

## ABSTRACT

CAVE, MIRANDA DAWN. Impact of Community Service Learning on Middle School African and Latino Americans' Understanding of Mathematics. (Under the direction of Karen F. Hollebrands.)

The purpose of this study is to examine how community service learning affects students' engagement and mathematical understanding of geometric transformations.

Six African American and four Latino American sixth grade students participated in the study. These students attended an after-school community learning service activity over the course of a semester. The community service activity centered on promoting art and culture awareness in their school while the academic goal focused on geometric transformations.

The questions that guided the study are (1) how can community service learning engage African and Latino Americans in learning geometry, and (2) what is the nature of African and Latino Americans' growth in understandings of geometric transformations.

For each research question, both quantitative and qualitative data was collected and analyzed. Quantitative data included a pre-and posttest Engagement questionnaire and a pre-and posttest Mathematics Understanding assessment. Qualitative data involved researcher notes, transcriptions, reflection journals, interviews, and Mathematics Understanding assessment. Quantitative data was analyzed by employing nonparametric statistical methods. For the qualitative data, Lave & Wenger's (1991) framework on legitimate peripheral participation was applied to examine participants' engagement in mathematics. Also, Pirie & Kieren's (1994) growth in mathematical understanding model was used to analyze students' improvement in their mathematical understanding of transformations. The findings from the quantitative data did not demonstrate a statistically significant improvement in African and Latino Americans' engagement or their growth in understanding geometric transformations.

The results from the qualitative data showed that community service learning engages African and Latino Americans in the mathematics and the activity and may promote students' understanding of growth in understanding of geometric transformations.

Impact of Community Service Learning on Middle School African and Latino Americans'  
Understanding of Mathematics

by  
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## DEDICATION

I would like to dedicate my work to my family and friends who have always been there for me and especially to my loving and supportive fiancé Kevin who helped me achieve things I never thought possible.

"Our truest life is when we are in our dreams awake."

-Henry David Thoreau

## BIOGRAPHY

Miranda Cave was born on March 13, 1980 in Elkin, North Carolina as the daughter of Michael and Deborah Cave. She lived in Dobson, North Carolina until she was sixteen years old. Dobson is a small town, located at the foothills of the mountains near the Virginia border. Her parents are currently living in Lowgap, NC, a small town where her father grew up. At the age of sixteen, Miranda moved to Durham, North Carolina to attend a boarding school. She lived in Winston-Salem, NC and Raleigh, NC to attend college and graduate school. Presently, she lives in Raleigh, NC.

During high school, Miranda wanted to become a dermatologist and research skin cancer. Accordingly, she volunteered as a Candy Striper for a local hospital and a hospice center. Miranda then transferred to a college preparatory boarding school located in Durham, NC in 1996. The boarding school required all students to volunteer to repay the community for the free tuition of the school. Miranda fulfilled her volunteer requirement for the school by tutoring mathematics at a local community college. While tutoring, Miranda discovered that she loved teaching mathematics and loved the diversity at the community college. As a result, she decided to become a mathematics instructor at a community college.

In order to pursue a mathematics-teaching career, Miranda attended undergraduate school at Wake Forest University from 1998 to 2001 where she majored in mathematics and minored in education. While at Wake Forest University, she received a North Carolina Teaching License for secondary mathematics. One of the requirements for this license was a student teaching experience, which she completed at R.J. Reynolds High School in Winston-

Salem, NC. Upon graduating in 2001 with a B.S. in mathematics, Miranda decided to further her mathematics education and obtain her Master's degree in mathematics at North Carolina State University in Raleigh, NC. While at North Carolina State University, she worked as a teaching assistant in the mathematics department and also worked at the Sylvan Learning Center teaching mathematics and study skills to elementary, middle, and high students. As a result, Miranda was exposed to a variety of mathematics, from elementary to undergraduate levels. As her love for teaching and for mathematics increased, she had to learn more about teaching mathematics.

After she achieved her M.S. in 2003, Miranda decided to continue her education at North Carolina State and obtain a Ph.D. in Mathematics Education. While working on her Ph.D., she taught mathematics at a community college. By simultaneously attending school and working at the community college, her teaching has improved and she has been able to implement new ideas from her mathematics education courses. Miranda is scheduled to receive her Ph.D. in 2008.

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## CHAPTER 1. INTRODUCTION

### *Research Problem*

Despite efforts to lessen the achievement gap in mathematics between Caucasian Americans and African and Latino Americans, discrepancies in test scores among these different racial groups still exist. “By 12th grade, the average African American and Hispanic student can only do math and read as well as a white eighth grader” (American Education Research Association, 2004, p. 1). Many policy makers have taken note of such discrepancies and as a result passed legislation, such as the No Child Left Behind Act (U.S. Department of Education, 2001), that requires schools to address this problem directly. Also, the National Council of Teachers of Mathematics (2000) states that every student should have the chance and support to learn mathematics no matter the student’s background. The desire to ensure that all students are successful in mathematics juxtaposed with the presence of this achievement gap has raised concerns about how mathematics teachers and researchers can address this problem.

The presence of this mathematics achievement gap also has implications for the United States’ economy (Kober, 2001; National Academy of Sciences, National Academy of Engineering, & Institute of Medicine of the National Academies, 2007; Tate, 1997). According to Kober (2001), “by 2010, Black and Hispanic children are projected to make up 34% of the school-age population” (p. 10). In other words, the racial minority appears to be slowly emerging as the racial majority in the United States (Kober, 2001; Tate, 1997). If these students continue to be underserved in schools, then there will exist a large proportion



of high school graduates who will not be prepared to enter college or the workforce.

Consequently, the mathematics achievement gap does not only affect individual students, it also affects the nation as a whole.

Concerns with the national economy have spurred some educational initiatives that suggest the mathematics achievement gap is improving (Tate, 1997). However, Table 1 from the National Center for Education Statistics shows that, at the end of 2007, there were still significant differences between Caucasian Americans' and African and Latino Americans' mathematical achievement. The data suggests that changes in approaches to teaching may be needed in order to assist African and Latino Americans in learning mathematics and to close the achievement gap (Ladson-Billings, 1997; Lubienski, 2002).

Table 1. 2007 eighth-grade national average scale scores for mathematics from the NAEP reports (National Center for Education Statistics, n.d.).

<b>Black</b>	<b>Hispanic</b>	<b>White</b>
259	264	290

Note: Scale Score ranges from 0 to 500

Research has shown that community service learning has positive, and even statistically significant, effects on African and Latino American students' core GPA and mathematics grades (Melchior, 1998). According to the Learn and Serve America (Melchior, 1998) findings, students' core GPA had a statistically significant increase ( $p=0.01$ ) and their mathematics grade had a statistically significant increase ( $p=0.05$ ) when engaged in community service. Melchior (1998) Some of the community service activities that were examined in the Learn and Serve America Evaluation included students working in hospitals to learn about the national health care debate, sponsoring a student/police basketball game for

an anti-violence campaign, and assisting in revitalizing a park by partnering with the Park and Recreation Department (Melchior, 1998).

### *Purpose*

The purpose of this study is to examine the affects of community service learning on African and Latino American students' engagement and understanding of mathematics. Although the achievement gap exists across all areas of mathematics, this study focuses primarily on middle school African American students' struggles with geometric topics. According to research, "elementary and middle school students in the United States are...woefully underprepared for the study of more sophisticated geometric concepts and proof, especially when compared to students from other nations" (Clements & Battista, 1992, p. 421). The Third International Mathematics and Science Study (TIMSS) reports that seventh grade students in the United States answered only 44% of the geometry questions problems correctly and 36% correctly on measurement questions (Beaton et al., 1996). In comparison, Japanese seventh graders answered 70% of the problems correctly in geometry and 62% correctly in measurement (Beaton et al., 1996). Not only are American middle school students struggling internationally, African and Latino Americans are struggling nationally with geometry and measurement. According to the National Assessment of Educational Progress (NAEP) data, White American eighth grades are still significantly outperforming both Black and Hispanic American eighth graders in both geometry and measurement (Table 2). Therefore, there is a need to address African and Latino Americans' educational needs to close the mathematics achievement gap in the United States; topics that

warrant special attention are geometry and measurement.

Table 2. Average scale scores with percentages for mathematics measurement and geometry for eighth graders. Data used in NAEP reports after 2001 (National Assessment of Educational Progress, n.d.).

<b>Race/ethnicity used in NAEP reports after 2001</b>	<b>Average Scale Score for Mathematical Measurement</b>	<b>Average Scale Score for Mathematical Geometry</b>
White	289	284
Black	244	254
Hispanic	255	261
Asian Amer/Pacif Isl	293	290
American Indian	262	264
Unclassified	276	276

Note: Scale Score ranges from 0 to 500.

### *Research Questions*

The objective of this study is to explore the mathematical experiences of African and Latino Americans as they engage in a community service learning project. The phenomena to be examined are African and Latino Americans' engagement in learning mathematics through community service experiences and how community service learning affects their understanding of geometric concepts. Accordingly, participants in this study are African and Latino American students who are currently in sixth grade, taking a mathematics course, and participating in a community service learning activity. The questions that guide the study are (1) how can community service learning engage African and Latino Americans in learning geometry? and (2) what is the nature of African and Latino Americans' growth in understandings of geometric transformations in the plane, which include reflections, translations, and rotations, during the course of a semester when they are involved in a community service learning activity?

### *Definition of Terms*

There are many definitions and theories of community service learning and engagement. Both terms are defined below.

#### *Community service learning*

Schine & Halsted (1997) define service learning as the “the pairing of meaningful volunteer work with opportunities to reflect critically on the experience through regular group discussions” (p. 198). Melchior (1998) extends this definition by stating that service learning “link[s] meaningful service in the community with a structured learning experience” (p.1). To maintain a structured learning environment, community service learning must include reflection (Arman & Scherer, Spring 2002; Schine & Halsted, 1997; Totten & Pedersen, 1997). Community service learning also helps students develop a sense of caring (Silcox, 1995). Other definitions include students’ personal development and growth as citizens (Schukar, 1997; Thompson & Carpenter, 2001). For example, Dunlap (1994) states that “service learning is an educational method which engages young people in service to their communities as a means of enriching their academic learning, promoting personal growth, and helping them to develop the skills needed for productive citizenship” (as cited in Thompson & Carpenter, 2001, p. 177). There are other types of definitions that focus on service learning as a teaching method (Atchison & Tumminia, 1998; Bartsch, 2001; Thompson & Carpenter, 2001; Totten & Pedersen, 1997). For this study, community service learning, (CSL), is defined as a teaching method that connects a meaningful community service with a planned academic learning concept and encourages students to reflect critically

and continuously throughout their experiences (Melchior, 1998; Schine & Halsted, 1997).

### *Engagement*

This research study will investigate whether complementing traditional instruction with CSL will provide students with more opportunities to become engaged in mathematics learning. If students are engaged in mathematics, they learn and retain more (Akey, 2006). Accordingly, CSL relies on students' engagement. While examining students' engagement, this study utilizes the following definition:

Student engagement can be defined as the level of participation and intrinsic interest that a student shows in school. Engagement in schoolwork involves both behaviors (such as persistence, effort, attention) and attitudes (such as motivation, positive learning values, enthusiasm, interest, pride in success). Thus, engaged students seek out activities, inside and outside the classroom, that lead to success or learning. They also display curiosity, a desire to know more, and positive emotional responses to learning and school. (Akey, 2006, p.3)

In addition, the definition will be extended to incorporate the concept that engagement includes reflection. For example, engagement involves “intentionality as an ongoing flow of reflective moments of monitoring” (Giddens, 1979, as cited in Lave & Wenger, 1991, p. 54). Lave & Wenger (1991) contend that “this flow of reflective moments is organized around trajectories of participation” (p. 54). Hence, student engagement consists of ongoing reflection and as a result defines the type of student participation. Therefore, student's engagement will be assessed based on students' type of participation and level of reflection (Figure 1).

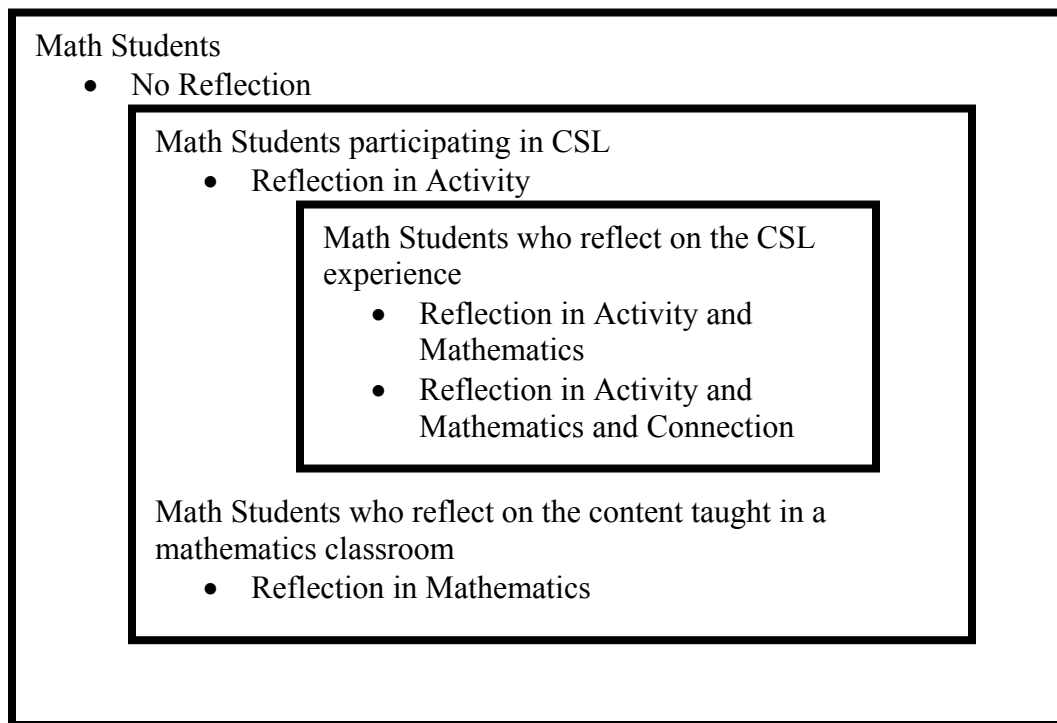


Figure 1. Engagement Diagram

### *Significance*

National and International comparisons suggest that there are inequities in the mathematical performance of students from different racial backgrounds (Beaton et al., 1996; Ladson-Billings, 1997; Lubienski, 2002; National Assessment of Educational Progress, n.d.; National Center for Education Statistics, n.d.; Tate, 1997). NCTM (2000) states “Equity does not mean that every student should receive identical instruction; instead, it demands that reasonable and appropriate accommodations be made as needed to promote access and attainment for all students” (p. 11). One modification to teaching mathematics equitably is to incorporate new teaching strategies. CSL is one strategy that has been successfully implemented into various fields, specifically science, medicine, and student improvement

programs (Atchison & Tumminia, 1998; Bartels, 1998; Battistoni & Hudson, 1997; Boston, 1998 - 1999; Carnegie Council on Adolescent Development, 1989; Cohen, Johnson, Nelson, & Peterson, 1998; George, 1997; Laplante, 1995; Macnee, White, & Hemphill, 1998; Norbeck, Connolly, & Koerner, 1998; Schine, 1997; Schukar, 1997; Solo, 1995; Thompson & Carpenter, 2001; Weah & Wegner, 1997). For example, Schukar (1997) reported how CSL is used in science and social studies to connect knowledge gained in the classroom with real world situations. In its Connections Standard, NCTM (2000) suggests that all students should be able to “recognize and apply mathematics in contexts outside of mathematics”(p. 63). Since CSL has been successful in connecting other subjects to real world situations, it seems appropriate to apply community service learning to mathematics. There are several CSL projects that focus on mathematics (Caniglia, 2003; Duke, 1999; Nagchaudhuri & Conway, 1999; O'Donnell, 2001; Root & Thorne, 2001). However, specific mathematics concepts have not been the main learning objective for CSL and have not been thoroughly researched (Root & Thorne, 2001). As a result, this study will provide insight to the effects of CSL on African and Latino Americans’ understanding of transformations as well as their engagement in learning mathematics.

### *Justification of Participants*

With the existence of the mathematics achievement gap, African and Latino Americans are the focus of the study. In addition, middle school students are underperforming in geometry and are not prepared for higher level geometry (Beaton et al., 1996; Clements & Battista, 1992). Specifically, eighth grade African and Latino American

students are struggling in geometry compared to Caucasian students (National Assessment of Educational Progress, n.d.). Because students are performing low on geometry and transformations are introduced in the sixth grade, the level of mathematics for this study is sixth grade. Hence, the participants in this study are African and Latino Americans and are in the sixth grade.

### *Justification of Methodology*

In order to examine African and Latino American students' engagement and understanding of mathematics, qualitative and quantitative methods are used. Qualitative methods are used to study students' reasoning and understanding. Students' understanding is "a whole, dynamic, leveled but non-linear, transcendentally recursive process" (Pirie & Kieren, 1994, p. 166). Hence, students continuously refer back to their previous knowledge as well as skip several levels of understanding (Pirie & Kieren, 1994). The only way to observe these occurrences is to utilize qualitative methods (Pirie, 1996). Additional information about students' learning and understanding of mathematical ideas can be obtained through quantitative measures as well. These measures will provide the researcher with additional data regarding changes in students' understandings of geometric transformations as a result of the community-service learning activity and will allow the researcher to compare students participating in the activity with those who do not participate.

### *Organization of Remaining Chapters*

The following chapter reviews the literature associated with geometric transformations, past and present research on CSL, and the conceptual frameworks that guide



this study. Chapter 3 outlines the methods used in this study. The findings are discussed in Chapter 4 and Chapter 5 concludes and summarizes the study.

## CHAPTER 2. LITERATURE REVIEW

In order to examine African and Latino Americans' engagement and understanding of mathematics, specifically geometric transformations, a review of past and present research on geometric transformations, community service learning, and theoretical frameworks is provided. The goal of this chapter is to review the literature that guides this study.

### *Geometric Transformations*

In this section, geometric transformations and how they are defined in college mathematics and for sixth grade students are presented, followed by a discussion of research related to students' learning of geometric transformations. A geometric transformation on the plane is formally defined as “a one-to-one correspondence from the set of points in the plane onto itself” (Martin, 1982, p. 1). In other words, a point in the plane  $(x, y)$  can be mapped to another point in the plane  $(x', y')$ . Table 3 includes definitions for each type of transformation.

Each transformation can be defined in terms of a composition of reflections. For example, two reflections in parallel lines results in a translation and two reflections in intersecting lines form a rotation (Martin, 1982). Glide reflections are a composition of reflections and a specific kind of translation (Martin, 1982). The direction of the translation is parallel to the line of reflection (Martin, 1982). Glide reflections can begin with a reflection and end in a translation or they can begin with a translation and end with a reflection (Martin, 1982). In addition, reflection in a line defines bilateral symmetry (Genkins, 1975). Also, “any rigid motion can be replaced by at most three line reflections”

(Genkins, 1975, p. 8). Hence, reflections are crucial in the understanding of transformations, their distinct characteristics, and relationships they share.

Table 3: Geometric Transformations (Martin, 1982)

Geometric Transformation	Definition
Translation	Mapping having equations of the form $\begin{cases} x' = x + a \\ y' = y + b \end{cases}$ (p. 14)
Reflection	$\sigma_m$ in a line $m$ is the mapping defined by $\sigma_m = \begin{cases} P, & \text{if point } P \text{ is on } m \\ Q, & \text{if } P \text{ is off } m \text{ and } m \text{ is the perpendicular bisector of } \overline{PQ} \end{cases}$ (p. 24)
Rotation	About a point $C$ through directed angle of $\Theta^\circ$ is the transformation $\rho_{C,\Theta}$ that fixes $C$ and otherwise sends a point $P$ to the point $P'$ where $CP' = \vec{CP}$ and $\Theta$ is the directed angle measure of the direction angel from $\vec{CP}$ to $\vec{CP'}$ (p. 39)

A thorough understanding of transformations is essential for the researcher in order to assess students' understanding of transformations. However, this study focuses on transformations as they are defined for sixth grade mathematics. The transformations included in the sixth grade curriculum are reflections, rotations, and translations that occur in the coordinate plane. In many sixth grade text books a reflection is defined as a transformation that “moves a figure about a line so that its new position is its mirror image on the opposite of the line” (Larson, Boswell, Kanold, & Stiff, 1999, p. 667). Rotations are

defined as “an operation that turns a figure a given angle (clockwise or counterclockwise) about a point” (Larson et al., 1999, p. 671). In this study, all rotations are counterclockwise. The last type of transformation is a translation. Translations are simply slides, “mov[ing] a figure without turning or flipping” (Larson et al., 1999, p. 670).

### *Students’ understanding of transformations*

In addition to understanding geometric transformations, it is crucial for the researcher to compare students’ understanding of transformations with other research. For elementary students, bilateral symmetry is an essential concept in children’s study of geometric transformations because of its closeness to a reflection (Genkins, 1975). Children are exposed to symmetry at birth, however their understanding of symmetry is not fully developed until twelve years of age (Clements, 2003; Genkins, 1975). “Vertical bilateral symmetry is easier for students to handle than horizontal symmetry (Clements, 2003, p. 162). Students especially struggle with diagonal line of reflection (Hollebrands, 2004; Schultz & Austin, 1983). Hollebrands (2004) conducted task-based interviews with six tenth grade students and found that “most students seemed to envision flipping the preimage over the line of reflection but did not carefully consider that the line of reflection would be the perpendicular bisector of the segments created by joining corresponding preimage and image points” (p. 208). Students appear to view rotations as turning, however they struggle with the center of rotation (Hollebrands, 2004). Specifically, students have difficulties with rotations about a point that is not on the figure (Hollebrands, 2004). In addition, many of the students did not consider that the points on the preimage and image are equidistance from the center

of the rotation (Hollebrands, 2004). In regards to translations, students are able to slide figures and conserve the congruency of the preimage and image (Hollebrands, 2004). On the other hand, the translating vector creates uncertainties for the students and how it impacts the image (Hollebrands, 2004). Correspondingly, the direction of any transformation may create problems for students (Clements, 2003; Hollebrands, 2004; Schultz & Austin, 1983). In addition, “slides appear to be the easiest motions for students, then flips, then turns” (Clements, 2003, p. 162). In contrast, Hollebrands (2004) discovered that translations are the hardest transformation for students. In her study, Hollebrands (2004) included translating vectors where as Clements (2003) complied studies that utilized directional descriptions instead of translating vectors. In addition, Hollebrands (2004) examined high school students’ and Clements (2003) examined elementary students’ understanding of geometric transformations. Thus, “the presence of the vector may have confused students” (Hollebrands, 2004, p. 212). After examining students’ difficulties with the line of reflection, center of rotation, and translating vector, students appear to view transformations as actions or procedures instead of as a object or a mathematical group (Edwards, 1991; Hollebrands, 2004; Natsoulas, 2000).

Although students are exposed to transformations throughout their life, students still struggle with conceptually understanding geometric transformations. Technology is one way of helping students develop concepts of reflections, translations, and rotations. Logo, Geometer’s Sketchpad, and other computer software and games are currently being utilized so students can physically examine properties of transformations (Clements, 2003; Clements,

Battista, & Sarama, 2001; Edwards, 1991). Through visual examination, students can gain a deeper understanding of geometric transformations. In this study, students utilize digital photographs to visually examine geometric transformations in a real world context.

### *Community Service Learning*

One way to promote visual examinations of transformations is to utilize new teaching strategies. One strategy that allows incorporation of visualizations is community service learning (CSL). CSL integrates the curriculum with the real world, thus providing students with meaningful visuals. CSL is defined as a teaching method that “link[s] meaningful service in the community with a structured learning experience” (Melchior, 1998, p. 1) and provides students with “opportunities to reflect critically on the experience through regular group discussions” (Schine & Halsted, 1997, p. 198). Consequently, the two main components of CSL are community service and the learning opportunities it provides for students. The five phases of CSL used in this study are planning, service, academic, reflection, and celebration. The following sections discuss the phases, benefits, and challenges of CSL.

#### *Planning*

In order for student learning to take place, CSL involves several components. These components include planning, service, academic, reflection, and celebration. The first component of CSL is guided planning. (Thompson & Carpenter, 2001, p. 180). Planning involves finding a community service need that is suitable for your students (Macnee et al., 1998; Thompson & Carpenter, 2001). Collaboration with the community is essential to

ensure selecting a suitable community service learning activity (Carnegie Corporation of New York, 2000; Carnegie Council on Adolescent Development, 1989; Wade, 1997c).

Through collaboration with the community, teachers can establish community support for their schools. In 1986, Carnegie Corporation of New York formed a council of educators, researchers, government officials, health care workers, nonprofit agents, and philanthropist (Carnegie Council on Adolescent Development, 1989). The council was designed to address challenges during the adolescent years (Carnegie Council on Adolescent Development, 1989). One recommendation that the council suggested is to:

Connect schools with communities, which together share responsibility for each middle grade student's success, through identifying service opportunities in the community, establishing partnerships and collaborations to ensure students' access to health and social services, and using community resources to enrich the instructional program and opportunities for constructive after-school activities. (Carnegie Council on Adolescent Development, 1989, p. 9-10)

Teachers can utilize local agencies established in the community (Bartsch, 2001; Carnegie Council on Adolescent Development, 1989; Schine & Halsted, 1997). For example, the YMCA, YWCA, Boy Scouts, and Girl Scouts can guide you in age appropriate activities (Carnegie Council on Adolescent Development, 1989). "The surrounding community is an enormous potential resource for educating young adolescents" (Carnegie Corporation of New York, 2000, p. 209). Local businesses, universities, and government agencies can also provide support by providing schools with a locality, supplies, and financial assistance

(Carnegie Council on Adolescent Development, 1989; Schine & Halsted, 1997; Wade, 1997c). In turn, the CSL activity gains administrative and political support (Carnegie Corporation of New York, 2000; Carnegie Council on Adolescent Development, 1989; Schine & Halsted, 1997; Thompson & Carpenter, 2001; Wade, 1997c). Another step in planning is recruiting students to select and participate in the community service activity (Schine & Halsted, 1997; Wade, 1997f). It is important to encourage students from all academic levels to join the CSL activity (Schine & Halsted, 1997).

