- How much money was spent on brand Y? $\square$

19. Write the equation of the line, with the given properties, in slope-intercept form.

Through \((-7, -5)\) and \((-5, 7)\)

The equation of the line is \(\square\).

(Simplify your answer. Type your answer in slope-intercept form.)
20. Solve: \[8x = 55 + 5y\]
\[
4x + 8y = -4
\]

\[x=\]

\(\text{A. No solution}\)

\(\text{B. } -5\)

\(\text{C. None of these}\)

\(\text{D. Infinitely many solutions}\)

\(\text{E. } 5\)

\[y=\]

\(\text{A. Infinitely many solutions}\)

\(\text{B. } -3\)

\(\text{C. } 3\)

\(\text{D. No solution}\)

\(\text{E. None of these}\)

21. Perform the Indicated Operations: \[\frac{3}{8} - \frac{8}{7}\]

Select the simplified answer below:

\(\text{A. } \frac{475}{87}\)

\(\text{B. } \frac{421}{56}\)

\(\text{C. } \frac{517}{56}\)

\(\text{D. } \frac{475}{448}\)

\(\text{E. None of these}\)

\(\text{F. } \frac{475}{56}\)
22. Multiply: \(-\dfrac{3}{19} \cdot \dfrac{11}{13}\)

- A. \(\dfrac{39}{209}\)
- B. \(\dfrac{248}{247}\)
- C. \(\dfrac{33}{247}\)
- D. None of these
- E. \(\dfrac{209}{39}\)

23. Solve: \(6x + 7y = -10\)
\(18x + 21y = -2\)

Answer: \(x=\quad\)
\(y=\quad\)

If there is no solution put a capital N in both boxes, if there are infinitely many solutions put a capital I in both boxes.

24. Solve: \(9x - 8y = -21\)
\(27x - 24y = -63\)

\(x=\)
- A. -5
- B. No solution
- C. 5
- D. None of these
- E. Infinitely many solutions

\(y=\)
- A. -3
- B. None of these
- C. 3
- D. Infinitely many solutions
- E. No solution
25. A bag of fertilizer covers 1800 square feet of lawn. Find how many bags of fertilizer should be purchased to cover a lawn with an area of 38800 square feet.
   Answer: ___ bags

26. What are the intercepts for the graph: $-6x + 3y = 10$
   Enter each answer as an ordered pair:
   X-Intercept: ___
   Y-Intercept: ___

27. The sum of three consecutive integers is 273. What is the largest integer?
   - A. 93
   - B. 90
   - C. None of these
   - D. 89
   - E. 91

28. What is the y-intercept of the line $x + 9 = 8$
   - A. (0,0)
   - B. (0,17)
   - C. (0,1)
   - D. There is no y-intercept
   - E. None of these
## APPENDIX G

Test Scores SLC 2011

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<th>First name</th>
<th>Diagnostic Test</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
<th>Final</th>
<th>Class</th>
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# APPENDIX H

## GROUP AVERAGES

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