Once the CSL activity is selected, the rationale and learning outcomes of the community service must be stated (Schine & Halsted, 1997; Thompson & Carpenter, 2001; Wade, 1997f). For example, the rationale should address the following questions:

1. What are the pressing needs in the community? What are the students' most pressing concerns? How can the two be addressed in a mutually beneficial manner?
2. How will service make learning relevant? What connections can be made between the service experience and academic subject areas?
3. What impact will the service have on the children?
4. If the program is successful, how will the young people have changed as a result of their experience? What skills and sensitivities will they have gained in their community work? (Schine & Halsted, 1997, p. 201)

The last phase of planning includes finalizing the logistics (Schine & Halsted, 1997).

Logistics include transportation, time commitment, permission forms, site confirmation,



supervisors, and on-site guidelines (Schine & Halsted, 1997; Wade, 1997f). An orientation should be held in order to train students on the site-guidelines as well as hear students' initial ideas about the community service activity and learning (Schine & Halsted, 1997; Seigel, 1995; Totten & Pedersen, 1997; Wade, 1997f).

### *Service*

One of the major components of CSL is service. Service allows students to become directly involved in their community (Schukar, 1997; Wade, 1997h). "Community service refers mainly to a variety of individual voluntary efforts" (Boyte, 1991, as cited in Totten & Pedersen, 1997, p. 2). Hence, students are volunteering their time to impact the community (Macnee et al., 1998). In order to make a difference within the community, the service activity must be meaningful, meeting needs that the community deems important and also impacts the students (Norbeck et al., 1998; Seigel, 1995; Thompson & Carpenter, 2001; Wade, 1997h). Through community service, students begin to feel responsible for their community (Thompson & Carpenter, 2001; Wade, 1997h). In its evaluation, Learn and Serve America found that 92.9% of middle school students who participated in the program felt that the service they performed was helpful to the community (Melchior, 1998). Hopefully, students begin to consider "service as a lifelong commitment" (Macnee et al., 1998, p. 67).

### *Academic*

In addition to service, CSL includes an academic goal. According to Wade (1997d), "the components of curriculum integration and reflection are, in fact, what distinguishes

service-learning from community service” (p. 20). Hence, the community service must possess academic integrity (Thompson & Carpenter, 2001; Wade, 1997d). The difference between many service learning programs is the emphasis on the academic portion of service learning. During the 1996-1997 school year, Scales (1999) examined three middle schools in Kentucky, Massachusetts, and Missouri. Each school participated in a wide range of CSL activities (Scales, 1999). Scales (1999) discovered that “Among the service-learning teachers, increasing academic achievement was the *least* important of six possible goals for service-learning” (p. 42). On the other hand, the Traverse Outreach Project (TOP), a CSL program for counselors at the University of New Mexico, “places a greater value on students ‘learning’ than on ‘service’ to the community” (Arman & Scherer, Spring 2002, p. 73). However, Atchison & Tumminia (1998) state that, for the nursing CSL curriculum at Northern Virginia Community College “the actual intent of service-learning is that service and learning are equal in weight *and* emphasis” (p. 77). Therefore, the goal of service learning is “to integrate service and social action into academic programming by encouraging schools to develop curricula that connect life experiences with learning” (Weah & Wegner, 1997, p. 230). Advocates of CSL, such as the Learn and Serve Program, highly support the integration of service into the academic curriculum (Carnegie Council on Adolescent Development, 1989; Melchior, 1998; Schukar, 1997; Wade, 1997e).

Through integration of service into the school curriculum, students will have opportunities to experience how the classroom connects to the real world (Bartsch, 2001; Melchior, 1998; Schine & Halsted, 1997; Schukar, 1997). A national evaluation of middle

and high schools that participated in the community-based programs from Learn and Serve America was conducted in the 1995-1996 school year with a follow up study in 1997 (Melchior, 1998). In 1993, the National and Community Service Trust Act instituted the Learn and Serve America programs (Melchior, 1998). The goal of the program was to help students connect meaningful service to learning as well as provide services needed in the community (Melchior, 1998). According to the national evaluation, “Service helped [students] make the connection between the ‘real world’ and what they were learning in their classroom...the service itself was meaningful – that their work was making a difference in the lives of others” (Melchior, 1998, p. 53). By making learning meaningful, students begin to see a reason to learn (Carnegie Council on Adolescent Development, 1989; Melchior, 1998; Schukar, 1997; Totten & Pedersen, 1997; Wade, 1997e). One student from the Learn and Serve Program reported that

And, if you were working with the elderly, you could actually go in and see what’s Medicare and Medicaid and how it does apply. You could actually look at the facts. I wouldn’t say I went in and took some of this and, applied it. But once you have the background and the facts, you do apply it. And, you see how everything fits together. (Melchior, 1998, p. 56)

Thus, CSL allows students to actively learn (Totten & Pedersen, 1997). CSL creates student-centered approach to learning (Schukar, 1997).

CSL also focuses on students’ long-term understanding and learning. “Education reformers view service-learning as an effective tool for helping young people learn more and

retain more of what they learn” (Wade, 1997d). Specifically, service learning improves problem-solving skills, critical thinking skills, decision making skills, communication skills, project specific skills, creativity, and self-directed learning skills (Bartsch, 2001; Carnegie Council on Adolescent Development, 1989; Cohen et al., 1998; Macnee et al., 1998; Norbeck et al., 1998; Schukar, 1997; Thompson & Carpenter, 2001; Totten & Pedersen, 1997; Wade, 1997d, 1997e). In addition, service learning helps students see connections between school, employment, and community (Arman & Scherer, Spring 2002; Atchison & Tumminia, 1998; Bartels, 1998; Bartsch, 2001; Macnee et al., 1998; Norbeck et al., 1998; Thompson & Carpenter, 2001; Totten & Pedersen, 1997). Also, due to service learning’s interdisciplinary nature, students see the connections between the academic subjects (Arman & Scherer, Spring 2002; Bartsch, 2001; Carnegie Council on Adolescent Development, 1989; Macnee et al., 1998; Schukar, 1997; Weah & Wegner, 1997). Hence, students gain a deeper academic understanding through seeing and applying the connections between the classroom and the community, between theory and practice (Arman & Scherer, Spring 2002; Cohen et al., 1998; Norbeck et al., 1998; Thompson & Carpenter, 2001). For example, Arman & Scherer (Spring 2002) studied seven graduate students in the CSL preparation for counselors and observed that “Combining theory and practice helps deepen the understanding of the course content for students” (p. 71).

Another educational value of CSL is preparing students to be contributing citizens and take active roles in the community (Bartels, 1998; Bartsch, 2001; Carnegie Council on Adolescent Development, 1989; Kinsley & McPherson, 1995; Macnee et al., 1998; Melchior,

1998; Norbeck et al., 1998; Schine & Halsted, 1997; Schukar, 1997; Thompson & Carpenter, 2001; Wade, 1997d). Schine & Halsted (1997) state that service learning makes “civic education come to life” (p. 197). Hence, CSL makes learning socially and personally relevant to the students (Totten & Pedersen, 1997). In addition, students experience diverse populations and cultural empowerment (Roberts-Weah, 1995; Wade, 1997d). As a result, students learn tolerance and acceptance of diversity (Wade, 1997d).

### *Reflection*

In order for students to actually learn from a service-learning activity, students need to reflect on their experiences (Arman & Scherer, Spring 2002; Atchison & Tumminia, 1998; Macnee et al., 1998; Norbeck et al., 1998; Scales, 1999; Schine & Halsted, 1997; Seigel, 1995; Thompson & Carpenter, 2001; Toole & Toole, 1995; Totten & Pedersen, 1997; Wade, 1997g). “Reflection engages the individual in a cycle of thought and action based on experience, introspection, shared and examined analysis, and finally synthesis” (Silcox, 1993, as cited in Atchison & Tumminia, 1998, p. 81). Through reflection, students learn to self assess and share ownership in the community and their own learning (Thompson & Carpenter, 2001). In addition, reflection allows students to grow intellectually by developing their critical thinking skills, problem solving skills, higher order thinking skills, and creativity skills (Arman & Scherer, Spring 2002; Macnee et al., 1998; Toole & Toole, 1995; Wade, 1997g). Reflection also helps students become aware of their own abilities and the learning that is actually taking place (Thompson & Carpenter, 2001). Toole & Toole (1995) created a service-learning cycle that incorporates reflection in all levels of the spiral, not just

as a summary at the end of the project (See Figure 2).

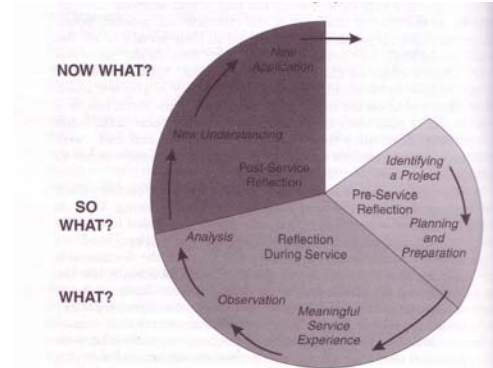


Figure 2. Reflection Spiral (Toole & Toole, 1995, p. 104)

Others also feel that reflection should be continuous, occurring before, during, and after the community service activity (Arman & Scherer, Spring 2002; Seigel, 1995; Thompson & Carpenter, 2001; Toole & Toole, 1995; Wade, 1997g). As such, students should be given time to reflect as well as be required to reflect (Arman & Scherer, Spring 2002; Scales, 1999; Schine & Halsted, 1997; Wade, 1997g). Reflection should be structured and guided in order to promote analytic and critical thinking skills (Arman & Scherer, Spring 2002; Atchison & Tumminia, 1998; Norbeck et al., 1998; Thompson & Carpenter, 2001; Wade, 1997g). As stated by Atchison & Tumminia (1998), “Critical reflective thinking by nursing students is a key fact in the service-learning project, but it is a learned skill” (p. 81). Through continuous reflection, students are given the opportunity to develop their reflection skills as well as improve their conceptual understanding.

There are several methods that encourage reflection. Learning logs, reflection logs, written assignments, journals, classroom discussions, artistic displays, portfolios, presentations, and student/peer assessments are a few examples of ways to encourage student

reflection (Arman & Scherer, Spring 2002; Macnee et al., 1998; Scales, 1999; Seigel, 1995; Thompson & Carpenter, 2001; Toole & Toole, 1995; Wade, 1997g). For older students, critiques and papers can be assigned (Arman & Scherer, Spring 2002; Macnee et al., 1998; Seigel, 1995; Toole & Toole, 1995). Another method is utilizing individual conferences to get students to reflect verbally prompted by the teacher (Macnee et al., 1998; Toole & Toole, 1995; Wade, 1997g). The more students reflect, learn how to reflect, and see how reflection helps their knowledge grow, students can utilize reflection on their own and outside of the classroom (Toole & Toole, 1995; Wade, 1997g). Through prolonged reflection, students become self-directed and lifelong learners (Toole & Toole, 1995; Wade, 1997g).

### *Celebration*

After students complete the community service activity and reflect on their experiences, they should be rewarded for their hard work (Arman & Scherer, Spring 2002; Schine, Summer 1997; Schine & Halsted, 1997; Thompson & Carpenter, 2001; Wade, 1997a). First, “celebrations that recognize student success can contribute to students’ self-esteem and self-efficacy” (Wade, 1997a, pp. 116-117). Second, celebrations make CSL fun (Wade, 1997a). Also, it teaches students how to reward themselves and acknowledge their contributions to the community (Thompson & Carpenter, 2001; Wade, 1997a). Celebrations are also for the community. Inviting the community to the celebration allows the students and the school to demonstrate their gratitude for the community’s support (Wade, 1997a). Furthermore, by attending the celebration, the community shows their appreciation to the school and the students (Schine & Halsted, 1997). Consequently, celebrations promote

students to continue participating in CSL, recruit new students to partake in community service learning, create stronger community connections, and increase community support (Thompson & Carpenter, 2001; Wade, 1997a).

### *Youth improvement*

One benefit of CSL is that it affects youths on a social level. First, working with other students, teachers, adults, and other citizens in the community assists students in developing positive relationships with others (Bartels, 1998; Schine, Summer 1997; Wade, 1997d). In addition, students develop a sense of social reality (Macnee et al., 1998; Thompson & Carpenter, 2001). For example, while participating in service learning, students explore various social issues that they may have never encountered or had first hand experience (Weah & Wegner, 1997). As a result, students develop a sense of social responsibility and realize that they can take an active role in helping the world around them (Arman & Scherer, Spring 2002; Schine, Summer 1997; Schukar, 1997; Wade, 1997d). Students also grow ethically and morally while participating in CSL (Arman & Scherer, Spring 2002; Bartels, 1998; Carnegie Council on Adolescent Development, 1989; Wade, 1997d). CSL allows students to perform good works for others (Arman & Scherer, 2002). Therefore, students become more caring and empathic towards others (Atchison & Tumminia, 1998; Carnegie Council on Adolescent Development, 1989; Wade, 1997d). Another aspect of youth's personal improvement is psychological. By participating in service learning, students' self-esteem, self-confidence, and self-image improve (Arman & Scherer, Spring 2002; Macnee et al., 1998; Schukar, 1997; Wade, 1997d). Hence, students



are less depressed, become more assertive and empowered in accomplishing their goals, and gain a sense of self competence (Arman & Scherer, Spring 2002; Schine & Halsted, 1997; Wade, 1997d). Because middle school students are in the transition of developing socially, psychological, and morally, they need constructive experiences to help them make a positive change. Research has shown that service learning provides excellent experiences for middle school students to grow personally as well as become informed citizens (George, 1997; Schine & Halsted, 1997; Schukar, 1997; Totten & Pedersen, 1997).

### *Community benefits*

Students are not the only ones who benefit from CSL. The community itself profits from CSL. This is especially important since “We are witnessing a profound loss of community in the United States” (Solo, 1995, p. 43). Through CSL, partnerships can be built between the school and community (Carnegie Council on Adolescent Development, 1989; Schukar, 1997; Wade, 1997d). Communities can provide resources for schools as well as support student learning and growth (Bartsch, 2001; Carnegie Corporation of New York, 2000; Wade, 1997d). In addition, schools can provide resources for the community (Bartsch, 2001; Thompson & Carpenter, 2001). “One of the most powerful outcomes of CSL is the shift in the community’s perception of schools and students” (Bartsch, 2001, p. vii).

Typically, communities do not view students as resources for solving or addressing problems in the community, however through CSL, students gain recognition as legitimate participants in the community (Bartsch, 2001; Wade, 1997d). For example, through CSL students provide direct aid desperately needed in the community (Arman & Scherer, Spring 2002;

Macnee et al., 1998; Melchior, 1998; Schukar, 1997; Wade, 1997d; Weah & Wegner, 1997). At the same time, students impart a youthful perspective on what needs to be addressed in the community and how to do so (Wade, 1997d). In other words, the community will be reinvented through students CSL (Schine & Halsted, 1997). As a result, schools treat the community as an extension to the classroom and the communities can consider schools as indispensable assets to the community (Carnegie Corporation of New York, 2000; Negroni, 1995). “In the long term, students come to see themselves as community-minded citizens and communities come to see youth as one of their most valuable resources” (Wade, 1997d, p. 29).

#### *History and examples*

If implemented appropriately, CSL can be a wonderful teaching method. The report Turning Points: Preparing American Youth for the 21<sup>st</sup> Century, recommended the use of youth service in order to help students become

- An intellectually reflective person;
- A person enroute to a lifetime of meaningful work;
- A good citizen;
- A caring and ethical individual; and
- A healthy person (Carnegie Council on Adolescent Development, 1989, p.15).

The United States government agreed and, as a result, the National Community Service Act was passed in 1990 (Schine, Summer 1997; Wade, 1997d). Three years later, the National and Community Service Trust Act was also approved (Schine, Summer 1997; Silcox, 1995;

Wade, 1997d). In particular, the Learn and Serve America K-12 section of Trust Act involved student learning through CSL (Melchior, 1998; Schine, Summer 1997). After several years of implementation, the Learn and Serve America program conducted a national wide evaluation.

Based on the data from the 1995-96 school year, the Learn and Serve programs in this study had a positive, statistically significant post-program impact on measures of civic attitudes and behavior and on several measures of educational attitudes and school performance (Melchior, 1998, p. 17).

Consequently, several schools and programs are incorporating CSL into the curriculum. One example of a community service education program is the International Baccalaureate Organization, (IBO). The IBO partners with different schools across the country to integrate community service in students' learning (International Baccalaureate Organization). For example, the IBO's middle school program promotes holistic learning, intercultural awareness, reflection, and communication (International Baccalaureate Organization, 2002). Through participation in an IBO, students gain "skills, attitudes and knowledge needed to participate in an increasingly global society" (International Baccalaureate Organization, 2002, p.3).

Other instances of CSL are found in the fields of science, social studies, youth improvement, education, and medicine (Arman & Scherer, Spring 2002; Atchison & Tumminia, 1998; Bartels, 1998; Battistoni & Hudson, 1997; Boston, 1998 - 1999; Carnegie Council on Adolescent Development, 1989; Cohen et al., 1998; George, 1997; Laplante,

1995; Macnee et al., 1998; Norbeck et al., 1998; Schine, Summer 1997; Schukar, 1997; Solo, 1995; Thompson & Carpenter, 2001; Weah & Wegner, 1997). Several nursing programs are incorporating CSL by devoting a course or part of a course to CSL (Atchison & Tumminia, 1998; Cohen et al., 1998; Macnee et al., 1998; Norbeck et al., 1998). Counselor education is also including CSL in its curriculum (Arman & Scherer, Spring 2002). Recently, a case study was conducted on service learning and a college interior design course (Sterling, 2007). Sterling (2007) concluded that “Coupling experiential learning with design across the curriculum offers an innovative pedagogy to achieving many of the *must* and *should* indicators described by the Council for Interior Design Accreditation in its accreditation manual” (p.342). Hence, the government, schools, and other education programs are utilizing and advocating CSL.

### *Challenges*

Despite the wide spread use of community service, there are challenges and criticisms. One of the challenges is the structure of the public schooling in the United States (McPherson & Kinsley, 1995; Silcox, 1995; Wade, 1997b). First, students are evaluated based on individual performance and not on ability to help others (Wade, 1997b). Students may see CSL irrelevant to their schoolwork. Also, teachers do not have time to thoroughly plan an effective community service activity (Wade, 1997b). Schools do not collaborate with the community when designing the school curriculum (Wade, 1997b). Therefore, teachers may not have access to community resources or be able to include all students in CSL (Silcox, 1995). Consequently, teachers lack the support from the community, the school, and

the students (McPherson & Kinsley, 1995; Wade, 1997b).

Another challenge is the logistics behind CSL (Wade, 1997b). Lack of funding, supplies, transportation, scheduling, and volunteers discourage many teachers and schools from participating in CSL (Wade, 1997b). The service itself creates a third challenge (McPherson & Kinsley, 1995; Wade, 1997b). Students must deal with real controversial social issues (Beane, 1997; McPherson & Kinsley, 1995). As a result, students encounter different people with different culture and socioeconomic backgrounds (Wade, 1997b). Consequently, stereotypes and prejudices can be reinforced (McPherson & Kinsley, 1995). Also, students may not provide efficient service (Wade, 1997b). Students may develop a defeatist attitude because they realize more needs to be done (Wade, 1997b).

The fourth challenge is ensuring that reflection occurs (Wade, 1997b). Research has shown that even when reflection does occur it is not always a focus and students sometimes lack the skills to thoroughly reflect (Wade, 1997b). Another challenge is that schools do not integrate community service into their curriculum (Wade, 1997b). CSL is reserved for after school activities and clubs (Wade, 1997b). An additional challenge is that CSL can become routine and trivialized if it is not implemented correctly (McPherson & Kinsley, 1995). Also, teachers are afraid to integrate CSL because it is hard to assess students' performance (Wade, 1997b). In spite of these challenges, there is a national movement to incorporate CSL into the curriculum of elementary, middle, and high school. Learn and Serve America and the International Baccalaureate Organization illustrate this movement (International Baccalaureate Organization, 2002; Schine, Summer 1997).

Based on prior research and examples, CSL demonstrates its potential to engage students in learning mathematics as well as promote growth in understanding of mathematics. The CSL activity for this study is designed based the five phases of CSL. Planning, service, academic, reflection, and celebration are implemented according to the research, giving the service and academic phase equal emphasis.

Despite the growing trend, the only research that examines how CSL affects the learning of mathematics focuses on statistics concepts (Duke, 1999; Root & Thorne, 2001). Other research that investigates CSL and mathematics do not focus on a particular mathematics concept (Caniglia, 2003; Nagchaudhuri & Conway, 1999; O'Donnell, 2001). Nevertheless, the research shows that CSL involving mathematics provides a culturally relevant pedagogy to teaching (Caniglia, 2003). In conclusion, CSL may be a viable method for engaging students, particularly African and Latino Americans, in mathematics as well as help lessen the mathematics achievement gap.

### *Conceptual Framework*

In order to examine the research questions for this study, two frameworks are used. For the first question, how can community service learning engage African and Latino Americans in learning geometry?, Lave & Wenger's (1991) Legitimate Peripheral Participation is utilized. Pirie & Kieren's (1994) growth in mathematical understanding model is applied to the second question, what is the nature of African and Latino Americans' growth in understandings of geometry, specifically transformations in the plane including reflections, translations, and rotations, during the course of a semester when they are

involved in a community service activity?

*Legitimate peripheral participation*

The conceptual framework that is used for examining the research question of how community service learning can engage African and Latino Americans in learning mathematics is Lave & Wenger's (1991) Legitimate Peripheral Participation (LPP). Based on the LPP framework, being engaged is defined by a person legitimately participating in an activity involving mathematics (Lave & Wenger, 1991). The word legitimate implies that the individual feels a sense of belonging (Lave & Wenger, 1991). Peripheral "is about being located in the social world" (Lave & Wenger, 1991, p. 36). Combining legitimate and peripheral with participation, individuals engaged in mathematics would feel that the activity had meaning to them (Lave & Wenger, 1991). In addition, the activity would place them in a social context interacting with peers and colleagues, teachers and superiors, community members, or parents and family members as well as with the activity itself (Lave & Wenger, 1991).

Legitimate peripheral participation has its advantages and disadvantages. One advantage of LPP is that it promotes motivation by "provid[ing] an immediate ground for self-evaluation" (Lave & Wenger, 1991, p.111) as well as increasing the level of participation. In addition, individuals can form or change their identity through legitimate participation (Lave & Wenger, 1991).

However, there are disadvantages to LPP. A crucial concern is access. "Access is liable to manipulation, giving legitimate peripherality an ambivalent status: Depending on

the organization of access, legitimate peripherality can either promote or prevent legitimate participation” (Lave & Wenger, 1991, p. 103). Another disadvantage is how LPP is used methodologically. Because Lave & Wegner’s (1991) LPP is individualistic, a control group cannot be used (Lagache, April 12-14, 1993). Hence, supporters of quantitative studies would not advocate LPP as a valid conceptual framework for a study.

Despite the disadvantages, legitimate peripheral participation is becoming well known and used. For example, Lave & Wegner (1991) examined apprentices from various walks-of-life, such as butchers, midwives, tailors, quartermasters, and alcoholics, through the lenses of LPP. In addition, Morell (2004) studied urban-youth through employing LPP as its conceptual framework. By applying the LPP framework, Morrell (2004)

demonstrated that critical educators in urban schools can prepare students to participate as critical citizens in a civil society while facilitating the development of academic skills that will serve students well in engaging university coursework, obtaining empowering employment, and participating in community research and activism. (p. 145)

By considering both the level of participation (peripheral) and legitimacy of participation, LPP can examine the individual’s experiences and hence level of engagement.

Since legitimate peripheral participation encourages motivation and identity development, LPP is the appropriate framework when examining middle school African and Latino Americans’ experiences of being engaged in mathematics. First, if individuals are legitimately participating, then they are engaged in learning mathematics (Lave & Wenger,



1991). Second, development of identity is important for African and Latino Americans (Brown, 2001; Ladson-Billings, May/June 2000). As a result, LPP will be the framework utilized in investigating the research question how can community service learning engage African and Latino Americans in learning mathematics.

In order to use legitimate peripheral participation as a framework, a model based on individuals' participation in mathematics and CSL needs to be constructed. Based on Lave & Wenger (1991) and Lagache (April 12-14, 1993), the model created to describe LPP in students' engagement in mathematics is shown in Figure 3. The inner most layer corresponds to students who are the legitimately participating in the community service activity involving mathematics. With the use of the model and Lave & Wenger's (1991) construct of LPP, students' engagement in mathematics and community service can be analyzed.

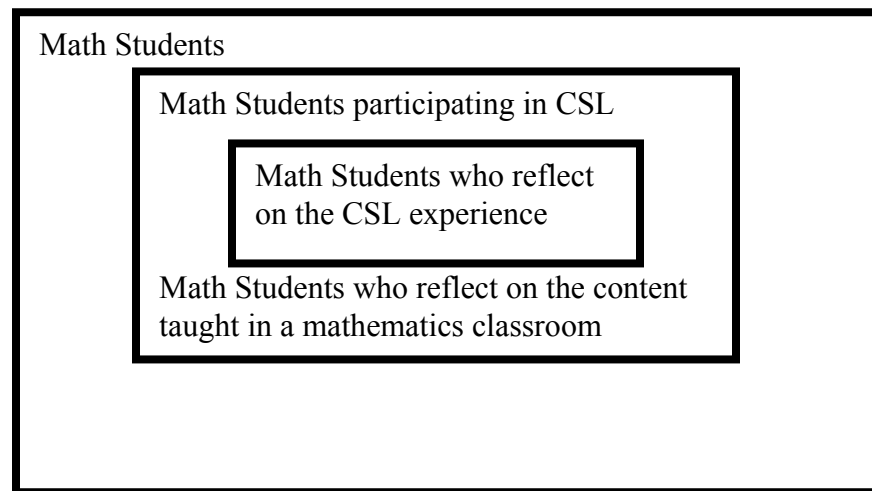


Figure 3. LPP Conceptual Framework Model Constructed for This Study

### *Growth in mathematical understanding*

In order to examine the nature of African and Latino Americans' growth in understandings of geometry, specifically transformations in the plane including reflections, translations, and rotations, during the course of a semester when they are involved in a community service activity, Pirie & Kieren's (1994) growth in mathematical understanding model is employed (See Figure 4). Based on their constructivist view of learning, Pirie and Kieren's (1994) growth model assumes that learning is a "dynamic, levelled but non-linear, transcendentally recursive process" (p. 166). Accordingly, the growth in mathematical understanding consists of eight embedded circles where, depending on the student and the mathematical concept, students may fall into any of the levels and may retreat or proceed at any time to any level (Pirie & Kieren, 1994).

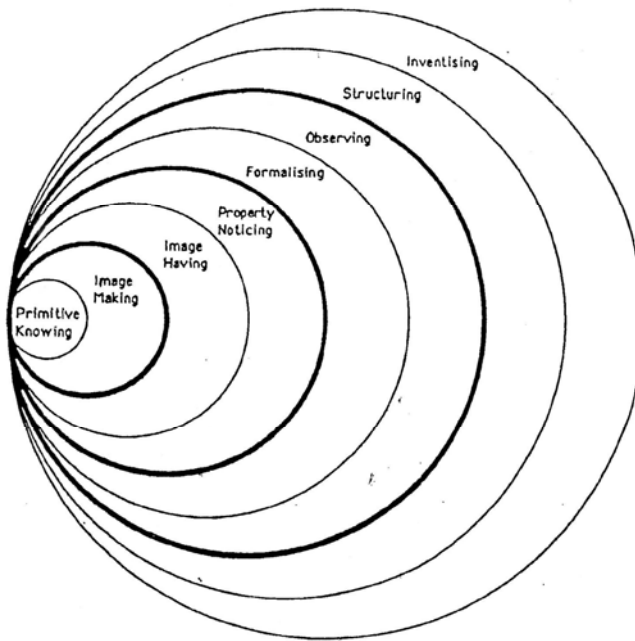


Figure 4. Growth in Mathematical Understanding Framework (Pirie & Kieren, 1994, p. 167)

Initially, understanding begins with *primitive knowledge*. Primitive knowledge is defined as the knowledge and skills the observer assumes the students have before the learning activity takes place (Pirie & Kieren, 1994). Using their primitive knowledge, students can form physical images by categorizing, combining, or using their knowledge in new and different ways (Pirie & Kieren, 1994). The ability to physically construct images occurs in the next level, *image making*. The third level is *image having*, where “a person can use a mental construct about a topic without having to do the particular activity which brought it about” (Pirie & Kieren, 1994, p. 170). In other words, students no longer have to draw or use manipulatives to visualize the concept. While envisioning their images of the concept, students can now detect particular features of those images and discover “context specific, relevant properties” (Pirie & Kieren, 1994, p. 170). This happens at the *activity property noticing* level. At the next level, *formalising*, students are able to abstract the properties from the images (Pirie & Kieren, 1994). Reflecting on their formalizations, students can develop theorems or what Pirie and Kieren (1994) label as noticed properties. This level is called *activity observing*. Once the students are “aware of how a collection of theorems is inter-related and calls for justification or verification of statements through logical or meta-mathematical argument” (Pirie & Kieren, 1994, p. 171), the students have entered the *structuring* level of understanding. The last level of understanding, *inventising*, occurs when students look at the full structure of the concept and develop questions that may lead to a new concept (Pirie & Kieren, 1994).

According to Pirie & Kieren (1994), students can move about the levels in any

manner. For example, a student may be in the *image having* level but never needed a physical activity of *image making* to construct it. In addition, students can *formalize* mathematical concepts without going through the *property noticing* level. This is also true about students in the *structuring* level; they can justify concepts using theorems without developing the theorems themselves. Hence, students in the *structuring* level do not necessarily go through or need the *activity observing* level. Pirie and Kieren (1994) identify this movement as “‘Don’t Need’ Boundaries” (p. 173).

Students can also move backwards through the levels. When students encounter a perturbation at any level, they need to ‘fold back’ to preceding levels in order to build their understanding (Pirie & Kieren, 1994). For example, students may be attempting to *formalize* the vertex of a parabola. However, not all of the students will be able to meet this task. By folding back to the *image making*, *image having*, and *activity property noticing* levels, students can improve their previous knowledge of parabolas by examining how parabolas are graphed, focusing specifically on the vertexes. By folding back, students can enhance their previous knowledge, which will allow students to extend their knowledge and progress through the levels. According to Pirie & Kieren (1994), “Different students will move in different ways and at different speeds through the levels, folding back again and again to enable them to build broader, but also more sophisticated or deeper understanding” (p. 173).

While moving through the levels, it is necessary for students to act and express. In order to move on to the next level, students need to be able to act and express within each level (Pirie & Kieren, 1994). Acting is the mental or physical activity that takes place within

the level and expressing is the ability to explain the activities to oneself or to others (Pirie & Kieren, 1994). For example, in the *property noticing level*, acting includes property prediction (Pirie & Kieren, 1994). Referring to the parabolas example, property prediction would include observing that the graphs are “U-shaped” and the vertexes shift the graph up, down, left, and right throughout the coordinate plane. Expressing is the ability to verbalize or write an explanation of what properties one noticed of parabolas, and each level contains a distinctive acting and expressing phase (See Figure 5).

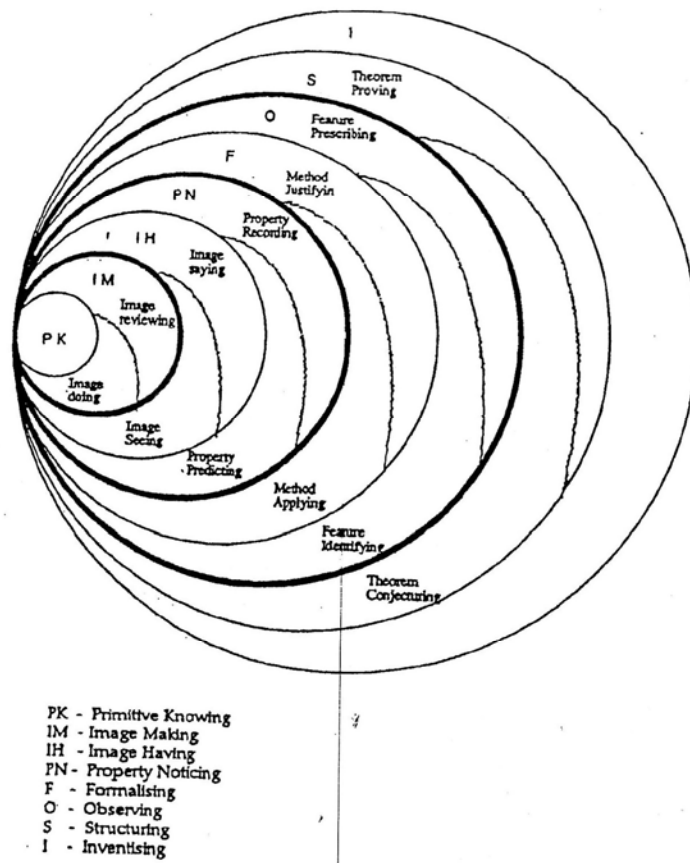


Figure 5. The Complementarities of Acting and Expressing (Pirie & Kieren, 1994, p. 175-176)

In order to apply Pirie & Kieren's (1994) growth of mathematical understanding as a theoretical framework, a map of the students understanding will be constructed. "This notion of mapping entails plotting as points on a diagram of the model, observable understanding acts and drawing continuous or disconnected lines between these points, dependent on whether or not the student's understanding is perceived to grow in a continuous, connected fashion" (Pirie & Kieren, 1994, p. 182). It is important to note that the mapping is based on the observations of the researcher (Pirie & Kieren, 1994). An example of a map on growth of mathematical understanding is shown in Figure 6. The letters represent different activities, examples, or questions the student was involved in during the lessons. Notice that the student folded back from C to D. Also, the student moved from *image making* J to *formalising* K without progressing through all of the inner levels. In addition, the student displayed disjoint understanding G, identified by disconnected lines and a cross. At point J, the student acted and expressed in the image making level for a length of time. This is notated with a zigzag line.

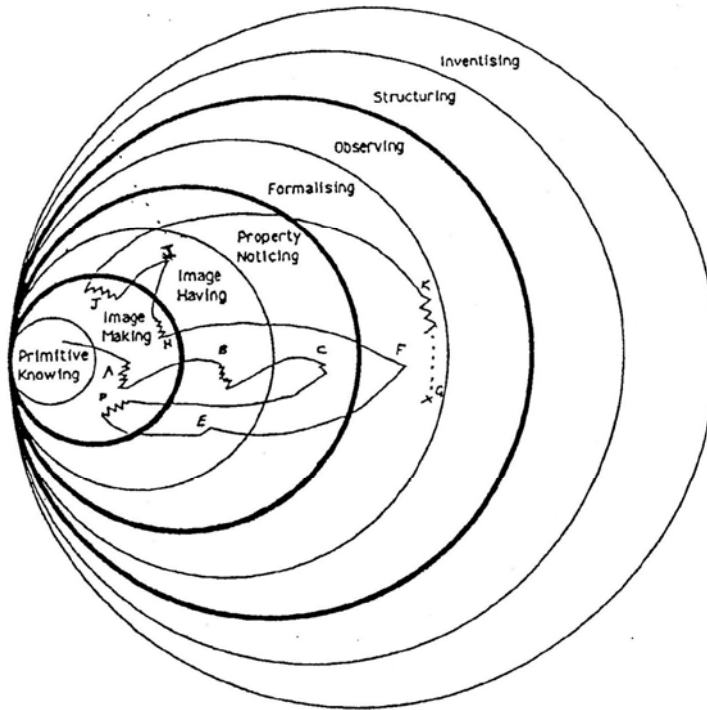


Figure 6. Katia's Growth of Mathematical Understanding of the Addition of Fractions Map (Pirie & Kieren, 1994, p. 186)

Currently, Pirie & Kieren are developing a theory to support teachers in utilizing growth maps so that they can intervene in their students' understanding (Pirie & Kieren, 1994; Towers, Martin, & Pirie, 2000). This will allow teachers to guide their students to fold back or to move forward when appropriate and as a result teachers can help students broaden their mathematical understanding (Pirie & Kieren, 1994; Towers et al., 2000). In addition, "this method of representing students' paths of growth of mathematical understanding has the potential to allow researchers to study in detail the actual nature of this growth for either an individual over several topics, or for many students within the learning of a specified topic" (Pirie & Kieren, 1994, p. 186) Accordingly, Pirie & Kieren's (1994) growth of mathematical

understanding model will be used to analyze how African and Latino Americans' understanding of mathematics changes over a semester when they are involved in a CSL.

The CSL activity for this study is designed based on the literature review for transformations and community service learning. Chapter 3 discusses the community service learning activity, how it adheres to the research, and the methods used in this study. Also, the conceptual frameworks from this chapter are utilized in Chapter 4.



### CHAPTER 3. METHODOLOGY

This study focuses on how CSL affects African and Latino Americans' engagement and understanding of a particular geometry concept, transformations. The design of the study follows the CSL model and takes place over a course of a semester with 10 sixth-grade students. Data is collected and analyzed using a situated learning framework from Lave & Wenger (1991) and a mathematical understanding framework from Pirie & Kieren (1994). Both qualitative and quantitative methods are employed for this study.

#### *Participants and Site*

The participants of this study are sixth-grade students who were recruited from an International Baccalaureate magnet middle school located in an urban city in the Southeast. During the 2004-2005 school year, the school consisted of 56% African American, 31% Caucasian, 9% Hispanic and Latino, 4% Asian, and less than 1% American Indian (Great Schools, 2006). 44% of students participated in a free or reduced lunch program (Great Schools, 2006). The school's performance composite score was 69.1 out of 100 on the state's ABCs Report Card Evaluation in 2006 (Wake County Public School System, 2006). This middle school was selected for two reasons. First, the school participates in the International Baccalaureate Organization Middle Year Program. This program requires middle school students to complete community service hours. Hence, it is easier to recruit students for a community service activity at this school. The demographics of the school is another reason it was selected. African and Latino Americans make up the majority of the school. Given that the study focuses on African and Latino Americans, this school provides

an ideal population to sample for the study. From this school, 10 students are selected from the sixth grade. Of these 10, 6 are African American, 4 are Latino American. Sixth-grade students were selected because geometric transformations in the coordinate plane are introduced in the sixth grade curriculum (Public Schools of North Carolina, State Board of Education, & Department of Public Instruction, 2003). For a comparison to examine the effects of community service learning, one sixth-grade mathematics class took the Mathematics Understanding Assessment (See Appendix E). The control group data was obtained during the following school year. Thus, one seventh-grade mathematics class took the post Mathematics Understanding Assessment (See Appendix E). Seventh-grade students were selected because the study's participants were in the seventh grade at the time of the control group data collection.

### *Community Service Learning Model*

In order to ensure student learning, it is recommended that the CSL activity proceed through six phases (Wade, 1997d). The six phases are planning, service, academic connections, reflection, celebration, and community benefits. These six phases guide the implementation of the CSL learning activity in this study.

#### *Planning*

During the planning phase of the CSL activity, the community and school were selected. For this activity, a local middle school was recruited. The community the activity served was the community of students, teachers, staff, and parents of the specific middle school. Next, a community service need was identified with the collaboration of the school.

A sixth grade teacher, the community service coordinator at the school, and the researcher chose art and cultural awareness of the communities within the school as the focus for the CSL activity. The school strongly emphasizes art and diversity and wanted sixth grade students to feel part of a community involving other students, teachers, and staff.

Furthermore, there are many students who transfer to this school and engaging students in an activity to create a product that depicts the art and culture of the school may assist new students to the school with their transition. Once the need was identified, the learning outcomes were affirmed. Teachers at the school indicated that students in the sixth grade have difficulty learning about geometric transformations, specifically reflections, rotations, and translations. Because transformations are introduced in the sixth grade and sixth grade students are new to the school and often not familiar with the school culture, sixth grade students were recruited. An information session was held in order to elicit student volunteers. The participating students attended ten two-hour sessions on Tuesdays after school at the middle school. The first session was an orientation to the CSL activity and its service and academic goals. The CSL sessions are outlined in Appendix A.

### *Service*

The students and the researcher implemented the plan to provide the service to the school. At the first session, students were informed on the service portion of the CSL activity, including how the service was selected and the goal of the service, to promote art and cultural awareness through a display of photographs that represented the community of students, teachers, staff, and parents of the middle school. In order to promote art and

cultural awareness, students were asked to take photographs of objects that can be used as symbols that reflect their individual cultural experiences as well as take photographs of art in their community. Their community involved students, teachers, staff, the school, parents, family, and other locations they encountered within the state of North Carolina. Students were not given a definition of art or culture and their photographs were based on what art and culture meant to them. Throughout the sessions, students discussed the meaning of culture and examples of art that can be found in their community. At the end of the study, the photographs were displayed in the sixth-grade hall of the school to promote art and culture awareness in their community of students, teachers, staff, and parents of the specific middle school.

#### *Academic*

Research has shown that incorporating art helps students develop a deeper understanding in mathematics (Schramm, 1997; Zaslavsky, 1996). “Bringing math to life through the medium of art gives students the kinds of physical experiences that are essential for the development of spatial thinking” (Zaslavsky, 1996, p. 140). In particular, geometry is more meaningful when students can experience concepts in the concrete form of art (Schramm, 1997; Zaslavsky, 1996). Schramm (1997) examines the integration of mathematics and art. In her study, students use geometry to design greeting cards within a computer software program (Schramm, 1997). In this activity, students see real world significance in mathematics as well as the connection between art and mathematics (Schramm, 1997). Zaslavsky’s (1996) students use quilt designs to examine line symmetry,

rotational symmetry, and color symmetry. Also, students investigate flips, turns, slides, and stretches by creating repeated patterns in borders (Zaslavsky, 1996). Through art, students are physically experiencing mathematics.

Students were not asked to take photographs that demonstrated transformations. The context of the photographs focused on art and culture. As students were collecting photographs, they were asked to identify different transformations that can be used to describe aspects of the pictures they have taken. For example, elements in the picture depicted in Figure 7 can be described using several different transformations. First, we can describe the two columns to be related by a reflection over the Stanley Cup. We can imagine a line that passes vertically through the center of the Stanley Cup. If we think of one column as the preimage then the other column can be viewed as its image under a reflection over this line. Also, we can view the bottom rings of the Stanley Cup as translations. If we consider the bottom ring as the preimage and use the distance between the rings as the magnitude of the translating vector and the direction of the vector as due North then we can view each ring above the preimage as an image of the ring directly below it.



Figure 7. Stanley Cup (Robinson, 2008)

In order to assist students in identifying geometric transformations in photographs, an

example was provided for each transformation. For reflections, students were asked to identify mirror images in the photographs and draw the corresponding mirror line (See Figure 8).



Figure 8. Reflection Line (Robinson, 2008)

Students were asked to locate objects that they could imagine are related by “sliding” for translations. For rotations, students were asked to identify two objects in a picture for which one could be turned about a point to obtain the other. After students identified these mappings and shared their findings, a formal definition for reflection, translation and rotation was provided. Each transformation was given an hour during a session for students to explore photographs, discuss their findings, and be informed about the formal definitions of each transformation.

Once the transformations have been identified and their definitions formalized, students designed a display of the photographs to be created to advocate art and cultural awareness in the school. The students selected the photographs, background, and captions for the display that represented art and cultural awareness in the community of students, teachers, staff, and parents. The researcher set up parameters for the display. The display had to be rectangular and the students were given four smaller rectangles that would make up

the larger rectangle. The four rectangles were selected to duplicate the Cartesian Plane. Each photograph started at the origin and lied in the first quadrant. Students stated if the photograph needs to be reflected, translated, and/or rotated from its starting position. For example, the photograph is translated right three units and up three units from the origin (See Figure 9). After students designed the display, they used the transformation directions to create the display.

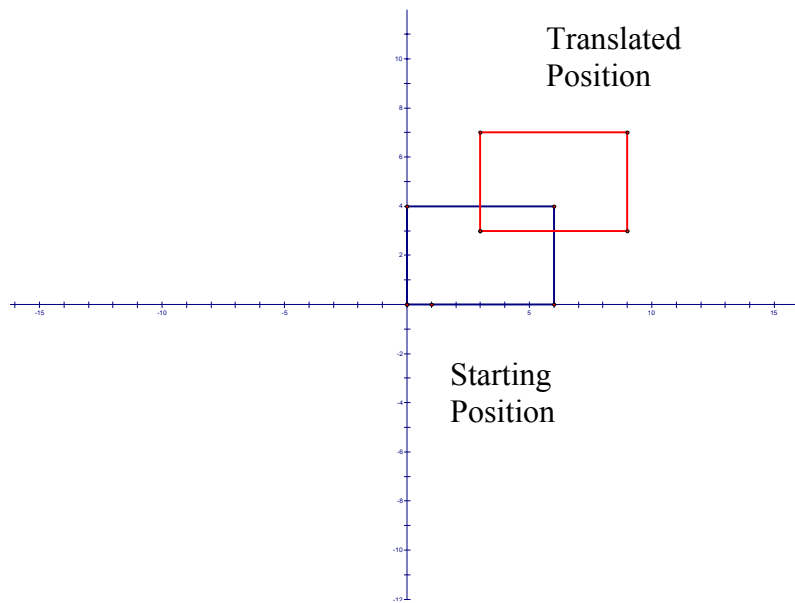


Figure 9. Display Design Example

The photograph investigation and the display design utilized the sixth-grade concepts of transformations. Hence, this CSL activity met a few objectives of the North Carolina Course of Study Standards for sixth grade mathematics Competency Goal 3:

3.03 Transform figures in the coordinate plane and describe the transformation.

3.04 Solve problems involving geometric figures in the coordinate plane (Public Schools of North Carolina et al., 2003).

### *Participants' Reflections*

Reflection was an ongoing component of the CSL activity. Each session that the researcher met with the students, she provided them with a prompt to encourage reflection about what they have done. For example, students were asked to write about how they would describe a translation to their classmates and to their teacher. Students described a translation as an action of sliding to their classmates. However, the same description was not accepted as a response to the teacher. Here, the researcher asked conceptual questions regarding translations. For example, the researcher posed the question

I:        Alright, so let's talk about these translations. To make it a translation, what are you looking for besides sliding? What else?

Students were forced to think beyond the act of sliding. Through guided reflection, students were encouraged to think about both the process and the concept of translations. In addition to research journals, students were asked to reflect on what they had learned during interviews conducted by the researcher. For example, at the post-interview the researcher asked, "Would you recommend a friend to participate in a community service learning activity?" In addition, the researcher included questions regarding the mathematics of the community service activity. One question had students to "Describe how your understanding of transformations has changed." Hence, students were encouraged to reflect about both the academic and the service phase of the CSL activity.



### *Celebration*

After the CSL was complete, the researcher hosted a party. Both the researcher and the students planned the event. Students voted for Chinese food and wanted music playing in the background. The celebration allowed students to be recognized for their hard work and achievement. Since in CSL, the celebration included the community being served. The students invited their family, friends, and teachers.

### *Community Benefits*

The display created by the students is hanging in the entrance of the sixth-grade hall. New students and parents will be able to view the arts and cultural awareness display as they tour the school in the summer. This display will help newcomers to the school become aware of the art and culture in the school community.

### *Data Collection*

This study is examining African- and Latino-American (1) students' engagement in learning mathematics and (2) their growth in mathematical understanding in the context of a community service learning activity. Both qualitative and quantitative data were collected to address these questions (See Table 4).

Table 4: Data Collection and Analysis Outline

Research Question	Quantitative Data	Qualitative Data
1. How can community service learning engage African and Latino Americans in learning geometry?	<ul style="list-style-type: none"> <li>• Pre- and Post-Engagement questionnaire (See Appendix B and C)</li> </ul>	<ul style="list-style-type: none"> <li>• Researcher Notes</li> <li>• Transcriptions</li> <li>• Reflection journals</li> <li>• Interview</li> </ul>
2. What is the nature of African and Latino Americans' growth in understandings of geometry, specifically transformations in the plane including reflections, translations, and rotations, during the course of a semester when they are involved in a community service activity?	<ul style="list-style-type: none"> <li>• Pre- and Post-Mathematics Understanding assessment (See Appendix D and E)</li> </ul>	<ul style="list-style-type: none"> <li>• Researcher Notes</li> <li>• Transcriptions</li> <li>• Reflection journals</li> <li>• Interview</li> <li>• Pre- and Post-Mathematics Understanding assessment (See Appendix D and E)</li> </ul>

#### *Research Question 1*

For the first research question, students' engagement in learning mathematics was assessed quantitatively using (a) a Pre- and Post- Engagement questionnaire (See Appendix B and C), and qualitatively using (b) notes taken by the researcher during and after each community service learning activity sessions, (c) videotapes from the community service learning activity meetings, (d) reflection journals, and (e) one interview of an African American student.

*Quantitative data.* In order to analyze students' engagement in mathematics, students' Pre- and Post- Engagement questionnaires are scored (See Appendix B and C). The Pre- and Post- Engagement questionnaire was adapted from the Student Self-Report for Middle School (Institute for Research and Reform in Education, 1998). The questions encompass

three domains: Ongoing Engagement (Questions 1-6), Perceived Autonomy (Questions 7-15), and Beliefs About Mathematics Beyond the Classroom (Questions 16-20). The questionnaire gave students four options. Option A was always applied, B was usually applies, C was sometimes applies, and D was does not apply at all. The questionnaire is scored on a 4 point scale, where A=4,B=3,C=2,D=1. For any negative questions (Questions 2, 4, and 5), the scores are calculated by subtracting the point value from 5. For example, an answer of A for a negative question would receive a 1. The engagement score for each domain is the mean of the questions that pertain to each domain. The final engagement score is the mean of the three domains' mean score. The maximum engagement-mean score is 4 and the minimum is 1. An engagement-mean score of 4 indicates the highest engagement level where a 1 indicates the lowest engagement level.

*Qualitative data.* A questionnaire does not allow the researcher to observe how students are being engaged in mathematics as they participate in the CSL activity. Hence, several types of qualitative data are collected in order to discern students' reflections on the CSL activity. The first data source is field notes taken during classroom observations. "The goal of observation is to understand the culture, setting or social phenomenon being studied from the perspective of the participants" (Hatch, 2002, p. 72). Hence, students' engagement of mathematics can be examined. While observing each session, field notes are taken (Creswell, 1998; Hatch, 2002). Also, a research journal is kept after each session (Hatch, 2002). In both field notes and research journal, any of the researcher's thoughts, feelings, and interpretations are kept separate from the actual data through bracketing (Hatch, 2002).

All sessions are videotaped to supplement observations (Creswell, 1998; Hatch, 2002).

Another method to assess students' engagement in mathematics is through written description (Hatch, 2002). Students kept a reflection journal throughout the community service activity. Not only is reflection an important component in community service learning, it is also an important qualitative research method (Creswell, 1998; Hatch, 2002). "The most obvious strength of journals as data is that they can provide a direct path into the insights of participants" (Hatch, 2002, p. 141). Therefore, reflection journals allow students to freely document their thoughts, feelings, and awareness of their own engagement in mathematics.

Interviews are the next source of data. According to Creswell (1998), in-depth interviews are the primary data resources for a phenomenological study. A phenomenological study "focuses not on the life of the individual but rather on a concept or phenomenon" (Creswell, 1998, p. 38). Hence, participants' experiences and meaning from their experiences are examined. Because the goal of the interviews is to discover if the CSL experience engaged African and Latino American students in learning mathematics, phenomenological interviews are conducted. Due to the allotted time with the students, only six students were asked to volunteer in a pre- and post- in one-hour interview per student, all of which will be videotaped. The first interview focuses on students' engagement and understanding of mathematics and transformations before the community service learning takes place. The last interview focuses on students' engagement and understanding of mathematics and transformations at the end of the CSL activity. Unfortunately, only one

student made the pre-scheduled interview, which occurred between the second and third sessions.

The three-interview series for a phenomenological study includes (1) establishing a focused life history, (2) collecting details of the experience, and (3) having participants reflect upon the meaning of their experience (Seidman, 1991). For this study, the first interview concentrates on the focused life history phase. Students' engagement in mathematics is the focused life history in this study. In order to establish a focused life history, Seidman (1991) suggest asking how questions. Therefore, the Pre-Engagement interview questions includes a multitude of "how" questions (see Appendix B). The next phase of the interview involves collecting details. In this phase, students' opinions of transformations are not the focus; however, the details of their understanding of transformations are desired. The Pre-Mathematics Understanding interview questions inquire about students' experiences with transformations (see Appendix D).

The last stage of the interview entails participants reflecting upon the meaning of their experiences of being engaged in mathematics. After participating in the CSL activity, students are interviewed again using the same Engagement and Mathematics Understanding Questions. In addition, students are prompted to reflect on how their experience has impacted their engagement and understanding of geometric transformations. Without the first interviews, students would not be able to reflect upon their own experiences of engagement and mathematical understanding to extend beyond the CSL activity itself.

The interview questions for this study are designed to elicit life history, details of the

experience, and reflection upon the meaning of the experience. In addition, the interviews and the interview questions are sequentially arranged to follow the three-series interview order. Also, all questions are open-ended, allowing the students to freely describe their own experiences in being engaged in mathematics and their own understanding of transformations.

### *Research Question 2*

For the second question, students' growth in mathematical understandings of geometric transformations will be assessed quantitatively using (a) a Pre- and Post-Mathematics Understanding assessment and qualitatively using (b) notes taken by the researcher during and after each community service learning activity sessions, (c) videotapes from the community service learning activity meetings, (d) reflection journals, and (e) one interview of an African American student.

*Quantitative Data.* In order to examine students' understanding of transformations, students' Pre- and Post- Mathematics Understanding assessments are scored (See Appendix D and E). The questions cover three transformations: Reflections (Questions 1, 5), Rotations (Questions 2, 6), and Transformations (Questions 3, 7). In order to quantitatively analyze understanding of transformations, the total of each of the three domains will be computed. Each question is worth four points with the exception of Question 4 which is worth 3 points and Question 8 which is worth twelve points (four points for each of the three parts). Students receive 4 points if their responses illustrate a sixth grade understanding of transformations, 3 points if their responses are missing one concept from a sixth grade understanding, 2 points if their

responses reveal half of the concepts, 1 point if their responses include only one concept, and 0 points if their responses do not demonstrate any understanding at a sixth grade level (Refer to the Literature Review for definitions). Each transformation score is the sum of the points from each question that represents each transformation. The final transformation score is the sum of the three transformation totals plus the total of question 4 and 10. The maximum transformation score is 39 and the minimum is 0.

*Qualitative Data.* The methods used for the first question can also be employed for the second question. In addition to the qualitative methods described for the first research question, the Pre- and Post- Mathematics Understanding assessment is used as written description. Instead of performing only mathematical processes, students also express their own mathematical understanding by describing various types of transformations and explaining how figures are transformed in a coordinate plane.

### *Data Analysis*

#### *Research Question 1*

*Quantitative data.* The statistical methods used in this study were nonparametric statistical methods under the assumption that the participant population is not normal and the sample size is small. Three tests were conducted and ties were accounted for according to the procedures described by Hollander & Wolfe (1999). In other words, ties were not thrown out, instead the ties were included in the statistical tests. The first test involved all participants' Pre and Post scores from the Pre- and Post- Engagement questionnaire. The Wilcoxon Signed Rank Test was employed to analyze a shift in location due to the treatment

of the CSL activity (Hollander & Wolfe, 1999). This study assumed the shift in the median of the differences of post-test scores minus pre-test scores was greater than zero. The domains of Ongoing Engagement, Perceived Autonomy, and Beliefs About Mathematics Beyond the Classroom were analyzed using the Wilcoxon Signed Rank Test. For each domain, the alternative hypothesis assumed the shift in the median of the differences of the post-test scores minus the pre-test scores was greater than zero.

The second test examined only the African and Latino American participants' Pre- and Post- scores from the Pre- and Post- Engagement questionnaire. The Wilcoxon Signed Rank Test was also employed to analyze a shift in location due to the treatment of the CSL activity (Hollander & Wolfe, 1999). This study assumed the shift in the median of the differences of post-test scores minus pre-test scores was greater than zero. The domains of Ongoing Engagement, Perceived Autonomy, and Beliefs About Mathematics Beyond the Classroom were analyzed using the Wilcoxon Signed Rank Test. For each domain, the alternative hypothesis assumed the shift in the median of the differences of the post-test scores minus the pre-test scores was greater than zero.

*Qualitative data.* The interpretive analysis proposed by Hatch (2002, p. 181) was employed in order to analyze the data collected from the interviews. First, the data from the videotapes was transcribed. Then, all of the data (transcriptions, reflection journals, and pre/post transformation assessments) was read and reviewed to get a sense of the data as a whole. Impressions were recorded in memos on Post-It's®. Some of the initial impressions include family and background for community and understanding and school for engagement. Next,



the data was read carefully to identify more impressions found in the data and these new impressions were recorded in memos. Other impressions that emerged were entertainment for community and second chance for engagement. All of these memos were studied for significant interpretations. These interpretations will be discussed in details in Chapter 4.

After interpretations were formed, the data was reread and coded in places that supported or disputed these interpretations. All of the data was coded using Post-It's®, color coding, and conceptual mapping based on the interpretations. In addition, an expert peer reviewed the data. Lave & Wenger's (1991) framework on legitimate peripheral participation was used to examine participants' engagement in mathematics (Refer to the Literature Review Chapter for details). Engagement involves "intentionality as an ongoing flow of reflective moments of monitoring" (Giddens, 1979, as cited in Lave & Wenger, 1991, p. 54). Lave & Wenger (1991) contend that "this flow of reflective moments is organized around trajectories of participation" (p. 54). Hence, student engagement consists of ongoing reflection and as a result defines the type of student participation. Correspondingly, this study used how students reflect upon their mathematical experiences to define their level of engagement and hence their level of participation. The following model displays how students were categorized (See Figure 10). Students who are legitimately participating in the CSL activity fell within the inner rectangle. Levels of participation decrease as one moves through the model to the outer rectangle.

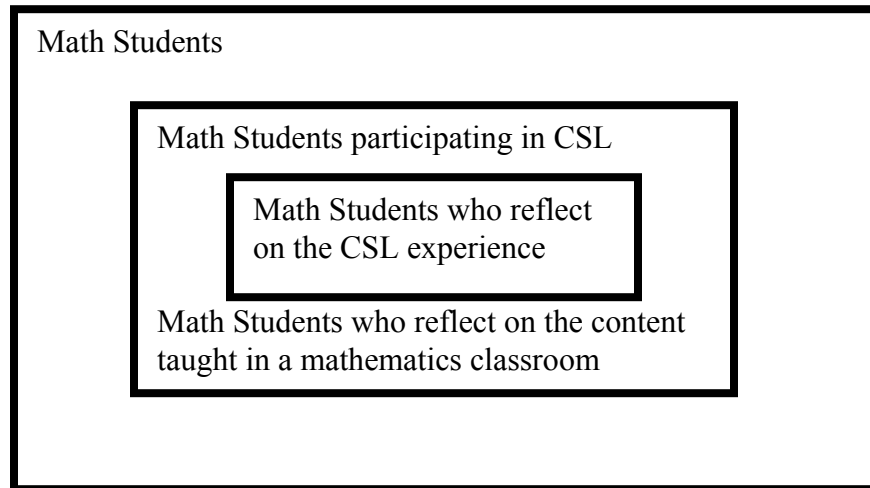


Figure 10. LPP Conceptual Framework Model Constructed for This Study

Student's engagement will be categorized based on students' type of participation and level of reflection (See Figure 11).

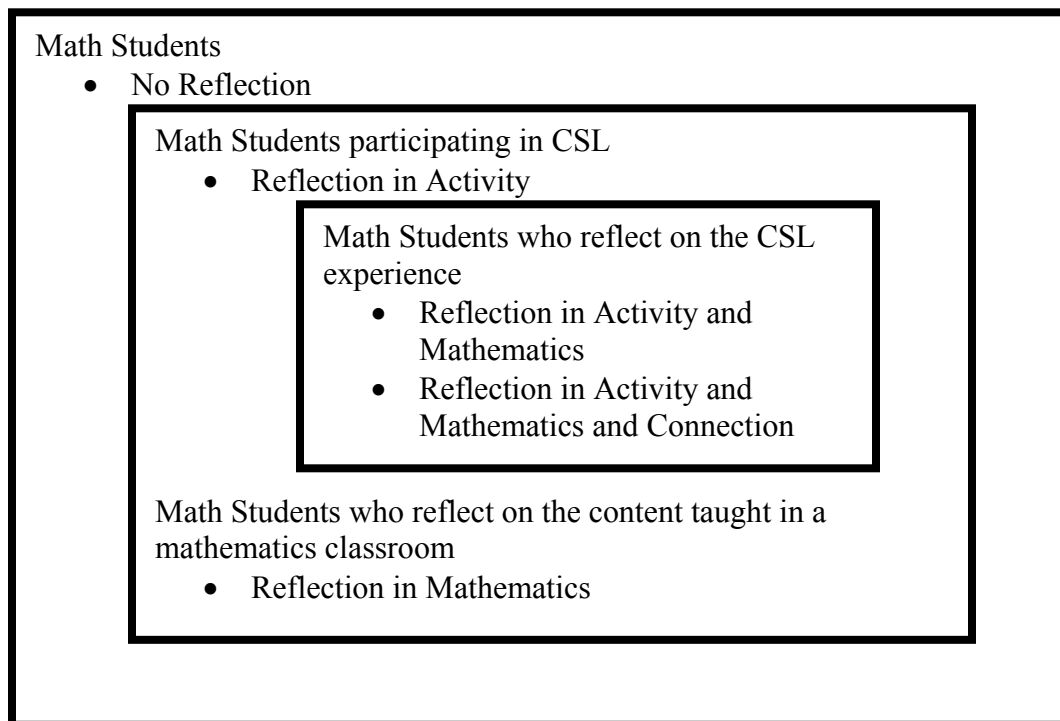


Figure 11. Engagement Diagram

The summary of the findings were drafted and then revised. This revision resulted in the Findings Chapter of this study. Hatch (2002) suggests reviewing the interpretations with participants; however, due to the students' ages, the researcher decided not to let the participants review the data. Consequently, all interpretations portrayed by the research have not been verified by the participants.

### *Research Question 2*

*Quantitative data.* The statistical methods used in this study were nonparametric statistical methods under the assumption that the participant population is not normal and the sample size is small. Three tests were conducted and ties were accounted for according to the procedures described by Hollander & Wolfe (1999). The first test involved all participants' Pre and Post scores from the Pre- and Post- Mathematics Understanding assessment. The Wilcoxon Signed Rank Test was employed to analyze a shift in location due to the treatment of the CSL activity (Hollander & Wolfe, 1999). This study assumed the shift in the median of the differences of post-test scores minus pre-test scores was greater than zero. Reflections, rotations, and translations were analyzed using the Wilcoxon Signed Rank Test. For each transformation, the alternative hypothesis assumed the shift in the median of the differences of the post-test scores minus the pre-test scores was greater than zero.

The second test examined only the African and Latino American participants' Pre and Post scores from the Pre and Post Mathematics Understanding assessment. The Wilcoxon Signed Rank Test was also employed to analyze a shift in location due to the treatment of the CSL activity (Hollander & Wolfe, 1999). This study assumed the shift in the median of the

differences of post-test scores minus pre-test scores was greater than zero. Reflections, rotations, and translations were analyzed using the Wilcoxon Signed Rank Test. For each transformation, the alternative hypothesis assumed the shift in the median of the differences of the post-test scores minus the pre-test scores was greater than zero.

A third test compared the treatment effect of the CSL activity for African and Latino American students to the control group (African and Latino sixth grade students who did not participate in the CSL activity). Using a Jonckheere Test, Post scores from the Post Mathematics Understanding assessment were analyzed for an increasing treatment effect (Hollander & Wolfe, 1999). This study assumed the median of the CSL participants' post-test scores would be higher than the mean of the control group's scores.

*Qualitative data.* Pirie & Kieren's (1994) growth in mathematical understanding model was employed to analyze individual students' improvement in their mathematical understanding of transformations, examining reflections, rotations, and translations individually (Refer to the Literature Review Chapter for details). Based on their constructivist view of learning, Pirie and Kieren's (1994) growth model assumes that learning is a "dynamic, levelled but non-linear, transcendently recursive process" (p. 166). Accordingly, students' growth in mathematical understanding was categorized based on the eight circles in Pirie and Kieren's (1994) model (See Figure 12). Depending on the student and the mathematical concept, students could fall into any of the levels and could retreat or proceed at any time to any level (Pirie & Kieren, 1994).

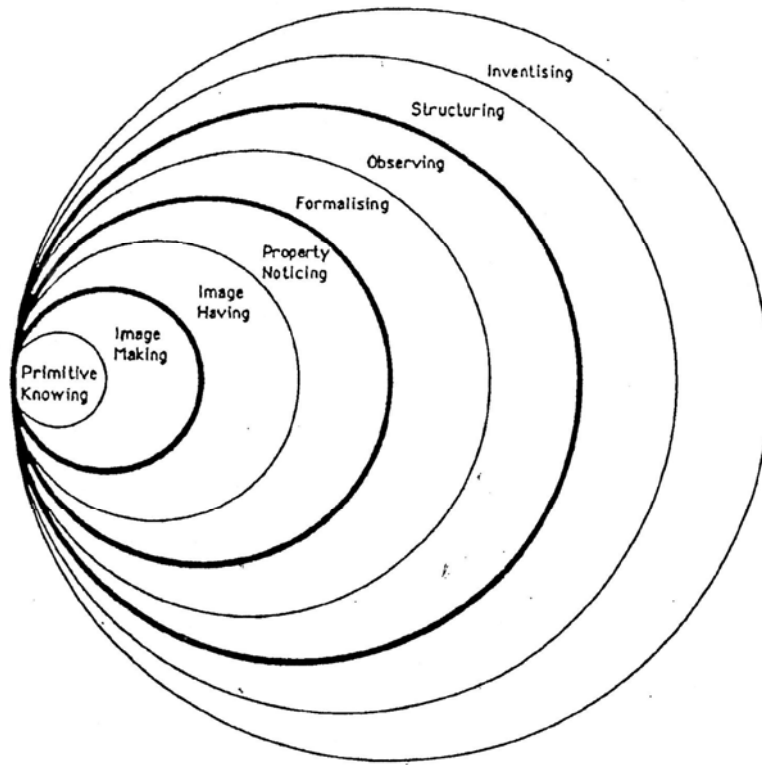


Figure 12. Growth in Mathematical Understanding Framework (Pirie & Kieren, 1994, p. 167)

In order to apply Pirie & Kieren's (1994) growth of mathematical understanding as a theoretical framework, a map of the students' understanding was constructed. "This notion of mapping entails plotting as points on a diagram of the model, observable understanding acts and drawing continuous or disconnected lines between these points, dependent on whether or not the student's understanding is perceived to grow in a continuous, connected fashion" (Pirie & Kieren, 1994, p. 182). It is important to note that the mapping is based on the observations of the researcher (Pirie & Kieren, 1994). An example of a map on growth of mathematical understanding is shown in Figure 13.

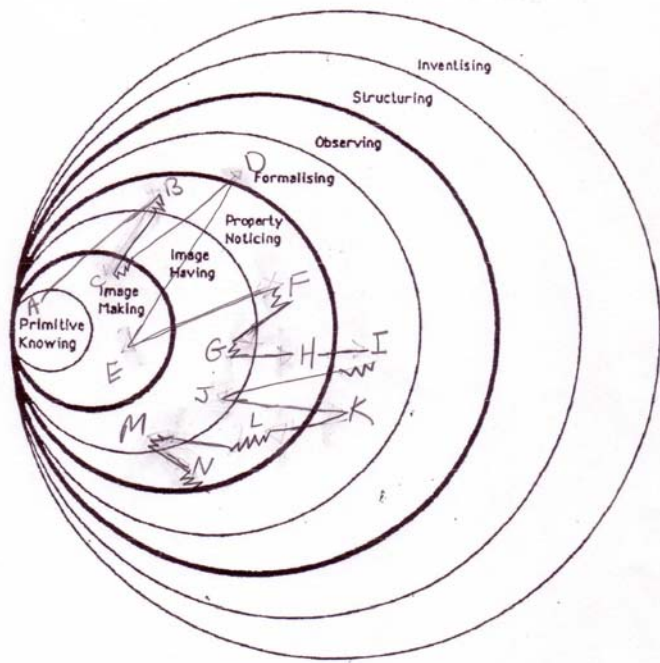


Figure 13. Student 6's Growth in Mathematical Understanding of Transformations

Student 6's map of her growth in mathematical understanding of transformations is described in detail in Chapter 4. The summary of the findings were prepared and then amended. The final interpretations are discussed in the Findings Chapter of this study.

### *Verification*

In order to check for verification, Creswell (1998) created eight verification procedures. He stated that "examining these eight procedures as a whole, I recommend that qualitative researchers engage in at least two of them in any given study" (Creswell, 1998, p. 203). This study met six of the eight recommendations. The first procedure attained was "clarifying researcher bias" (Creswell, 1998, p. 202). Before the study began, the researcher's biased was revealed and written in the researcher's subjectivity statement. By

thoroughly describing the participants, the data collection, and the data analysis, the next recommendation achieved was “rich, thick description allow[ing] the reader to make decisions regarding transferability” (Creswell, 1998, p. 203). In addition, multiple data resources and different methods, both qualitative and quantitative, were used to for data triangulation (Creswell, 1998; Hatch, 2002). Weekly contact with the participants meant that a “prolonged engagement and persistent observation” occurred (Creswell, 1998, p. 201). The last procedures met were providing external checks by utilizing peer reviews and external auditors (Creswell, 1998). By attaining six recommendations, this study meets the verification standards established by Creswell (1998).

#### *Summary*

This chapter describes the methodology employed to examine how CSL effects students’ engagement and understanding of mathematics. Both quantitative and qualitative data are collected and analyzed. The results of the data analysis are reported in the Findings Chapter.

## CHAPTER 4. FINDINGS

The results from applying the data analysis methods discussed in Chapter 3 are reported in this chapter. Both quantitative and qualitative data are analyzed to examine (1) how community service learning can engage African and Latino Americans in learning geometry, and (2) the nature of African and Latino Americans' growth in understandings of geometric transformations in the plane, which include reflections, translations, and rotations, during the course of a semester when they are involved in a community service learning activity. This chapter is divided into two sections: Findings Related to Research Question 1 and Findings Related to Research Question 2. Each section begins with an examination of quantitative data and is followed with findings from qualitative data. This will include examples of students' participation and levels of their engagement in addition to examples of students' understandings of geometric transformations as they were used to address the research questions.

### *Findings Related to Research Question 1*

#### *Quantitative Data*

The participants were given a Pre- and a Post- Engagement Questionnaire (See Appendix B and C). The questionnaire was scored on a 4 point scale, where A=4,B=3,C=2,D=1. For any negative questions (Questions 2, 4, and 5), the scores were calculated by subtracting the point value from 5. For example, an answer of A for a negative question received a 1. The engagement score for each domain was the mean of the questions that pertain to each domain. The final engagement score was the mean of the three domains'



mean score. The maximum engagement-mean score is 4 and the minimum is 1. An engagement-mean score of 4 indicates the highest engagement level where a 1 indicates the lowest engagement level. The differences in the participants' final engagement post-test and pre-test scores were calculated. Figure 14 reveals the ten sixth-grade students' final mean pre-test score, final mean post-test score, and the differences in their scores. The Wilcoxon Signed Rank Test was employed to analyze a shift in location due to the treatment of the CSL activity (Hollander & Wolfe, 1999). The test was conducted using only the students who completed both the pre-and posttest. For example, Student 3 and 8 did not take the pre- or post-test and thus were not included in the test. Also, Student 9 and 10 did not take the post-test and were not part of the test. Hence, only six students were incorporated into the Wilcoxon Signed Test. For this test, the null hypothesis that there are no differences between the median differences of post-test scores minus pre-test scores due to CSL activity was tested against the alternative hypothesis that the median differences of post-test scores minus pre-test due to CSL activity was greater than zero (See Table 5).

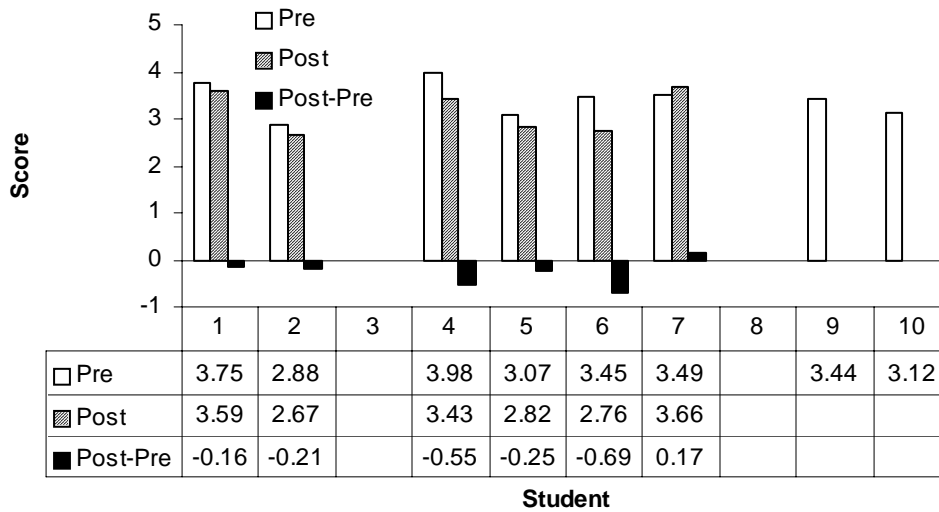


Figure 14. Pre- and Post- Engagement Questionnaire Results

Table 5. Wilcoxon Signed Rank Test for Engagement

Test	Description
Hypothesis	$H_0: \theta=0 \rightarrow$ No differences between the median differences of post scores minus pre scores due to treatment $H_a: \theta>0 \rightarrow$ The median differences of post scores minus pre scores due to treatment was greater than zero
Test Statistic	SAS Signed Rank Statistic: $S = -8.5$  $S = T^+ - E_0(T^+)$ $E_0(T^+) = \frac{n(n+1)}{4} = \frac{6(7)}{4} = \frac{42}{4} = 10.5$  $S = T^+ - E_0(T^+)$ $-8.5 = T^+ - 10.5$ $T^+ = 2$
p-value	SAS p-value: $2P_0(T^+ \geq 2) = 0.0938$  $P_0(T^+ \geq 2) = 0.05$

For  $\alpha = 0.05$ ,  $p\text{-value} = 0.05 = \alpha$ , do not reject the null hypothesis. There is not enough evidence to support an increase in engagement scores due to CSL activity. Therefore, the

quantitative data does not confirm that CSL engaged the African and Latino American participants in learning geometry.

Figure 15 exhibits the students' Ongoing Engagement mean pre-test score, mean post-test score, and the differences in their scores.

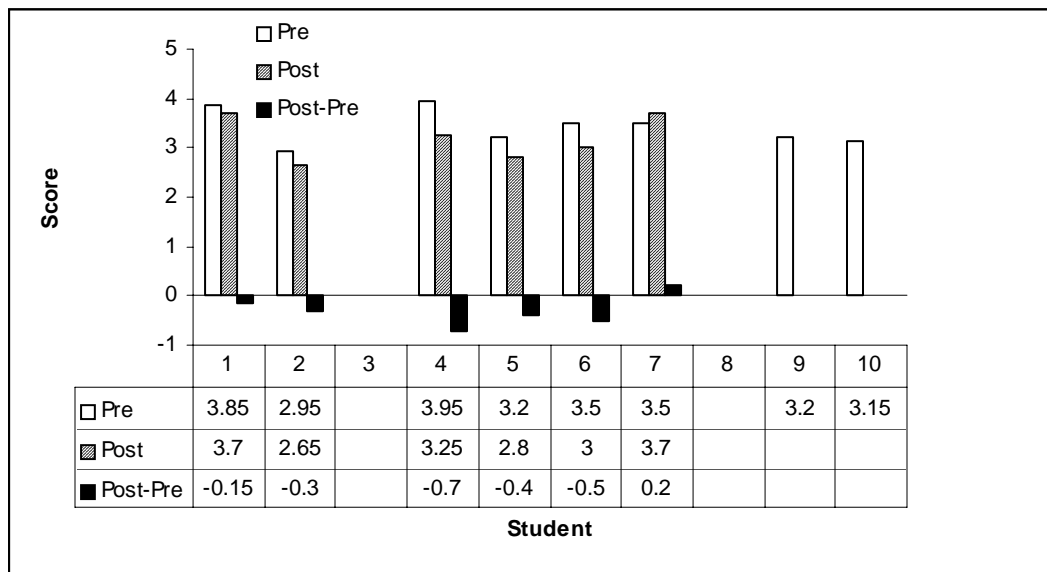


Figure 15. Ongoing Engagement Pre- and Post- Engagement Questionnaire Results

The Wilcoxon Signed Rank Test was employed to analyze the students' Ongoing Engagement and the results are displayed in Table 6.

Table 6. Wilcoxon Signed Rank Test for Ongoing Engagement

Test	Description
Hypothesis	$H_0: \theta=0 \rightarrow$ No differences between the median differences of post scores minus pre scores due to treatment $H_a: \theta>0 \rightarrow$ The median differences of post scores minus pre scores due to treatment was greater than zero
Test Statistic	SAS Signed Rank Statistic: $S = -8.5$  $S = T^+ - E_0(T^+)$ $E_0(T^+) = \frac{n(n+1)}{4} = \frac{6(7)}{4} = \frac{42}{4} = 10.5$  $S = T^+ - E_0(T^+)$ $-8.5 = T^+ - 10.5$ $T^+ = 2$
p-value	SAS p-value: $2P_0(T^+ \geq 2) = 0.0938$  $P_0(T^+ \geq 2) = 0.05$

For  $\alpha = 0.05$ , p-value =  $0.05 = \alpha$ , do not reject the null hypothesis. There is not enough evidence to support an increase in Ongoing Engagement scores due to CSL activity.

Figure 16 displays students' Perceived Autonomy mean pre-test score, mean post-test score, and the differences in their scores.

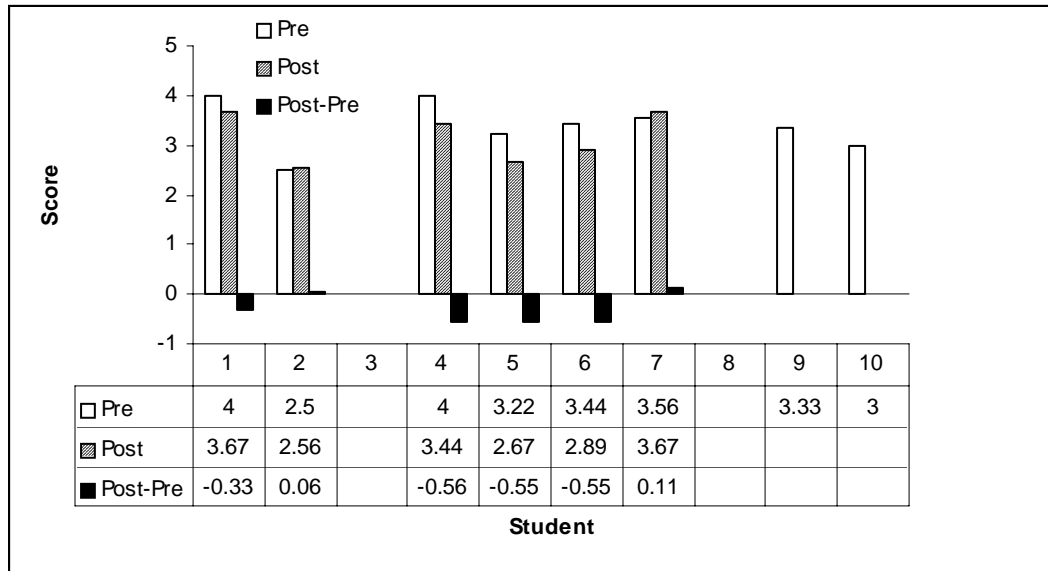


Figure 16. Perceived Autonomy Pre- and Post- Engagement Questionnaire Results

The Wilcoxon Signed Rank Test was used to examine the students' Perceived Autonomy and the results are displayed in Table 7.

Table 7. Wilcoxon Signed Rank Test for Perceived Autonomy

Test	Description
Hypothesis	$H_0: \theta=0 \rightarrow$ No differences between the median differences of post scores minus pre scores due to treatment $H_a: \theta>0 \rightarrow$ The median differences of post scores minus pre scores due to treatment was greater than zero
Test Statistic	SAS Signed Rank Statistic: $S = -7.5$  $S = T^+ - E_0(T^+)$ $E_0(T^+) = \frac{n(n+1)}{4} = \frac{6(7)}{4} = \frac{42}{4} = 10.5$  $S = T^+ - E_0(T^+)$ $-7.5 = T^+ - 10.5$ $T^+ = 3$
p-value	SAS p-value: $2P_0(T^+ \geq 3) = 0.1563$  $P_0(T^+ \geq 3) = 0.08$

For  $\alpha = 0.05$ ,  $p\text{-value} = 0.08 > \alpha$ , do not reject the null hypothesis. There is not enough evidence to support an increase in Perceive Autonomy scores due to CSL activity.

Figure 17 demonstrates students' Beliefs About Mathematics Beyond the Classroom mean pre-test score, mean post-test score, and the differences in their scores.

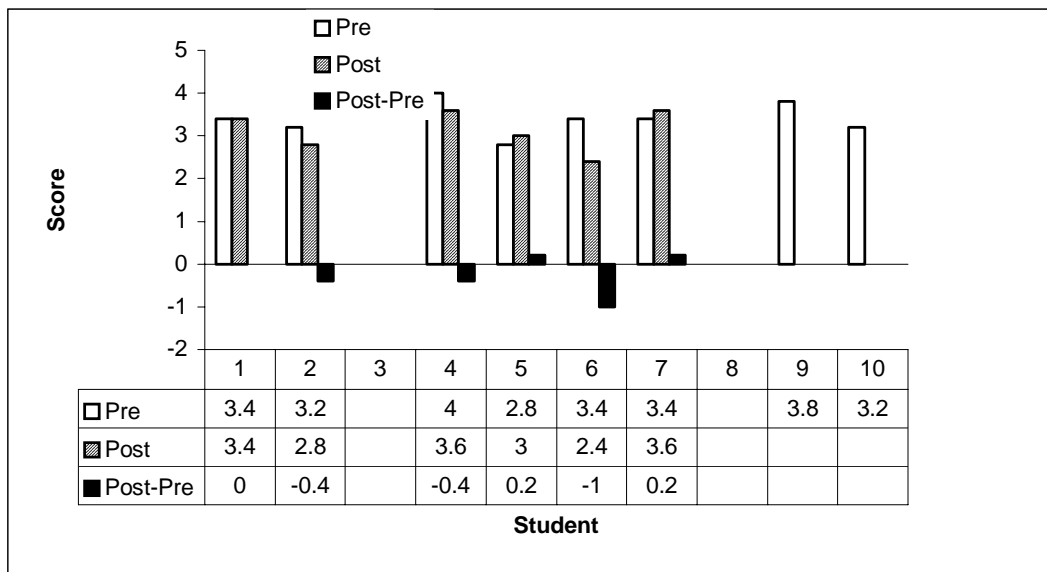


Figure 17. Beliefs About Mathematics Beyond the Classroom Pre- and Post- Engagement Questionnaire Results

The Wilcoxon Signed Rank Test was utilized to analyze students' Belief About Mathematics Beyond the Classroom and the results are displayed in Table 8.

Table 8. Wilcoxon Signed Rank Test for Beliefs About Mathematics Beyond the Classroom

Test	Description
Hypothesis	$H_0: \theta=0 \rightarrow$ No differences between the median differences of post scores minus pre scores due to treatment $H_a: \theta>0 \rightarrow$ The median differences of post scores minus pre scores due to treatment was greater than zero
Test Statistic	SAS Signed Rank Statistic: $S = -4.5$  $S = T^+ - E_0(T^+)$ $E_0(T^+) = \frac{n(n+1)}{4} = \frac{6(7)}{4} = \frac{42}{4} = 10.5$  $S = T^+ - E_0(T^+)$ $-4.5 = T^+ - 10.5$ $T^+ = 6$
p-value	SAS p-value: $2P_0(T^+ \geq 6) = 0.3125$  $P_0(T^+ \geq 6) = 0.16$

For  $\alpha = 0.05$ ,  $p\text{-value} = 0.16 > \alpha$ , do not reject the null hypothesis. There is not enough evidence to support an increase in Beliefs About Mathematics Beyond the Classroom scores due to CSL activity. Therefore, the quantitative data does not confirm that CSL engaged the African and Latino American participants in learning geometry at an Ongoing Engagement, Perceived Autonomy, or Beliefs About Mathematics Beyond the Classroom level.

### *Qualitative Data*

A questionnaire does not allow the researcher to observe how students are being engaged in mathematics as they participate in the CSL activity. Hence, qualitative data was collected, including research notes, videotapes of each session, reflection journals, and interviews. Lave & Wenger's (1991) framework on legitimate peripheral participation was used to examine participants' engagement in mathematics. Since student engagement

consists of ongoing reflection and defines the type of student participation, students' level of engagement was assessed based on their level of reflection. Figure 18 presents the levels of reflection used to analyze students' engagement. These levels were developed based on Lave & Wenger's (1991) legitimate peripheral participation and on CSL. In particular, CSL consists of a service (activity) and an academic (mathematics) component and for this study students could reflect on the CSL activity of promoting art and cultural awareness, the mathematics of geometric transformations, on the activity and the mathematics simultaneously, or the connection between the activity and mathematics.

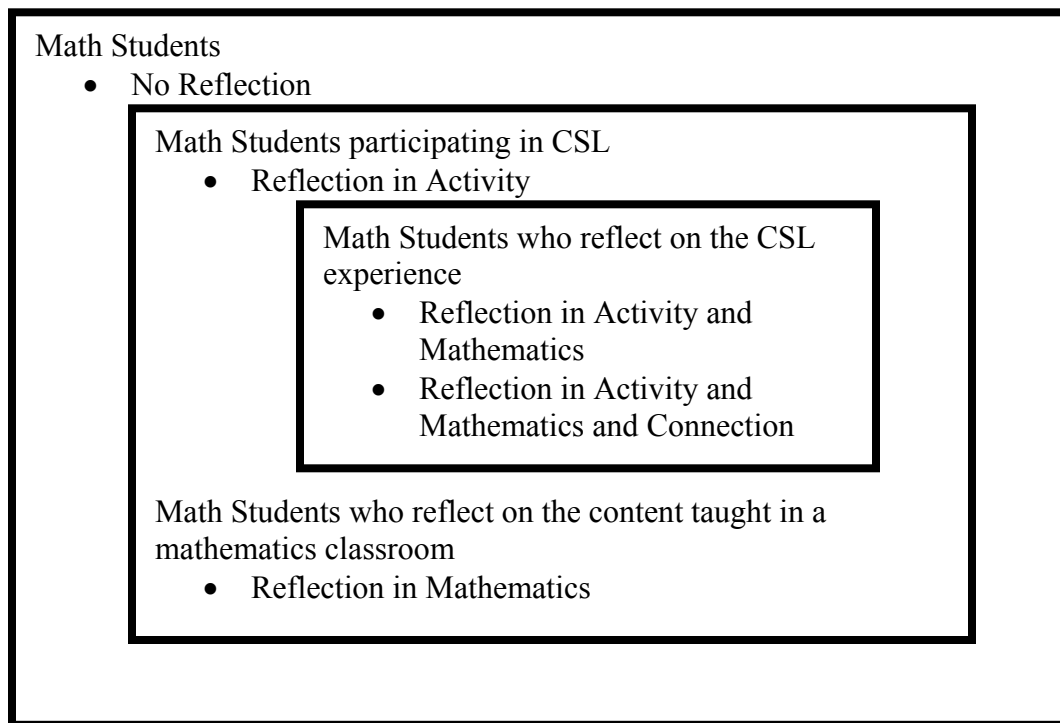


Figure 18. Engagement Diagram



*Reflection in activity.* The first type of reflection was reflecting in the activity. The activity for this study was to promote art and cultural awareness for the local middle school. For the first session of the study, students discussed definitions of art and culture. Students defined art as pictures, paintings, sculptures, and displays and defined culture as any item or theme that described an individual person or an individual place. While students reflected on what represented art and culture in their community, four main themes emerged:

1. Family, friends, and pets
2. Racial, ethnical, and religious background
3. Entertainment
4. Location.

These themes appeared by applying Hatch's (2002) interpretive analysis and distinguishing the most common responses from students. The first theme was that students identified their family, friends, and pets as representing culture and art. Most of the photographs from the students included pictures of their parents, siblings, friends, and pets. Student 7's explanation of why her photographs displayed culture and art supports this theme:

S7: Uh, (*pause*) I don't know, just people who, that are in my community, my friends, my family, uh (*pause*) I don't know.

The next theme that emerged was students' racial, ethnical, and religious background. While selecting photographs for the display, Student 6 noticed no one wanted to include a photograph of the Bible Story Book (See Figure 19).

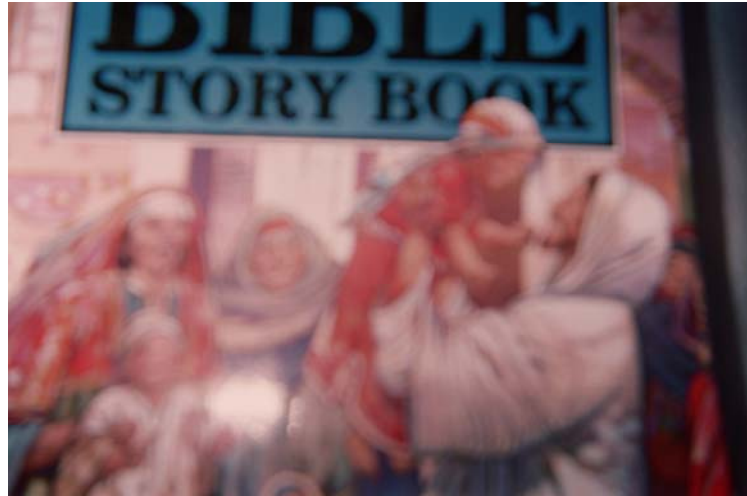


Figure 19: Bible Story Book Photograph

This discovery prompted her to investigate other students' religions:

S6: No one signed the Bible Story Book. I will. I will sign it in big letters.

S6: Raise your hand if you're a Christian.

S1: I am.

S6: Hold them up. What are you? Muslim? Nothing? You're nothing?

S4: Buddhist.

S6: You don't like the Bible Story Book one?

S1: You don't like that one?

S4: It doesn't represent me, so.

S6: Yes it does. It's a religion. She said in the community.

Student 8 provides another example of racial, ethnical, and religious background as she describes what she feels represents her culture.

S8: My background is Indian. I'm mixed. I'm Indian, Irish, France, French,

is that how you say it, some other stuff. My mom is white. My dad is black.

I'm a multiracial child.

Entertainment was the third theme that surfaced as students' ideas of art and culture in their community. Tinkerbelle, Sponge Bob Square Pants, and other cartoon figures appeared in students' photographs. In addition, cell phones, music, movies, sports, and other forms of entertainment were discussed and photographed throughout the CSL activity. The last theme to materialize was location. Students included photographs of places local to their state, their city, and their school. For example:

S5: I think mine represents like [city's name] and like North Carolina because the aquarium I went to was called North Carolina's Aquarium, and that's, that's, about it.

S7: The people, the people that I took pictures of, here, was about school,

Student 6 was very adamant about the photographs representing the community, not just the students and the school. For instance, Student 5 was only choosing photographs for the final display that depicted items and themes from the school itself. Student 6 restated that the display included the community, not just the school. Student 6 reflected on the community being served, the students, teachers, staff, and parents of the middle school.

After students selected photographs that they felt represented the art and culture in their community, they created a design to display these photographs. While designing the display, students continued to reflect and identified themes for which they thought represented art and culture. For example, even the location of the photographs on the display

was determined based on the categories they identified as representing of art and culture in their community:

S5: Where are we suppose to put them?

S6: What about all the people go over here, all the designs go over there.

S2: Put, okay, put me and S3 beside each other. Move those pictures, and put a border around S3 and put her beside of me.

S6: Okay.

S2: 'Cause it's like in the same category, where we're like

S6: Yeah, we're going to do people on this square, is that okay? And then designs on that square, but I don't know what's going on that one yet.

Student 3 also questioned the display's background colors and how their color choices characterized their community.

S3: Why didn't you do this one on blue?

S5: Green please.

S3: Why didn't ya'll do this one on blue? Who did this one?

S3: Who did that one? Why didn't you do it on blue?

S6: I don't know.

I: Why blue?

S6: That's the school's colors.

After this discussion, students agreed to use shades of blue and gray, the schools' colors, for the background. Also, Student 1 suggested writing the name of the school's mascot on the

display.

Students' reflection in the activity of promoting art and culture awareness revealed four themes. The themes included 1) friends and family, 2) racial, ethnical, and religious background, 3) entertainment, and 4) locations. All of these themes were personal and important to the students and hence the activity provided a legitimate form of participation for the students. As a result, students were able to reflect on the activity and thus engage in the service aspect of CSL.

*Reflection in mathematics.* The next type of reflection is reflecting in the mathematics. For this study, the mathematical concept was geometric transformations, which include reflections, translations, and rotations in the coordinate plane. While students were collecting photographs, they were asked to identify different transformations within those photographs. First, students looked for reflections. Four themes emerged for reflections through Hatch's (2002) interpretive analysis and identifying the most common responses from all of the students:

1. Folding or taking half
2. Conservation of congruency
3. Mirror
4. Preimage and image are equidistance from the line of reflection.

First, students noticed that folding or taking half of a symmetrical object creates a reflection.

For example, Student 6 stated that a reflection is constructed by:

S6:     Make it like half.

S6: We would flip the paper over and you could trace it. That's what I use to do.

The next theme for reflections was conservation of congruency. Students used the words 'identical' and 'same' to describe this property. Students stated that if a reflection is constructed by cutting an object in half, the top and bottom have to be the same:

S7: It has to have the same top and bottom.

S5: No, that one back there you can. No wait. Yeah, because it has to be kind of the same thing

S7: Because she said this is a reflection but that is not at the bottom.

The third theme that surfaced for reflections was mirror. Instead of physically folding or cutting items in half, students visualized reflections as mirror images. In other words, students realized that symmetrical objects are not the only types of reflections. Reflections can also move non-symmetrical objects to the opposite side of a reflection line. Students explained these reflections as forming their mirror images. For example, after students identified reflections in the photographs by cutting objects in half, they began reflecting physical objects in the room. Students were no longer cutting objects in half. They had to develop a new concept in order to explain how their transformations were actually reflections.

I: And so how, if I just had this note, and I said reflect it. What do, what do I mean to do? So if I had never heard the word reflection before, what what would I do?

S3: Put a mirror in front of it and flip it. (*laughs*)

While drawing mirror images, students noted that images and preimages of reflections faced the opposite way.

I: So let's talk about reflection. Reflection means you have to (pause) how do you get to the other side? What do you have to do?

S5: You have to have this, the opposite of this.

S7: Uh, I forgot one.

I: What do you mean the opposite?

S5: Like right here, you have to do the opposite, like that way. Instead of going this way, it has to go that way.

Here, Student 5 was using hand gestures to show the image was facing the opposite direction from the preimage.

The last theme to occur was that reflections' preimage and image are equidistant from the line of reflection. Students reflected several figures on the board, utilizing the coordinate plane. While constructing the points of the reflected image, students debated on where to place the vertices of the figures. Student 5 settled the debate by counting the number of tick marks in the coordinate plane from the preimage to the reflection line and from the reflection line to the image:

I: Why would this point be over here?

S5: 1, 2, 3, 4, 5, 6

S5: 1, 2, 3, 4, 5, 6

I: So 6. Why 6?

S3, S5, S6, S7: Because it's got to be the same distance.

Hence, these students realized that all the vertices of the image had to be the same distance from the reflection line as the preimage.

The second type of transformations examined was translations. Only two themes emerged for translations:

1. Result of sliding
2. Conservation of congruency.

The first theme was that translations are the result of sliding an object. Here, students were able to examine an image of a translation and visualize its preimage.

S7: It doesn't mean, look it doesn't mean what you can slide, it means what has already been slid.

S8: So this thing has already been slid?

In addition, students commented on the direction of the slide. For instance, students used up, down, left, right, sideways, backwards, and diagonal to describe how to slide the preimage.

Conservation of congruency between the preimage and image was the last theme to surface for translations. Students noticed that the image of a slide is the same size and same shape as its preimage. For example, Student 7 reflected on this property by asking:

S7: Can translations be it got small, but it's still slide?

However, toward the end of the translation session, Student 7 discovered that the figure must stay the same size:

I: Alright, so let's look at the the cat pictures. So, I see in between the eyes. So



how, what makes these a translation?

S7: You see the same thing, but they're just slid.

The third type of transformations was rotations. Three themes appeared for rotations as well:

1. Applications of rotations
2. Orientation of rotations
3. Result of turning.

The first theme students reflected on was the applications of rotations. Here, students noticed that any object could be turned. For example, Student 7 and Student 8 connected rotations with all items in the photographs and noticed that any object they saw in the photos could be rotated:

S8: Homework can get rotated.

S7: Everything can be rotated.

S8: Detention can be rotated.

Another theme to occur was an attention to the orientation of rotations. A rotation turns an object, but it does not change the order of the figure's components and hence conserves the preimage's shape. For example, Student 1 drew a picture of Garfield on the board and then rotated Garfield 90° clockwise. Student 4 noticed that S1's rotation was not the correct orientation:

S1: This goes right here.

S4: You did it wrong already. You did it wrong, because the eyes are suppose to

go on top.

The third theme that emerged was that rotations resulted from turning an object. Here, students visualized that turning a rotation's preimage creates its image. In order to turn an object, there must be a degree and direction of rotation. Student 4 commented on the direction of the turn, stating rotations go clockwise. Student 6 mentioned the degree of rotation, by suggesting 360 degrees.

Throughout this session, students were forced to reflect on the mathematics by comparing and contrasting transformations and their properties. Students discovered that different compositions of transformations result in other types of transformations. Student 7 even asked about different transformations in her pre-interview:

S7: It hasn't changed, so when it is the rectangle right here, you slide it, but it's the same and it hasn't changed. Couldn't you do it like this? It's a rectangle, but you can slide it and rotate it at the same time. Would it still be a translation?

During class discussion, Student 1 and 6 also detected this composition of transformations.

S1: They, they, they all, they all translate 'cause reflections can translate. And rotations can translate too.

S6: You could reflect it and slide it.

S1: Oh, very good.

Hence, the composition of transformations was the only theme to emerge from transformations as a collective group.

Students' reflection in the mathematics of geometric transformations resulted in various themes. The themes included noticing properties from reflections, translations, and rotations. Through physical examination of photographs and class discussions, students had legitimate opportunities to participate in learning geometric transformations. Hence, students were able to reflect on the mathematics and thus engage in the academic component of CSL. *Reflection in activity and mathematics.* The CSL activity included both an activity (service) and a mathematics (academic) component. As a result, students were able to reflect on each component of the CSL project separately. Only a few students reflected on the activity and the mathematics simultaneously. For those students, two themes occurred while students reflected in the activity of art and cultural awareness and the mathematics of geometric transformations:

1. Use of slides in design
2. Incorporating reflections in design.

The use of slides in the design of the display was the first theme to surface. In other words, students moved photographs within the display by sliding the photograph from one location (its preimage) to another location (its image). While designing the display, students were using four different colors of construction paper to create the background for a quadrant of the display. In order to make all of the construction paper fit, Student 5 and 7 utilized slides in their plan:

S5: This is how I did it. Okay, look. It goes on here, right. And I put another right here, and then I put another right here.

S7: Move this this way so we can make it bigger like that. (*inaudible*)

S9: No, no, no.

Although Student 7 did not use slides correctly, Student 9 pointed out that sliding does not make the item bigger. He slid one piece of construction paper to show Student 7 that the size did not change. Incorporating reflections in the design of the display was the second theme to emerge. Here, students moved a photograph from one location (its preimage) by reflecting it to another location (its image). For example, Student 5 wanted a photograph on the left side of the display. However, Student 7 placed the photograph on the right side of the display.

S5: What in the world, it's backwards.

S7: You can still move the picture. Wow, S5.

Here, Student 7 pointed out by moving the picture through a reflection across the y-axis, the photograph would be oriented the way Student 5 envisioned. Student 6 also integrated reflections in her plan:

S6: If you flip the cat, like if you hook it on to each other. No, not like that.

Student 1 also described her design using reflections:

S1: Oh, no, I was about to I was going to flip it.

By designing the display, students had opportunities to reflect on both art and cultural awareness and geometric transformations simultaneously. Only a few participants showed evidence of engaging in the activity and the mathematics. Many students missed at least one session and this could be a factor to why only a few students illustrated reflection in the

activity and the mathematics. However, no participant reflected on the activity and the mathematics and their connection. One factor could be that only a few students were able to reflect on the activity and the mathematics simultaneously, so only a few students could have the opportunity to add a third component to their reflections. Also, the study only included ten sessions and students might not have enough time to reflect on the connection between the activity and the mathematics.

*Legitimate peripheral participation.* Through reflection in the activity of promoting art and cultural awareness, students engaged in four themes that they felt were relevant to their school, their community, and themselves. For example, friends and family provided a personal piece to the activity. Also, students' identities defined by racial, ethnical, and religious background were promoted. Entertainment allowed students to bring fun and exciting ideas into the activity. In addition, students focused on locations important to them, including school and local attractions. By providing students with opportunities to reflect in the activity, the legitimate peripheral participation framework supports that students were engaged in the activity of promoting art and cultural awareness in their community.

Students engaged in various themes with reflections, translations, and rotations through reflecting on the mathematics of geometric transformations. By physically examining photographs, students constructed and observed a variety of properties for each type of transformation. Also, class discussions allowed students to compare, contrast, and connect these characteristics of transformations. Through reflection in mathematics, the LPP framework confirms students' engagement in the mathematics of geometric transformations.

Students reflected in the activity and the mathematics when designing the photo display for art and cultural awareness. In order to justify their design plan to the other participants, students incorporated geometric transformations in their arguments. While designing the display for art and cultural awareness through geometric transformations, students reflected in the activity and the mathematics. Hence, students were engaged in the learning of geometric transformations while involved in the CSL of art and cultural awareness according to the LPP framework.

After examining students' level of reflections, each student was categorized according to Figure 20.

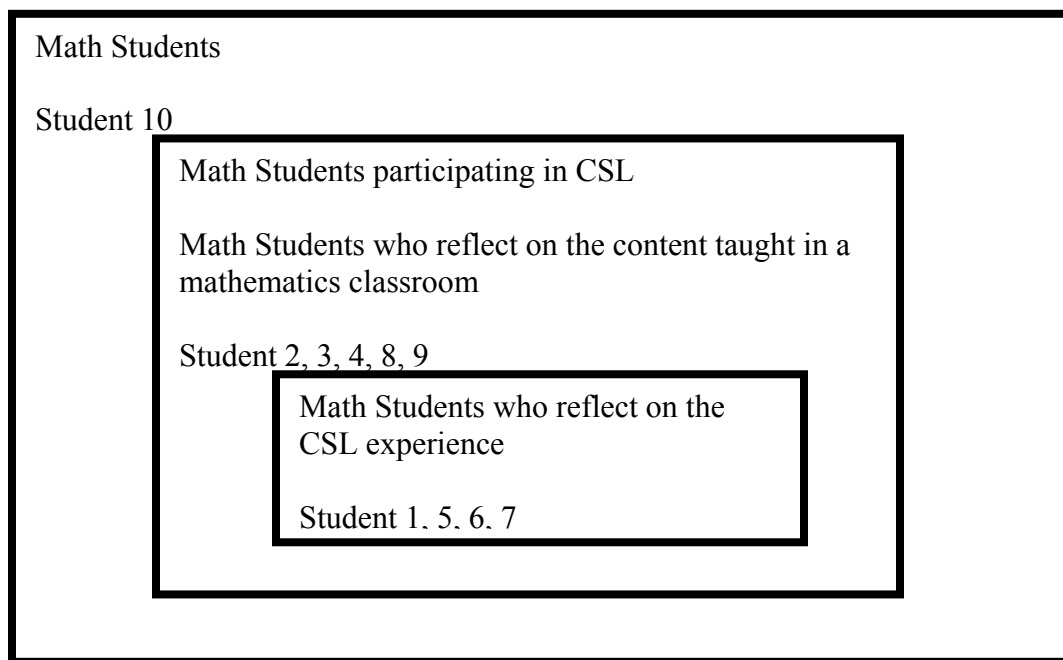


Figure 20. LPP Conceptual Framework Model Constructed for This Study

Students who did not participate in the sessions were placed in the outer level due to no record of reflection. Students who reflected on the activity or students who reflected on the mathematics were located in the middle level. And the students who reflected on the activity and the mathematics were assigned the inner level. All of the students except Student 9 were at least moderately engaged in learning geometric transformations when involved in a CSL activity. The qualitative findings show that CSL moderately or highly engages African and Latino Americans in learning geometric transformations.

### *Findings Related to Research Question 2*

#### *Quantitative Data*

The participants were given a Pre- and a Post- Mathematics Understanding assessment (See Appendix D and E). The differences in the participants' posttest and the pretest were calculated. Figure 21 reveals the ten sixth-grade students' scores, including the differences in their scores. Each question was worth four points with the exception of Question 4 which was worth 3 points and Question 8 which was worth twelve points (four points for each of the three parts). Students received 4 points if their responses illustrated a sixth grade understanding of transformations, 3 points if their responses were missing one concept from a sixth grade understanding, 2 points if their responses revealed half of the concepts, 1 point if their responses included only one concept, and 0 points if their responses did not demonstrate any understanding at a sixth grade level (Refer to the Literature Review for definitions). Each transformation score was the sum of the points from each question that represents each transformation. The final transformation score was the sum of the three

transformation totals plus the total of question 4 and 10. The maximum transformation score was 39 and the minimum was 0. The Wilcoxon Signed Rank Test was conducted to analyze a shift in location due to the treatment of the community service learning activity (Hollander & Wolfe, 1999). The test was conducted using only the students who completed both the pre- and posttest. For example, Student 3, 8, and 10 did not take the pre- or posttest and thus were not included in the test. Also, Student 9 did not take the posttest and therefore was not part of the test. Hence, only six students were incorporated into the Wilcoxon Signed Test. For this test, the null hypothesis that there are no differences between the median differences of post-test scores minus pre-test scores due to CSL activity was tested against the alternative hypothesis that the median differences of post-test scores minus pre-test due to CSL activity was greater than zero (See Table 9).

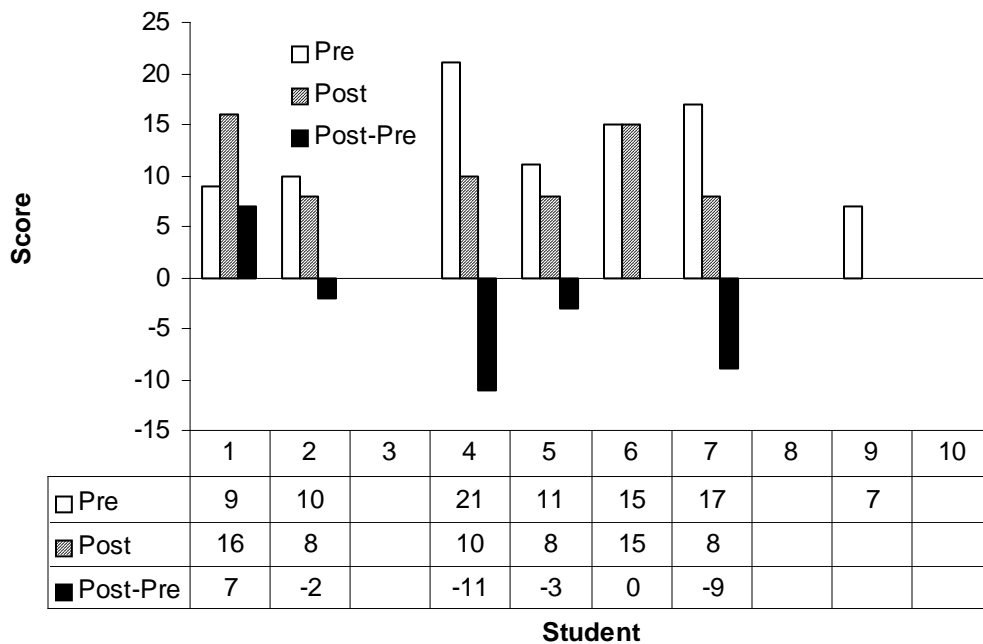


Figure 21. Pre- and Post- Mathematics Understanding Assessment Results



Table 9. Wilcoxon Signed Rank Test for Mathematical Understanding

Test	Description
Hypothesis	$H_0: \theta=0 \rightarrow$ No differences between the median differences of post scores minus pre scores due to treatment $H_a: \theta>0 \rightarrow$ The median differences of post scores minus pre scores due to treatment was greater than zero
Test Statistic	SAS Signed Rank Statistic: $S = -4.5$  $S = T^+ - E_0(T^+)$ $E_0(T^+) = \frac{n(n+1)}{4} = \frac{6(7)}{4} = \frac{42}{4} = 10.5$  $S = T^+ - E_0(T^+)$ $-4.5 = T^+ - 10.5$ $T^+ = 6$
p-value	SAS p-value: $2P_0(T^+ \geq 6) = 0.3125$  $P_0(T^+ \geq 6) = 0.16$

For  $\alpha = 0.05$ ,  $p\text{-value} = 0.16 > \alpha$ , do not reject the null hypothesis. There is no support a claim that an increase in mathematical understanding scores is due to the community service learning activity. In addition, there is not enough evidence to show a decrease in mathematical scores due to community service learning activity. This means there are no significant differences between the mean of pre-test or post-test scores.

Figure 22 shows the students' reflections pre-test score, post-test score, and the differences in their scores.

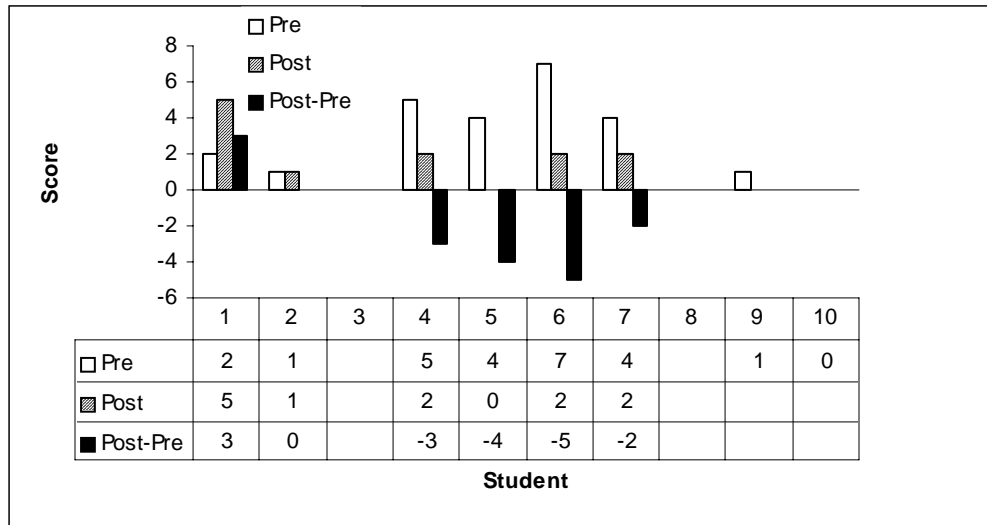


Figure 22. Pre- and Post- Reflections Mathematics Understanding Assessment Results

The Wilcoxon Signed Rank Test was employed to examine the students' understanding of reflections and the results are displayed in Table 10.

Table 10. Wilcoxon Signed Rank Test for Reflections Mathematical Understanding

Test	Description
Hypothesis	$H_0: \theta=0 \rightarrow$ No differences between the median differences of post scores minus pre scores due to treatment $H_a: \theta>0 \rightarrow$ The median differences of post scores minus pre scores due to treatment was greater than zero
Test Statistic	SAS Signed Rank Statistic: $S = -5$  $S = T^+ - E_0(T^+)$ $E_0(T^+) = \frac{n(n+1)}{4} = \frac{6(7)}{4} = \frac{42}{4} = 10.5$  $S = T^+ - E_0(T^+)$ $-5 = T^+ - 10.5$ $T^+ = 5.5$
p-value	SAS p-value: $2P_0(T^+ \geq 5.5) = 0.2500$  $P_0(T^+ \geq 5.5) = 0.13$

For  $\alpha = 0.05$ ,  $p\text{-value} = 0.13 > \alpha$ , do not reject the null hypothesis. There is not enough evidence to support an increase in reflection scores due to CSL activity.

Figure 23 displays students' translations pre-test score, post-test score, and the differences in their scores.

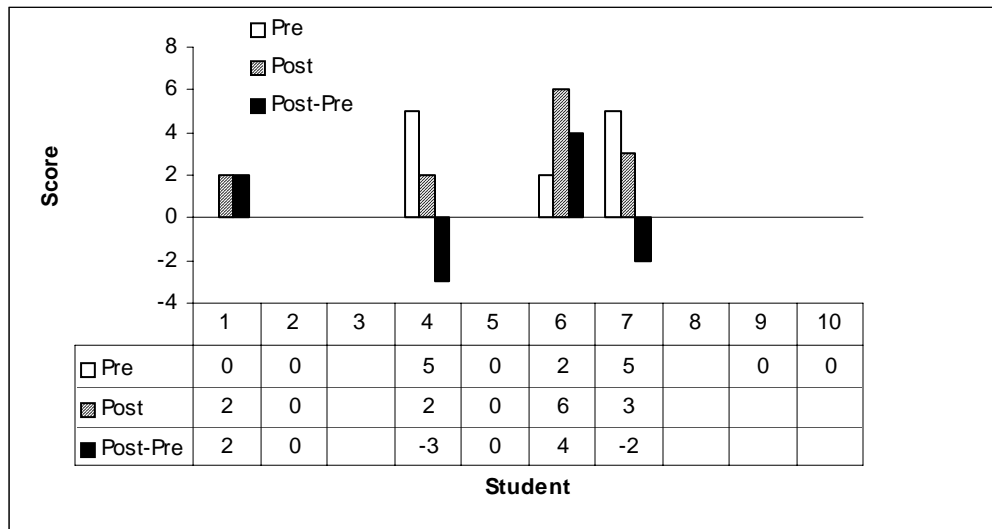


Figure 23. Pre- and Post- Translations Mathematics Understanding Assessment Results

The Wilcoxon Signed Rank Test was used to analyze the students' understanding of translations and the results are displayed in Table 11.

Table 11. Wilcoxon Signed Rank Test for Translations Mathematical Understanding

Test	Description
Hypothesis	$H_0: \theta=0 \rightarrow$ No differences between the median differences of post scores minus pre scores due to treatment $H_a: \theta>0 \rightarrow$ The median differences of post scores minus pre scores due to treatment was greater than zero
Test Statistic	SAS Signed Rank Statistic: $S = 0.5$  $S = T^+ - E_0(T^+)$ $E_0(T^+) = \frac{n(n+1)}{4} = \frac{6(7)}{4} = \frac{42}{4} = 10.5$  $S = T^+ - E_0(T^+)$ $0.5 = T^+ - 10.5$ $T^+ = 11$
p-value	SAS p-value: $2P_0(T^+ \geq 11) = 1.0000$  $P_0(T^+ \geq 11) = .50$

For  $\alpha = 0.05$ , p-value =  $0.50 > \alpha$ , do not reject the null hypothesis. There is not enough evidence to support an increase in translation scores due to CSL activity.

Figure 24 exhibits students' rotations pre-test score, post-test score, and the differences in their scores.

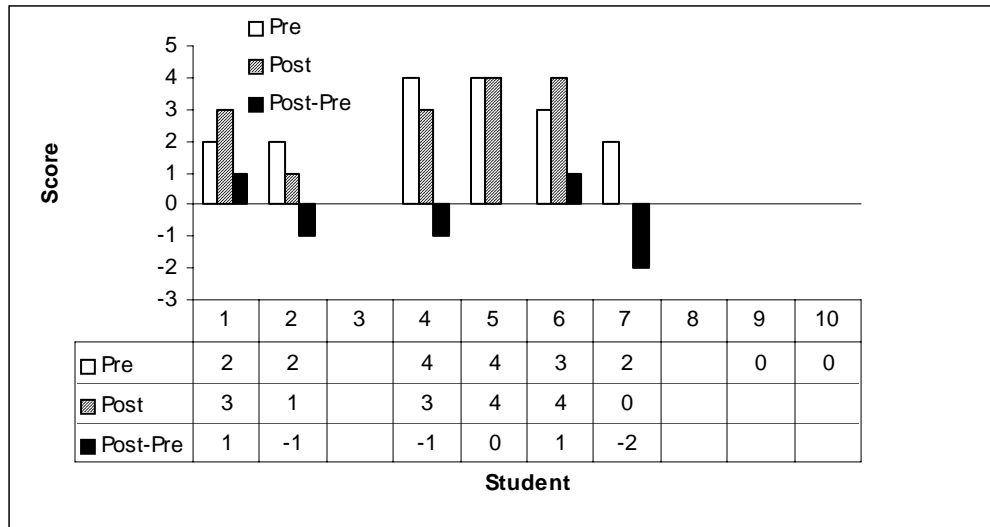


Figure 24. Pre- and Post- Rotations Mathematics Understanding Assessment Results

The Wilcoxon Signed Rank Test was used to examine the students' understanding of rotations and the results are displayed in Table 12.

Table 12. Wilcoxon Signed Rank Test for Rotations Mathematical Understanding

Test	Description
Hypothesis	$H_0: \theta=0 \rightarrow$ No differences between the median differences of post scores minus pre scores due to treatment $H_a: \theta>0 \rightarrow$ The median differences of post scores minus pre scores due to treatment was greater than zero
Test Statistic	SAS Signed Rank Statistic: $S = -2.5$  $S = T^+ - E_0(T^+)$ $E_0(T^+) = \frac{n(n+1)}{4} = \frac{6(7)}{4} = \frac{42}{4} = 10.5$  $S = T^+ - E_0(T^+)$ $-2.5 = T^+ - 10.5$ $T^+ = 8$
p-value	SAS p-value: $2P_0(T^+ \geq 8) = 0.7500$  $P_0(T^+ \geq 8) = 0.38$

For  $\alpha = 0.05$ ,  $p\text{-value} = 0.38 > \alpha$ , do not reject the null hypothesis. There is not enough evidence to support an increase in rotation scores due to CSL activity. Therefore, the quantitative data does not confirm that CSL promoted growth in understanding of reflections, translations, and rotations for the African and Latino American participants.

A third test examined the participants' posttest scores with a control group's scores. The control group consisted of sixth and seventh grade students who did not participate in the CSL activity (See Table 13). The Jonckheere Test was used to assess an increasing treatment effect (Hollander & Wolfe, 1999). For this test, the null hypothesis of no differences between post scores due to treatment given was compared against the alternative hypothesis of the treatment effect are higher for SCL participants (See Table 14).

Table 13. Control Group's Posttest Mathematical Understanding Scores

<b>Sixth Grade</b>	<b>Seventh Grade</b>
3	2
4	3
6	3
7	5
9	6
9.5	7
12	7
15	8
15	9
16	10
16	10
17	11
17	13
18	13
18	13
19	14
20	16
20	17
22	19
23	19
23	19
24	19
24	21
27	22
28	22
32.5	22
	23
	24
	24
	25

Table 14. Jonckheere-Terpstra Test for Mathematical Understanding

Test	Description
Hypothesis	$H_0: \tau_1 = \tau_2 \rightarrow$ No differences between treatment and control scores $H_a: \tau_1 < \tau_2 \rightarrow$ Treatment scores higher than control scores
Test Statistic	SAS Jonckheere-Terpstra: J =235
	Large Sample Statistic: Z = 1.5971
p-value	SAS p-value: $P_0(Z \geq 1.5971) = 0.06$

For  $\alpha = 0.05$ , p-value = 0.06  $> \alpha$ , do not reject the null hypothesis. There is not enough evidence to show higher mathematical understanding scores for the community service learning activity compared to the control group. Therefore, there are no significant differences in scores between the CSL group and the control group.

#### *Qualitative Data*

In order for the researcher to observe students' growth in mathematical understanding in the context of geometric transformations as they participate in the community service learning activity, qualitative data was collected. The data included the pre- and post-mathematics understanding assessment, research notes, videotapes of each session, reflection journals, and interviews. Pirie & Kieren's (1994) growth in mathematical understanding model was employed to analyze students' growth in their mathematical understanding of geometric transformations. Reflections, rotations, and translations were examined individually and using the Pirie-Kieren (1984) model, students could fall into any of the levels and could retreat or proceed at any time to any level (Pirie & Kieren, 1994). Students' growth was categorized based on the eight circles in Pirie and Kieren's (1994) model (See



Figure 25).

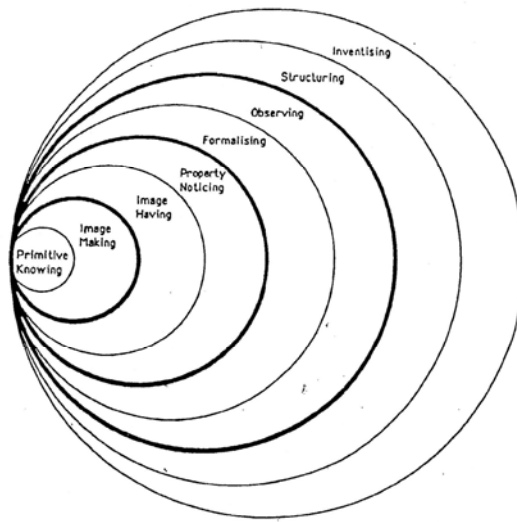


Figure 25. Growth in Mathematical Understanding Framework (Pirie & Kieren, 1994, p. 167)

*Primitive knowledge.* *Primitive knowledge* is the knowledge and skills the observer assumes the students have before the learning activity takes place (Pirie & Kieren, 1994). Hence, all students began at the *primitive knowledge* level. However, students possess their own *primitive knowledge* and thus *primitive knowledge* may differ from student to student.

*Image making.* The ability to physically construct images by categorizing, combining, or using their knowledge in new and different ways occurs in the next level, *image making* (Pirie & Kieren, 1994). Students who displayed understanding at this level were utilizing physical objects, specifically photographs, to understand transformations. For reflections, students were using the action of cutting an object in half.

S6: Make it like half.

S5: S6, is it ok if I cut you in half?

S5: I can cut your fry in half. I can cut your bag in half. I can cut S3 in half.

S5: I can cut the phone in half. I can (*inaudible*) cut in half.

S5: I can cut this in half.

S7: Cut the door in half.

S5: I can cut this in half. I can cut this in half.

Students continuously divided objects in half to represent reflections. In other words, the line that cut the object in half symbolized the line of reflection and one side of the cut represented the preimage and the other side of the cut represented the image. Other physical manipulations of objects were used. Student 6 used folding as a way to develop reflections, where the fold line corresponded to the line of reflection:

S6: Like I use to like turn my paper over and trace it and then see where it was on the back of the paper then put it back on here.

Students resumed making images by drawing letters and cutting them in half as well as writing their names and constructing reflection lines.

While examining translations, students observed the result of physical movements of objects within photographs. Student 7 and 8 referred to translations as simply moves.

S8: This, oh see this is perfect. This has moved.

S7: This has moved. Well, all these have moved.

For example, Student 7 and 8 would have said the windows in townhouse in Figure 26 have moved from the left side to the right side.



Figure 26. Translations

Student 4 drew a figure on the board and asked Student 3 to translate the figure. Student 3's translation consisted of a figure that was not congruent to the original figure. Through this physical representation, she was able to construct a new figure that displayed a correct translation.

S4: Translate it to that side.

S3: I can't draw.

S5: No, wrong. You drew it smaller.

S3: What is the difference?

While examining photographs for rotations, Student 7 and 8 also observed physical movements for rotations:

S8: Your daddy's cap can be rotated.

S7: The cup can get rotated.

S7: That does not like right, the necklace part.

S8: Uh-huh, the necklace can rotate.

S8: No, I was talking about this part right here. That can be rotated.

*Image having.* The third level is *image having*, where students no longer have to draw or use manipulatives to visualize the concept (Pirie & Kieren, 1994). Instead of cutting objects in half or physically manipulating objects, students used their mental images to discuss reflections. For example:

S5: Now, if you stick them together, they are going to be the same thing.

S7: Yeah, if you cut it off this way and if you cut it off this way, then it will still be a reflection

S3: Because if you turn it that way it was to be that going towards that way.

These students revealed their ability to visualize reflections by using the word *if* instead of constructing a physical model. Some students were also able to visualize translations.

Student 7 displayed her ability to visualize slides by stating that:

S7: It doesn't mean, look it doesn't mean what you can slide, it means what has already been slid.

Another example was Student 6 and 7's capability of describing the direction of the translations without having to slide the objects. While observing another student, Student 4 demonstrated *image having* for rotations.

S4: You did it wrong already. You did it wrong, because the eyes are suppose to go on top.

Students visualized transformation within games, sports, and other forms of entertainment. Without physically constructing models, these students revealed their mental concepts of transformations.

*Property noticing.* During *activity property noticing* level, the students can now detect particular features of those images and discover “context specific, relevant properties” (Pirie & Kieren, 1994, p. 170). Students detected that reflections flip the preimage to the opposite side of the reflection line to get the image. For example:

S3: Put a mirror in front of it and flip it. (*laughs*)

I: Put a mirror, that’s a that’s good, a mirror? What does a mirror do?

S6: (*inaudible*) gives you a reflection.

I: I don’t know what a reflection is.

S3: It shows the opposite.

Students noticed that translations are the result of sliding. They also recognized that the translations maintain the preimage’s size, shape, and orientation:

I: Alright, so let’s talk about these translations. To make it a translation, what are you looking for besides sliding? What else?

S6: The same shape and size, the similarities.

For rotations, students identified that turns need a direction. Many students included the actual degree of rotations in their descriptions:

S4: Clockwise. It goes clockwise. It goes

S5: It goes like around.

I: Alright, [S6] wrote 360.

Student 4 also discussed that an object rotates about a point. The students as a collective whole noticed all the properties of each transformation defined at a sixth grade competency

level.

*Formalising.* At the *formalizing* level, students are able to abstract the properties from the images (Pirie & Kieren, 1994). Students 3, 5, 6, and 7 displayed one formalization each. These students observed that preimages and images have to be the same distance from the reflection line. Other students formalized that a composition of different transformations can lead to another transformation. For example:

S1: They, they, they all, they all translate 'cause reflections can translate. And rotations can translate too.

S6: Inverse operations.

S6: You could reflect it and slide it.

S7: It could rotate and translate at the same time.

S7: What about ro, what about if it's rotating while it's trans translating?

S6: That's a transformation.

None of the participants reached the outer levels of *observing*, *structuring*, or *inventising* (Pirie & Kieren, 1994).

*Pirie & Kieren.* Because the mapping is based on a chronological time sequence, students were forced to jump the level boundaries, fold back between the levels, and stay within one level as time progressed. For example, students started the study with a Pre- Mathematics Understanding assessment. This assessment required students to jump from *primitive knowledge* to *image having* and *property noticing*. The next session required students to examine physical representations of reflections through photographs. At this stage students

folded back to *image making* and *image having*. Afterwards, students discussed properties of reflections and returned to *property noticing* level. The third session students repeated the examination of photographs and discussions with translations and then with rotations. Hence, due to their participation in the CSL activity, students went back and forth among *image making*, *image having*, and *property noticing*. In addition, students were asked to compare and contrast transformations, and here some students were able to jump to *formalizing*. At the end of the study, students ended with a Post- Mathematics Understanding assessment, hence students were forced to fold back to *image having* and *property noticing*. During the study, several students missed sessions, and hence did not have the opportunities to fold back or jump boundaries and as a result they stayed within a particular level.

After examining students' levels of growth in mathematical understanding, each student was categorized according to Figure 17. Some students' level of understanding jumped boundaries, while others folded back to previous levels. Other students stayed at a particular level for a while. This movement among levels was consistent with Pirie & Kieren's (1994) growth in understanding mapping model. The mapping of the ten participants' growth in understanding is displayed in Figures 27 through 36. The letters represent different activities, examples, or questions the student was involved in during the lessons. When students acted and expressed within a level for a length of time, a zigzag line was used to notate this phase. Point A represents the researcher's assumption that each student brought in prior knowledge to the CSL activity.

For Student 1, the pretest for the Mathematics Understanding Assessment occurred at

Point B. Student 1 identified properties of reflections and rotations, stating reflections as ‘mirror’ and rotations as moving figures ‘around’. At the next session, students identified reflections in photographs. Due to the nature of the activity, Student 1 fell back to image having at Point C by stating that the color of the objects do not have to match in order to be a reflection. Student 1 missed the next sessions that involved translations and rotations and did not comment on any transformations until the posttest for the Mathematics Understanding Assessment at Point D. Student 1 referred to reflections as a mirror, translations as a slide, and rotations as turns. Also, Student 1 formalized that by using a mirror to create a reflection, that all the images would face the opposite direction from the preimage.

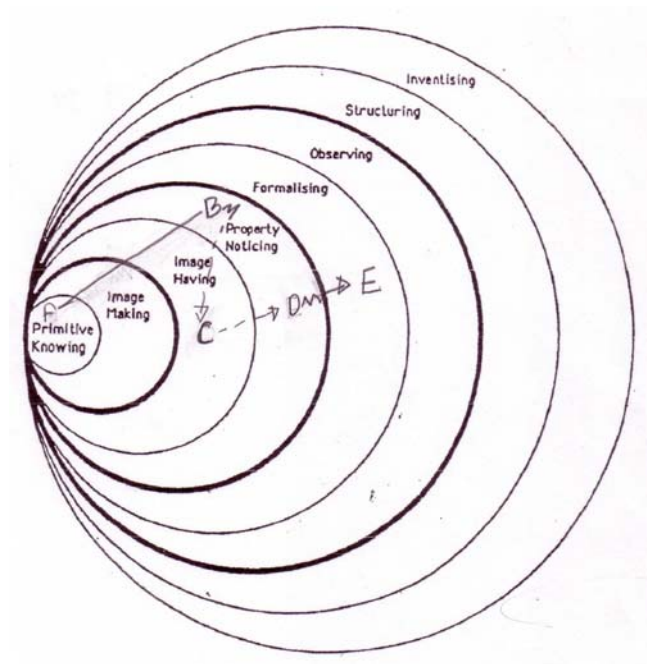


Figure 27. Student 1's Growth in Mathematical Understanding of Transformations

At Point B, Student 2 was noticing properties of reflections and rotations during the



pretest of the Mathematics Understanding Assessment. Here, she stated that reflections were mirrors and rotations revolve objects. Student 2 missed the sessions on reflections, rotations, and translations and thus stayed in the property noticing level. She continued at Point B during the posttest of the Mathematics Understanding Assessment. On the posttest, she observed that rotations turn objects and reflections transform objects to the other side of the reflection line. When asked about translations on the posttest, Student 2 folded back to primitive knowledge, commenting that translations are when you interpret one language into another.

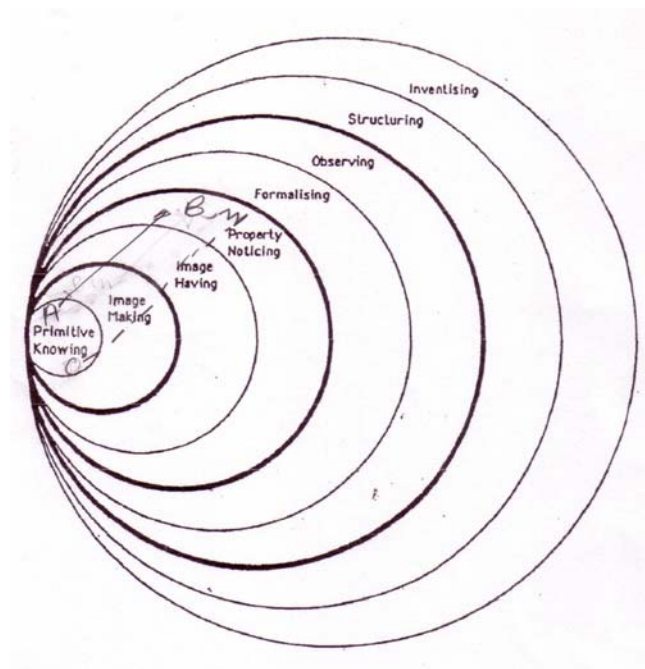


Figure 28. Student 2's Growth in Mathematical Understanding of Transformations

Student 3 did not take the pretest Mathematics Understanding Assessment. At Point B, Student 3 was examining photographs for reflections. She began by making images of

reflections. She started out by cutting objects in half. As she continued to cut objects in half, Student 3 began visualizing reflections and moved to Point C. As students began to reflect physical objects within the classroom, Student 3 could not reflect by cutting objects in half. She had to fold back to image making and develop a new way to construct reflections. This occurred at Point D. Student 3 then jumped to the property noticing level at Point E as she observed reflections transform objects to the opposite side of the reflection line. Students continued to explore reflections by drawing reflections on the board. At Point F, Student 3 abstracted that the preimage and image of reflections are the same distance from the reflection line. Students continued to draw reflections on the board and Student 3 folded back to image making at Point G as she investigated diagonal reflections. At the beginning of the next sessions, students wrote in their reflection journals. When describing reflections at Point H, Student 3 commented that reflections transform objects to the opposite side of the reflection line. Student 3 missed the translations and rotations sessions. However, at Point I, students were comparing and contrasting reflections, translations, and rotations. Here, Student 3 commented that all transformations can be applied to all shapes. At Point J, Student 4 drew a figure and asked Student 3 to translate the figure. When Student 3 drew her translation, the figure was smaller. Student 5 said her figure was smaller than the original and Student 3 asked what difference did it make. Student 3 folded back to the image making level because her image of translations was not correct. Student 3 did not take the posttest Mathematics Understanding Assessment.

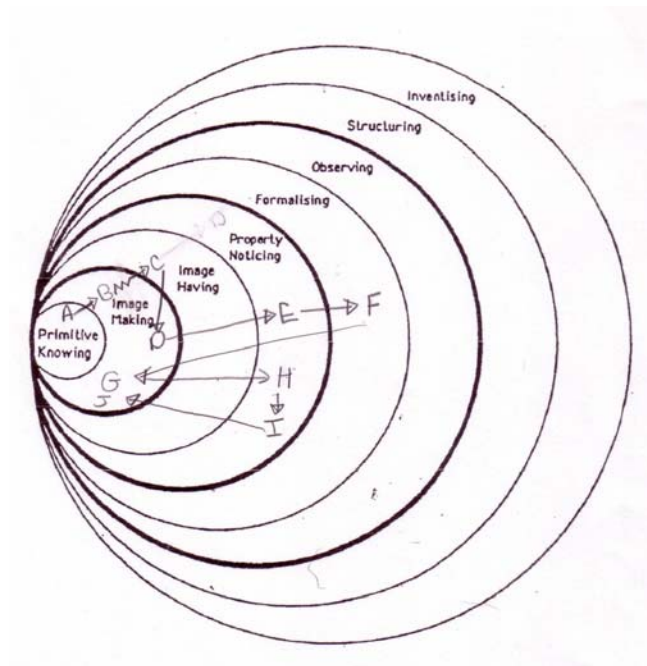


Figure 29. Student 3's Growth in Mathematical Understanding of Transformations

During the pretest of the Mathematics Understanding Assessment, Student 4 asserted that reflections were mirrors and the preimage and image were on the opposite of the reflection line. He also detected that rotations turn an object about a point and that translations change an object's location but nothing else changes. Student 2 remained at Point B throughout the pretest. Student 4 missed the reflection session. During the examination of photographs for translations, Student 4 did not talk. However, he folded back to the image making level during the rotation activity at Point C. Here, Student 4 began constructing rotations by asking the other students questions. Once Student 4 felt comfortable with rotations, he moved to the image having phase at Point D. Here, Student 4 commented that he knew what a rotation should look like. For example, Student 1 drew a

picture of Garfield on the board and then rotated Garfield. However, the eyes of Garfield were not in the correct orientation based on her rotation. Student 4 stated that the eyes were in the wrong location, but he did not explain any further why the eyes were in the wrong location. At the next session, students were asked to compare and contrast reflections, translations, and rotations. During this session, Student 4 identified various properties of all the transformations and moved to the property noticing level at Point E. Student 4 observed that rotations could go clockwise and that reflections transform objects to the opposite side of the reflection line. Student 4 remained in the property noticing level because he continued to identify properties of transformations on his posttest Mathematics Understanding Assessment.

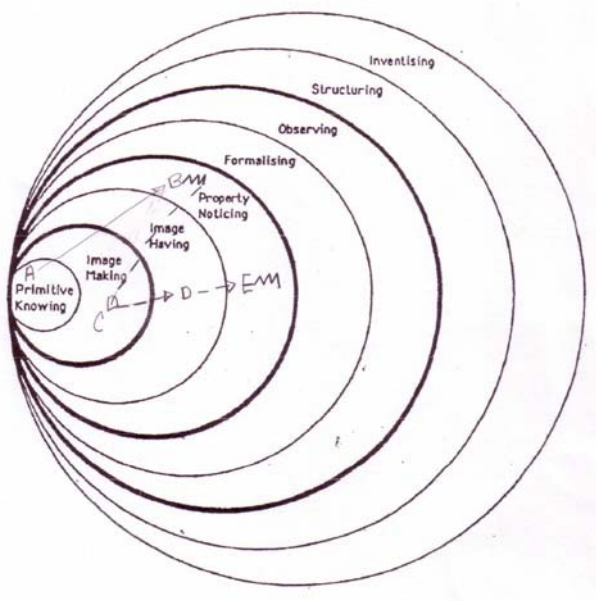


Figure 30. Student 4's Growth in Mathematical Understanding of Transformations

Student 5 began at Point B when he stated on his pretest Mathematics Understanding

Assessment that reflections are mirrors and rotations spin objects around. Student 5 folded back to image making as he explored reflections through photographs. At Point C, he constructed reflections by cutting objects in half. As students discussed reflections, Student 5 jumped to the property noticing level. Here, he observed that reflections transformed objects to the other side of the reflection line. Then, he folded back at Point E to image having as he visualized reflections as sticking the two sides of the reflection line together. Using this image, Student 5 was able to move to the property noticing level for he stated that the other side meant the opposite side of the reflection line. Student 5 bounced back and forth between image having and property noticing throughout the discussion of reflections. This occurred at Points D through G. As students began to draw reflections on the board, Student 5 jumped to the formalising level because he abstracted that the preimage and image of reflections are the same distance from the reflection line. Student 5 missed the translations and rotations sessions. However, he was present when students compared and contrasted reflections, translations, and rotations. Here, at Point I, Student 5 detected that reflections are mirrors, translations are slides, and rotations move objects around. When another student mentioned that reflections were opposites, he folded back to image having because he drew a reflection on the board, but the preimage and image were not facing the opposite direction. Here, Student 5 realized that his image was backwards and moved to Point K in the property noticing level. At Point L, Student 5 drew a translation on his posttest Mathematics Assessment and showed he had the image of translations. Later in the posttest, Student 5 identified several properties of transformations. He stated that rotations spin or turn objects,

reflections must have a line of reflection, and that translations keeps the objects the same.

This occurred at Point M.

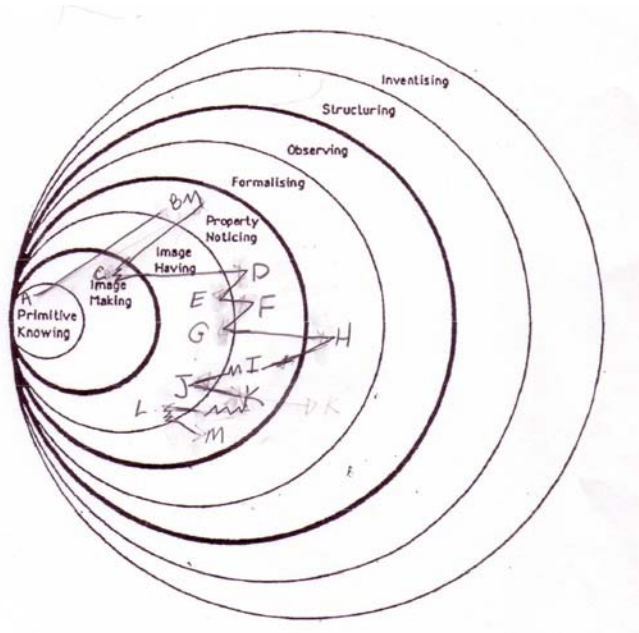


Figure 31. Student 5's Growth in Mathematical Understanding of Transformations

For Student 6, Point B occurred when she identified properties on her pretest Mathematics Understanding Assessment. Student 6 stated that reflections are mirrors or flips and transform an object to the opposite side of the reflection line. Also, she observed that rotations turn objects a certain degree. When students explored reflections through photographs, Student 6 folded back the image making as she cut objects in half at Point C. Student 6 was quiet most of the reflection session. However, when students drew reflections on the board, she was less shy. She jumped to a formalising level at Point D when she abstracted that the preimage and image of reflections are the same distance from the

reflection line. At Point E, Student 6 folded back to image making by folding objects. Then she jumped back to the property noticing level at point F when she stated that reflections transform an object to the opposite side of the reflection line. At the next session, students examined photographs for translations. Student 6 folded back to image having as she visualized an object moving left or right at Point G. While discussing translations, Student 6 moved to the property noticing level at Point H because she observed that the preimage and image of translations are the same shape and same size. Student 6 did not talk during the rotations activity. However, during the compare and contrast discussion, Student 6 abstracted that compositions of transformations would result in a transformation. Here, she moved into the formalising level at Point I. While describing translations, Student 6 folded back to her image of translations. This occurred at point J. Student 6 then repeated her formalization of the composition of transformations at Point K. Student 6 folded back to property noticing of translations and rotations stating that translations conserve congruency and you need to know the degree of rotation before you can turn an object. For Point M, Student 6 illustrated image having on her posttest Mathematics Understanding Assessment. Here, she visualized a translation moving left, right, down, or forward. She then observed that the preimage and image of translations are the same shape. Here, Student 6 fell into the property noticing level at Point N.

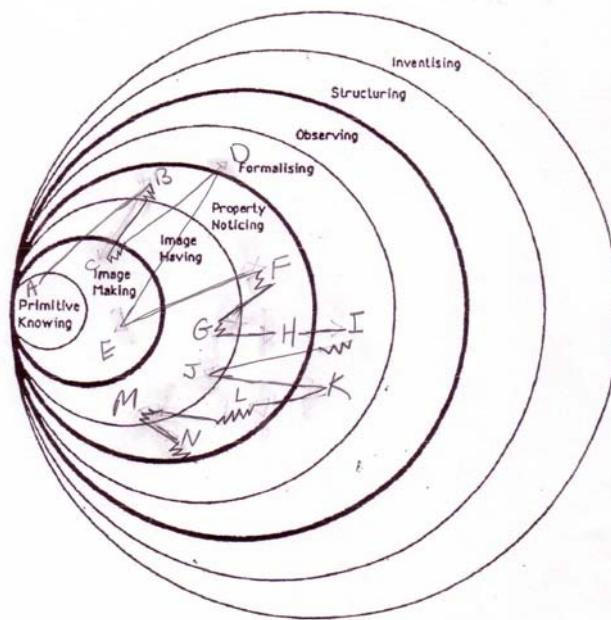


Figure 32. Student 6's Growth in Mathematical Understanding of Transformations

During the pretest Mathematics Understanding Assessment, Point B, Student 7 noticed that reflections are mirrors, translations are slides, and rotations turn an object  $90^\circ$ . While examining photographs for reflections, Student 7 folded back to image making. At Point C, she constructed reflections by cutting objects in half. While making reflections, Student 7 jumped to the property noticing level. Here, at Point D, she observed that preimage and image of reflections are identical. As students discussed reflections, Student 7 revealed she could visualize reflections by visualizing equal parts. This occurred at Point E. While students drew reflections on the board, Student 7 abstracted that the preimage and image of reflections are the same distance from the reflection line. Student 7 jumped to the formalising level at point F. Students continued to draw reflections on the board. At Point



G, Student 7 drew a reflection. However, she actually drew a translation and had to fold back to image making in order to correct her image of reflections. During her interview, Student 7 was asked to identify properties of transformations, so she jumped to Point H. She stated that reflections are mirrors, rotations are turns, and translations are slides. She then demonstrated her visualization of rotations by using her shoe as a prop. This occurred at Point I. At the next session, students were asked to write in their reflection journal. Student 7 described reflections as mirrors and translations as slides at Point J. Next, students explored photographs for translations. At Point K, Student 7 constructed rotations. After drawing on the photographs to investigate translations, she was able to visualize translations as the result of sliding. This occurred at Point L. Student 7 also abstracted the composition of transformations results in another transformation. Here, she jumped to the formalising level at Point M. As students discussed translations, Student 7 stated that translations only slide object, but the objects keep their same shape and size. She also illustrated she had an image of translation at Point O. The next activity required students to look at photographs for rotations. Student 7 folded back to Point P in order to construct an image of a rotation. During the compare and contrast session, Student 7 moved the image having level by demonstrating her visualization of a translation. This occurred at Point Q. Student 7 also abstracted the compositions of transformations. Here, at Point R, she jumped to the formalising level. At Point S, she also identified properties of rotations and translations, by observing that rotations are turns and translations are slides. For her posttest Mathematics Understanding Assessment, Student 7 drew illustrations of each transformation and folded

back to the image having level at Point T.

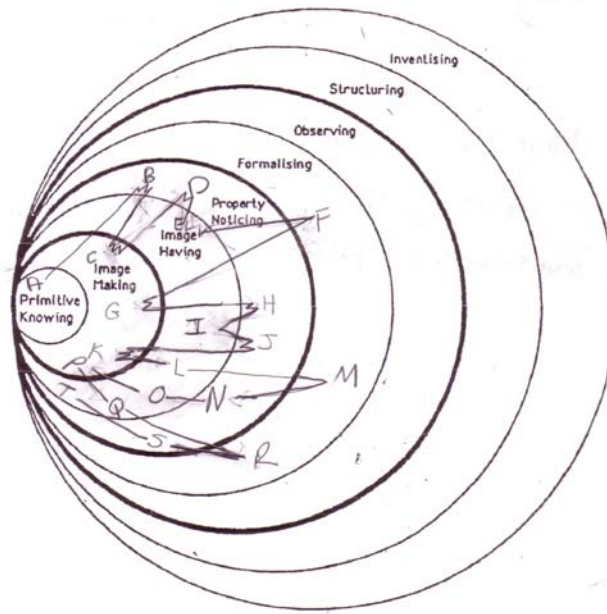


Figure 33. Student 7's Growth in Mathematical Understanding of Transformations

Student 8 only attended one session and did not take the pre- or post- Mathematics Understanding Assessment. At Point B, Student 8 was examining photographs for translations. She was unsure of what a translation was, and began to draw on the photographs to develop an image of a translation. Here, Student 8 was at the image making level. As she began to familiarize herself with translations, she jumped to the property noticing level and identified translations as the result of sliding. At Point D, Student 8 was exploring photographs for rotations. Here, she folded back to image making by drawing on the photographs to acquire a visualization of a rotation.

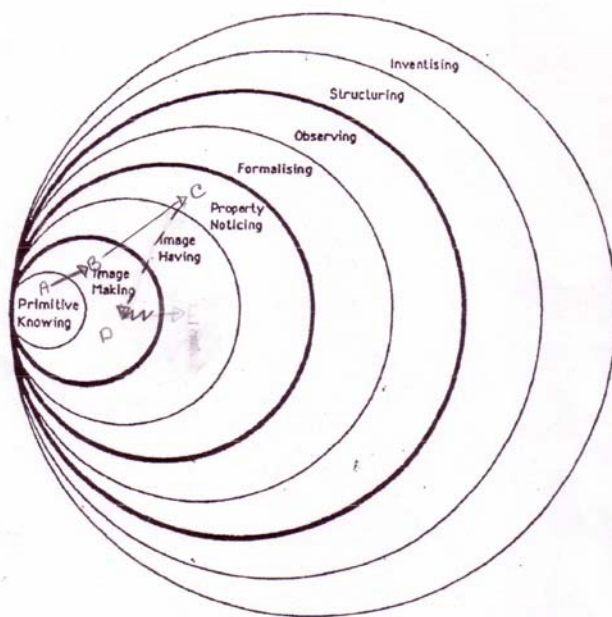


Figure 34. Student 8's Growth in Mathematical Understanding of Transformations

Student 9 took the pretest Mathematics Understanding Assessment, but did not reveal any levels of understanding. He did not attend any of the transformation sessions or take the posttest Mathematics Understanding Assessment. However, Student 9 began making images of translations as he designed the background for the display. This occurred at Point B. Also, Student 7 applied translations in her design, but stated that sliding makes the object bigger. Student 9 pointed out that sliding does not change the size of the object, and hence he moved to the property noticing level at Point C.

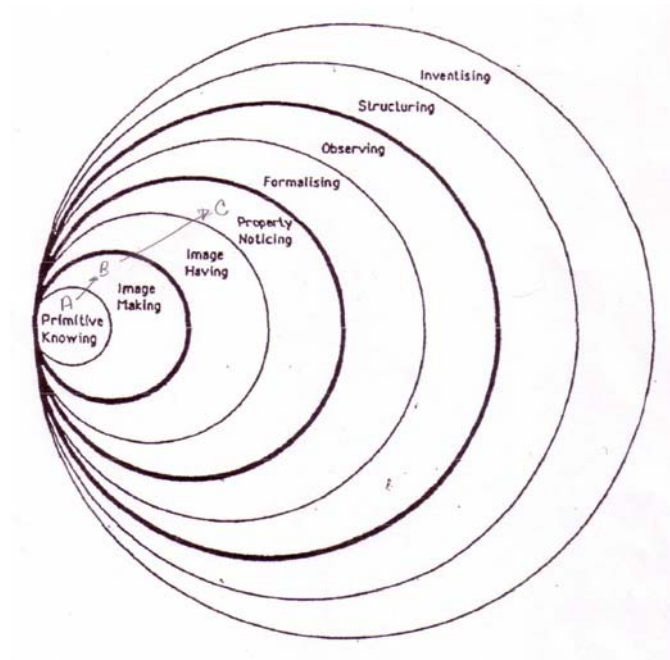


Figure 35. Student 9's Growth in Mathematical Understanding of Transformations

Student 10 took the pretest Mathematics Understanding Assessment, but did not attend any other session or take the post. On his pretest, Student 9 did not illustrate any of the levels of understanding.

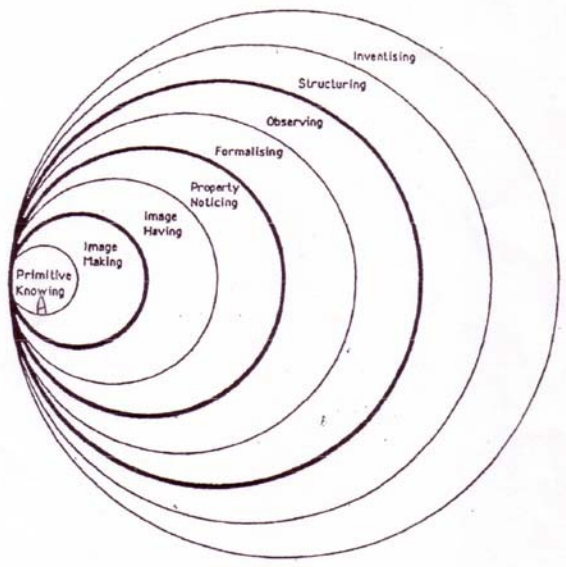


Figure 36. Student 10's Growth in Mathematical Understanding of Transformations

After examining the students' growth in mathematical understanding, the mappings reveal all students, except for Student 10 who only attended the first session of the CSL activity, showed growth in understanding of geometric transformations. A lot of students folded back, jumped boundaries, and remained within the same level demonstrating their growth in mathematical understanding of geometric transformations. Most of the growth occurred during the reflection activity. Class discussion, especially the compare and contrast session, really helped students grow in their understanding of geometric transformations. The pre- and post- Mathematics Understanding Assessment induced the students to notice properties where as the examination of the photographs encouraged students to the image making level.

### *Summary*

This chapter reported findings from both quantitative and qualitative data regarding students' participation and the levels of their engagement and students' understanding and the levels of their understanding. The next chapter discusses conclusions drawn from the findings and recommendations based on these conclusions.

## CHAPTER 5: SUMMARY AND DISCUSSION

The purpose of this chapter is to summarize the study as well discuss conclusions from the findings on African and Latino American's engagement and mathematical understanding when involved in a community service learning project. This chapter is divided into three sections. The first section provides a brief summary of study and conclusions from the quantitative and qualitative data in respect to the research questions that guided this study. The second section discusses limitations to the study. Lastly, recommendations for teaching and future research are offered.

### *Summary and Conclusions*

National and international comparisons suggest that there are inequities in the mathematical performances of students from different racial backgrounds. NCTM (2000) states that "reasonable and appropriate accommodations be made as needed to promote access and attainment for all students" (p. 11). Incorporating new teaching strategies is one modification that can be made to teach mathematics equitably. CSL is one strategy that has been successfully implemented into various fields, specifically science, medicine, and student improvement programs (Atchison & Tumminia, 1998; Bartels, 1998; Battistoni & Hudson, 1997; Boston, 1998 - 1999; Carnegie Council on Adolescent Development, 1989; Cohen et al., 1998; George, 1997; Laplante, 1995; Macnee et al., 1998; Norbeck et al., 1998; Schine, Summer 1997; Schukar, 1997; Solo, 1995; Thompson & Carpenter, 2001; Weah & Wegner, 1997). Because CSL has been successful in connecting other subjects to real world situations, it seems appropriate to apply CSL to mathematics. However, specific

mathematical concepts have not been the focal learning objective for CSL and consequently have not been thoroughly researched (Root & Thorne, 2001). Hence, the purpose of this study is to investigate how CSL affects students' engagement and mathematical understanding of transformations.

The participants for this study included ten sixth grade students. There were six African American students and four Latino American students. These students participated in an after school CSL activity over the course of a semester. The community service activity focused on promoting art and culture awareness in their school while the academic goal centered on transformations. The questions that guided the study are (1) how can community service learning engage African and Latino Americans in learning geometry, and (2) what is the nature of African and Latino Americans' growth in understandings of geometric transformations. Both quantitative and qualitative data was collected and analyzed. For the quantitative data, nonparametric statistical methods were used. For the qualitative data, Lave & Wenger's (1991) framework on legitimate peripheral participation was employed to examine participants' engagement in mathematics. Also, Pirie & Kieren's (1994) growth in mathematical understanding model was used to analyze students' improvement in their mathematical understanding of transformations. The findings for each individual student are summarized in Table 15.



Table 15. Summary of Findings for each student

Student	Quantitative Engagement		Qualitative Engagement	Quantitative Understanding		Highest Level of Qualitative Understanding
	Pre	Post		Pre	Post	
1	3.75	3.59	Highly	9	16	Formalising
2	2.88	2.67	Moderately	10	8	Property Noticing
3			Moderately			Formalising
4	3.98	3.43	Moderately	21	10	Property Noticing
5	3.07	2.82	Highly	11	8	Formalising
6	3.45	2.76	Highly	15	15	Formalising
7	3.49	3.66	Highly	17	8	Formalising
8			Moderately			Property Noticing
9	3.44		Moderately	7		Property Noticing
10	3.12		Not Engaged			Did not participate

Both the quantitative and qualitative findings for each research question are discussed below.

#### *Research Question 1 Conclusion*

According to the Wilcoxon Signed Rank Test, there was not enough statistical evidence to support an increase in engagement scores including the individual domains of Ongoing Engagement, Perceived Autonomy, and Beliefs About Mathematics Beyond the Classroom due to CSL (Hollander & Wolfe, 1999). As indicated by the quantitative data,

CSL did not help African and Latino Americans increase their engagement in learning geometric transformations. On the other hand, students demonstrated reflection in activity, reflection in mathematics, and reflection in mathematics and activity. Applying the legitimate peripheral participation model, Student 1, 5, 6, and 7 were highly engaged in learning transformations whereas Students 2, 3, 4, 8, and 9 were moderately engaged in learning transformations (Lave & Wenger, 1991). Based on the qualitative data, CSL engages these African and Latino Americans in learning the topic of this study, geometric transformations. However, the quantitative data did not substantiate this result.

#### *Research Question 2 Conclusion*

As indicated by the Wilcoxon Signed Rank Test, there was not sufficient statistical evidence to support an increase in mathematical understanding scores including reflections, translations, and rotations due to CSL activity (Hollander & Wolfe, 1999). In addition, the Jonckheere Test suggested that there was not enough evidence to support that mathematical understanding scores for the CSL activity were higher than the control group's scores (Hollander & Wolfe, 1999). Based on the quantitative data, CSL did not help these African and Latino Americans improve their mathematical understanding of geometry. On the contrary, Pirie & Kieren's (1994) growth in mathematical understanding model revealed that Students 1, 3, 5, 6, and 7 displayed understanding at a formalization level, the fifth highest level of understanding. Students 1 through 9 consistently noticed properties about each transformation. Therefore, based on the qualitative data, these African and Latino American students grew in mathematical understanding of transformations. However, the quantitative

data did not confirm this conclusion.

The contradiction between the quantitative and the qualitative data could be attributed to various factors. One factor could be due to the sensitivity of the testing instruments. For example, the Engagement questionnaire only allocates four possible answers and does not allow students to explain their reasoning. Also, it only observes students' engagement at one point in time. Another factor could be that students realized they were not reflecting on the mathematics inside or outside of the classroom. However, the legitimate peripheral participation model investigates students' engagement throughout the course of the semester, allowing students to discuss and reflect and hence engage in learning mathematics. In addition, the Mathematics Understanding assessment is very rigid, where students are assessed on their one-time answer. On the other hand, the Pirie-Kieren (1994) model examines students' responses throughout the study, allowing students to fold back and jump boundaries as they discuss and explore geometric transformations. The quantitative data analyzes students' engagement and understanding at one point in time whereas the qualitative data examines students' engagement and growth of understanding over a period of time. Another factor could be due to African and Latino Americans' test taking styles. For example, these African and Latino Americans could be better at verbal assessment over written assessment. Hence, qualitative data would show an improvement in engagement and understanding while quantitative data might not illustrate an improvement. These factors need further research.

### *Overall Conclusions*

Comparing the conclusions from research question 1 and research question 2, students who were highly engaged in learning transformations were also the students who had a higher level in mathematical understanding. Specifically, Students 5, 6, and 7 demonstrated reflection in activity and mathematics as well as formalizations. Hence, CSL may be an effective teaching strategy to help improve African and Latino American students' engagement in learning transformations. Further research is needed to conclude how CSL affects African and Latino Americans' understanding of geometric transformations.

### *Discussion*

#### *Limitations*

There are limitations to the study. Due to transportation constraints, the study only included one school. In addition, some students missed sessions because of transportation arrangements and other prior activities. Only one interview was conducted due to transportation and scheduling conflicts. These challenges are consistent with other research on CSL (Wade, 1997b). Also, to ensure volunteers, the study solicited a school that requires students to participate in community service. As a result, students who are not required to participate in community service were not included in the study. In addition, due to the use of one school, students were from a moderately homogeneous population. Another limitation is the researcher conducted the community learning sessions. Inadvertently, the researcher could have influenced students' responses.

Furthermore, most of the data is verbal transcriptions. Some students did not speak

out and other students were quiet and the camera did not pick up their thoughts. Because only one student attended her scheduled interview, the participants did not get a one-on-one chance to display their engagement and understanding. In addition, only 10 students participated in this study. This creates a small sample for the statistical analysis. Consequently, the statistical findings could be skewed.

### *Recommendations*

#### *Teaching Implications*

This study demonstrates that CSL engaged this group of African and Latino Americans in learning transformations. However, to improve their mathematical understandings of geometric transformations, students need to be highly engaged in the learning of transformations. Because ongoing reflection defines students' level of engagement, teachers should focus on the reflection component of CSL. In addition, teachers should consider multiple ways to assess reflection. Verbal communication, written reflection, prompted reflection, and free flowing reflection are just a few ways for students to display their reflections. In addition, when analyzing students' understanding through the Pirie & Kieren's (1994) model, it is key to remember that depending on the student and the mathematical concept, students can fall into any of the levels and could retreat or proceed at any time to any level (Pirie & Kieren, 1994). Hence, students may fold back to a previous level in order to gain a deep understanding.

#### *Future Research*

The current study was an after school activity that was on a volunteer basis. Hence,

future research in CSL and mathematics should be conducted within a classroom. In addition, other mathematical topics in both geometry and algebra should to be researched. Also, this study examined 10 students at one school. Hence, a larger scale study should be performed to include other schools and more students.

A result from the study that leads to further research is to examine the contradiction between quantitative and qualitative data for mathematical understanding of geometric transformations. A study should be conducted to analyze the sensitivity of quantitative and qualitative instruments. In addition, African and Latino Americans' assessment style should be researched.

### *In Conclusion*

Despite efforts to lessen the achievement gap in mathematics between Caucasian Americans and African and Latino Americans, discrepancies in test scores among these different racial groups still exist. "Certainly enough literature documents the mathematics failure of African American students. What is lacking is the documentation of successful practice of mathematics for African American students" (Ladson-Billings, 1997, p. 706). Fortunately, there are new teaching strategies being incorporated in the classroom to help overcome this gap. CSL has shown a positive and even statistically significant effects on African and Latino American students' core GPA and mathematics grades (Melchior, 1998). This study hopes to motivate further research into the positive effects of CSL on African and Latino Americans understanding of mathematics. CSL may be the key to diminishing the mathematics achievement gap between African and Latino Americans.

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## APPENDICES

## APPENDIX A

### Community Service Activity

Community Service Objective: Utilize Public Art to Promote Arts and Cultural Awareness

Mathematics Objective: NC Course of Study 6<sup>th</sup> Grade Standards

Competency Goal 3: The learner will understand and use properties and relationships of geometric figures in the coordinate plane.

Objectives:

3.03 Transform figures in the coordinate plane and describe the transformation.

3.04 Solve problems involving geometric figures in the coordinate plane.

Pre-Test: Given to students in all 6<sup>th</sup> grade classes to identify low achieving middle school students (for recruitment, but all 6<sup>th</sup> grade students will be invited to participate)

Outline:

- February 8th
  - Pizza Party
  - Letters Sent Home to Parents for Permission and Recruitment
- February 13th
  - FOCUS: Information Session
  - Pre-Test
  - Pre-Engagement Assessment
  - Pass out Cameras
  - Ask students to take pictures of Arts and Cultural Awareness at home and around their community
  - Set up interviews with 4 students: February 15<sup>th</sup> and February 22<sup>nd</sup> (Thursday)
  - Take pictures around the school (discuss mathematics and arts and cultural awareness)
- February 20<sup>th</sup>
  - BREAK (day after teacher workday)
- February 27<sup>th</sup>
  - FOCUS: Community Service
  - Discuss what pictures students took and how they relate to arts and cultural awareness
  - Discuss purpose of displaying arts and cultural awareness in the school

- Collect Cameras (develop the film for next week and examine for mathematics concepts)
- Pass out new cameras
- Ask students to take pictures of Arts and Cultural Awareness at home and around their community
- FOCUS: Mathematics
- Share developed photos
- Discuss mathematics focusing on Competency Goal 3 Objectives
  - Reflections
- March 6<sup>th</sup>
  - FOCUS: Mathematics
  - Share developed photos
  - Discuss mathematics focusing on Competency Goal 3 Objectives
    - Translations
  - Collect Cameras (develop the film for next week and examine for mathematics concepts)
  - FOCUS: Mathematics
  - Share developed photos
  - Discuss mathematics focusing on Competency Goal 3 Objectives
    - Rotations
  - Have students think about how they would like to create display for 6<sup>th</sup> grade wall (brain storm in small groups if possible, then discuss in large group)
- March 13<sup>th</sup>
  - FOCUS: Mathematics
  - Design Actual Display Plan (Purchase needed supplies, blow up any pictures, etc)
  - Discuss mathematics focusing on Competency Goal 3 Objectives
  - Connect
- March 20<sup>th</sup>
  - FOCUS: Mathematics
  - Discuss mathematics and display/arrangement
  - Discuss any changes needed to display (Purchases needed supplies, blow up any pictures, etc)
  - Set up interviews with last four students: April 19<sup>th</sup> and 26<sup>th</sup> (Thursday)
- March 27<sup>th</sup>
  - Break (day after teacher workday)

- April 3<sup>rd</sup>
  - Break (Spring Vacation)
- April 10<sup>th</sup>
  - FOCUS: Mathematics
  - Post mural/pictures on wall
  - Discuss mathematics of display/arrangement
- April 17<sup>th</sup>
  - FOCUS: Community Service
  - Any last minute changes
  - Discuss how display helps promote arts and cultural awareness
  - Negotiate Party (If finished with display)
- Week Between April 23<sup>rd</sup> and April 27<sup>th</sup>
  - Post-Test given to all sixth grade students
- April 24<sup>th</sup>
  - Post-Engagement Assessment
  - Enjoy Art Work!
  - Party!
- May 1<sup>st</sup>
  - Extra Day if Needed

## APPENDIX B

Pretest

Name: \_\_\_\_\_

Directions: The goal of pretest is to see how YOU feel. Be as honest as possible.

- |   |         |         |           |              |
|---|---------|---------|-----------|--------------|
| 1. I work very hard on my mathematics work.                               | A       | B       | C         | D            |
|   | Always  | Usually | Sometimes | Does Not     |
|   | Applies | Applies | Applies   | Apply at all |
|   |         |         |           |              |
| 2. I don't try very hard in my mathematics class.                         | A       | B       | C         | D            |
|   | Always  | Usually | Sometimes | Does Not     |
|   | Applies | Applies | Applies   | Apply at all |
|   |         |         |           |              |
| 3. I pay attention in my mathematics class.                               | A       | B       | C         | D            |
|   | Always  | Usually | Sometimes | Does Not     |
|   | Applies | Applies | Applies   | Apply at all |
|   |         |         |           |              |
| 4. I don't work very hard in my mathematics class.                        | A       | B       | C         | D            |
|   | Always  | Usually | Sometimes | Does Not     |
|   | Applies | Applies | Applies   | Apply at all |
|   |         |         |           |              |
| 5. When I'm in my mathematics class, I just act as if I'm working.        | A       | B       | C         | D            |
|   | Always  | Usually | Sometimes | Does Not     |
|   | Applies | Applies | Applies   | Apply at all |
|   |         |         |           |              |
| 6. It is important to me to do the best I can in my mathematics class.    | A       | B       | C         | D            |
|   | Always  | Usually | Sometimes | Does Not     |
|   | Applies | Applies | Applies   | Apply at all |
|   |         |         |           |              |
| 7. I do my mathematics homework because I want to understand the subject. | A       | B       | C         | D            |
|   | Always  | Usually | Sometimes | Does Not     |
|   | Applies | Applies | Applies   | Apply at all |
|   |         |         |           |              |
| 8. I work on my mathematics classwork because I think it is important.    | A       | B       | C         | D            |
|   | Always  | Usually | Sometimes | Does Not     |
|   | Applies | Applies | Applies   | Apply at all |
|   |         |         |           |              |
| 9. I work on my mathematics classwork because I want to learn new things. | A       | B       | C         | D            |
|   | Always  | Usually | Sometimes | Does Not     |
|   | Applies | Applies | Applies   | Apply at all |
|   |         |         |           |              |
| 10. I do my mathematics homework because I want to learn new things.      | A       | B       | C         | D            |
|   | Always  | Usually | Sometimes | Does Not     |
|   | Applies | Applies | Applies   | Apply at all |



11. I work on my mathematics classwork because doing well in mathematics is important to me.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
12. I do my mathematics homework because I like to do it.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
13. I work on my mathematics classwork because it's interesting.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
14. I do my mathematics homework because it's fun.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
15. I work on my mathematics classwork because it's fun.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
16. I feel that mathematics is useful to me.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
17. I try to find how mathematics applies to my own life.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
18. I feel that mathematics can help the community.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
19. I look for mathematics in art.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
20. I feel mathematics is an important subject to understand and will be useful to me in my future career.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all

## APPENDIX C

Posttest

Name: \_\_\_\_\_

Directions: The goal of pretest is to see how YOU feel. Be as honest as possible.

- |   |                        |                         |                             |                               |
|---|------------------------|-------------------------|-----------------------------|-------------------------------|
| 1. I work very hard on my mathematics work.                               | A<br>Always<br>Applies | B<br>Usually<br>Applies | C<br>Sometimes<br>Applies   | D<br>Does Not<br>Apply at all |
| 2. I don't try very hard in my mathematics class.                         | A<br>Always<br>Applies | B<br>Usually<br>Applies | C<br>Sometimes<br>Applies   | D<br>Does Not<br>Apply at all |
| 3. I pay attention in my mathematics class.                               | A<br>Always<br>Applies | B<br>Usually<br>Applies | C<br>Sometimes<br>Applies   | D<br>Does Not<br>Apply at all |
| 4. I don't work very hard in my mathematics class.                        | A<br>Always<br>Applies | B<br>Usually<br>Applies | C<br>Sometimes<br>Applies   | D<br>Does Not<br>Apply at all |
| 5. When I'm in my mathematics class, I just act as if I'm working.        | A<br>Always<br>Applies | B<br>Usually<br>Applies | C<br>Sometimes<br>Applies   | D<br>Does Not<br>Apply at all |
| 6. It is important to me to do the best I can in my mathematics class.    | A<br>Always<br>Applies | B<br>Usually<br>Applies | C<br>Sometimes<br>Applies   | D<br>Does Not<br>Apply at all |
| 7. I do my mathematics homework because I want to understand the subject. | A<br>Always<br>Applies | B<br>Usually<br>Applies | C<br>Sometimes<br>Applies   | D<br>Does Not<br>Apply at all |
| 8. I work on my mathematics classwork because I think it is important.    | A<br>Always<br>Applies | B<br>Usually<br>Applies | C<br>Sometimes<br>Applies A | D<br>Does Not<br>pply at all  |
| 9. I work on my mathematics classwork because I want to learn new things. | A<br>Always<br>Applies | B<br>Usually<br>Applies | C<br>Sometimes<br>Applies   | D<br>Does Not<br>Apply at all |
| 10. I do my mathematics homework because I want to learn new things.      | A<br>Always<br>Applies | B<br>Usually<br>Applies | C<br>Sometimes<br>Applies   | D<br>Does Not<br>Apply at all |

11. I work on my mathematics classwork because doing well in mathematics is important to me.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
12. I do my mathematics homework because I like to do it.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
13. I work on my mathematics classwork because it's interesting.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
14. I do my mathematics homework because it's fun.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
15. I work on my mathematics classwork because it's fun.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
16. I feel that mathematics is useful to me.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
17. I try to find how mathematics applies to my own life.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
18. I feel that mathematics can help the community.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
19. I look for mathematics in art.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all
20. I feel mathematics is an important subject to understand and will be useful to me in my future career.	A Always Applies	B Usually Applies	C Sometimes Applies	D Does Not Apply at all

## APPENDIX D

Pretest

Name: \_\_\_\_\_

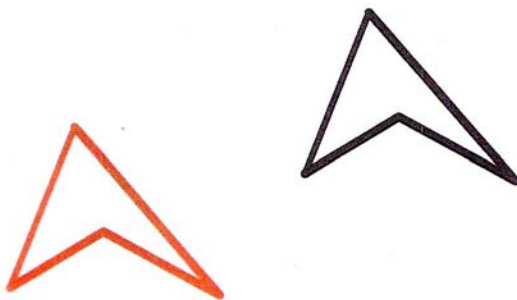
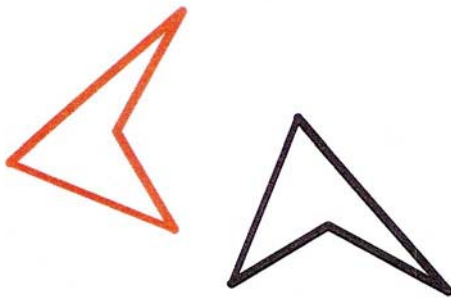
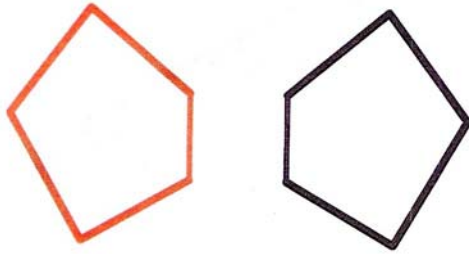
Directions: The goal of posttest is to see what you are thinking. Please write as much as you can to explain your answers. This pretest does not count as a grade for this class.

1. In your own words, describe what a reflection is.

2. In your own words, describe what a rotation is.

3. In your own words, describe what a translation is.

4. For the following pairs of figures, identify if the red figure was reflected, rotated, or translated to get the black figure. Describe how you decided that the figure was a reflection, rotation, or translation.



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8. Examine the following photos. Are there any reflections, rotations, and/or translations? If so, draw the lines of reflection, angles of rotation, and/or directions of translations. Describe your reasoning on where you placed the lines of reflections, angles of rotations, and/or directions of translations.



(Photo from [http://www.raleighskyline.com/stanley\\_cup\\_raleigh\\_071106.html](http://www.raleighskyline.com/stanley_cup_raleigh_071106.html))

## APPENDIX E

Posttest

Name: \_\_\_\_\_

Directions: The goal of posttest is to see what you are thinking. Please write as much as you can to explain your answers. This pretest does not count as a grade for this class.

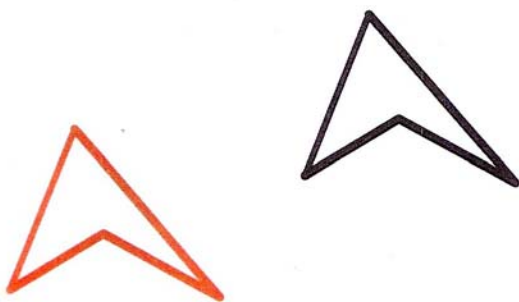
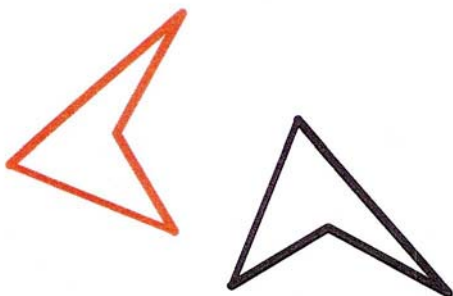
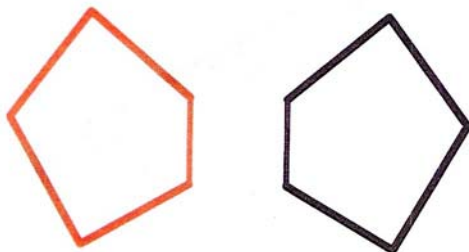
1. In your own words, describe what a reflection is.

2. In your own words, describe what a rotation is.

3. In your own words, describe what a translation is.



4. For the following pairs of figures, identify if the red figure was reflected, rotated, or translated to get the black figure. Describe how you decided that the figure was a reflection, rotation, or translation.



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8. Examine the following photos. Are there any reflections, rotations, and/or translations? If so, draw the lines of reflection, angles of rotation, and/or directions of translations. Describe your reasoning on where you placed the lines of reflections, angles of rotations, and/or directions of translations.



(Photo from [http://www.raleighskyline.com/stanley\\_cup\\_raleigh\\_071106.html](http://www.raleighskyline.com/stanley_cup_raleigh_071106.html))

APPENDIX F

**North Carolina State University**  
**INFORMED CONSENT FORM for RESEARCH**

Title of Study: Impact of community service learning on middle school African and Latino Americans' understanding of mathematics

Principal Investigator: Miranda Cave

Faculty Sponsor: Karen Hollebrands

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We are asking your child to participate in a research study. The purpose of the study is to examine the effects of a mathematically-focused community service activity on students' learning of geometry. In addition, the study will analyze how students' understanding of geometry changes over the course of a semester when they are involved in an extended mathematically-focused community service activity.

**INFORMATION**

If you and your child agree to participate in this study, your child will be asked to:

- (1) Complete two surveys about attitudes and experiences with mathematics
- (2) Complete two Geometry tests
- (3) Keep a weekly reflection journal
- (4) Provide answers to a videotaped interview throughout the project (the tape will be kept secure and confidential and used only for the purpose of evaluation of the project and research into the effects of community service on student learning)
- (5) Be (along with other participants) videotaped during the Service Lessons (the tape will be kept secure and confidential and used only for the purpose of evaluation of the project and research into the effects of community service on student learning).

The community service activity will take place after school for 2 hours from 2:30-4:30PM each Tuesday. Students will be under adult supervision. Parents can pick up students at 4:30PM in front of the school or students can ride the activity bus home at 4:30PM. The videotaped interviews will take about an hour and students will be asked to volunteer and if they accept, they will be interviewed twice during the duration of the project. The project will span from the end of January through the beginning of May.

**RISKS**

There are no risks associated with this study.

**BENEFITS**

There are two direct benefits students will gain through this study. First, the students will be learning sixth grade geometry topics, specifically transformations, while they participate in the community service project. In addition, the hours that the students participate in the project will count towards the community service hours required by the International Baccalaureate Organization Middle Years Program.

**CONFIDENTIALITY**

All information from this study will be kept strictly confidential. Data will be securely stored. No child will be identified in any oral or written reports associated with this study. After the study's approval, all tapes and videos will continued to be safely secured.

**COMPENSATION**

For participating in this study, you and your child will be invited to a party hosted at the end of the project. As a group, we will decide what type of refreshments. If your student withdraws from the study prior to its completion, he/she will still be invited to the end of the project party.

**CONTACT**

If you have questions at any time about the study or the procedures, you may contact the researcher, Miranda Cave, at NCSU, Campus Box 7801, Raleigh, NC 27695 or at 919-662-3554 (Wake Technical Community College Number). If you feel you have not been treated according to the descriptions in this letter, or if your or your child's rights as a participant in research have been violated during the course of this project, you may contact Dr. Matthew Zingraff, Chair of the NCSU IRB for the Use of Human Subjects in Research Committee, Box 7514, NCSU Campus (919-513-1834) or Mr. Matthew Ronning, Assistant Vice Chancellor, Research Administration, Box 7514, NCSU Campus (919-513-2148).

**PARTICIPATION**

Your child's participation in this study is voluntary; your child may decline to participate without penalty. If your child decides to participate, you may withdraw from the study at any time without penalty and without loss of benefits to which you are otherwise entitled. If your child withdraws from the study before data collection is completed, your child's data will be destroyed.

**CONSENT**

**“I have read and understand the above information. I have received a copy of this form. I agree to participate in this study with the understanding that I may withdraw at any time.”**

**Subject's signature**\_\_\_\_\_ **Date** \_\_\_\_\_

**Parent/Guardian's signature**\_\_\_\_\_ **Date** \_\_\_\_\_

**Investigator's signature**\_\_\_\_\_ **Date** \_\_\_\_\_

## APPENDIX G

### Individual Interview Guide

#### Introduction

I'm Miranda Cave. I really appreciate your taking the time to meet with me today. As you may know, I am interested in *learning about how you think about geometry*. The questions that I will ask you today may or may not be similar to what you are doing in class right now. What you do here will not have any effect on your grade in your mathematics class and what you say will remain anonymous.

Because I am interested in how you think about geometry, it would really help me if you would *talk as much as you can*. While you are talking, I will probably ask questions to be sure I understand what you are saying. I am asking because I am really interested. I am not asking a question because what you say is correct or incorrect, but rather I just want to make sure I understand what you are saying. Chances are I probably just missed something you said. Likewise, if I ask a question that does not make sense to you, please tell me.

I might take a few notes to help me remember. But, because I don't want to take too many notes, I would like to tape our conversation. The video camera will be focused on what you are writing or doing.

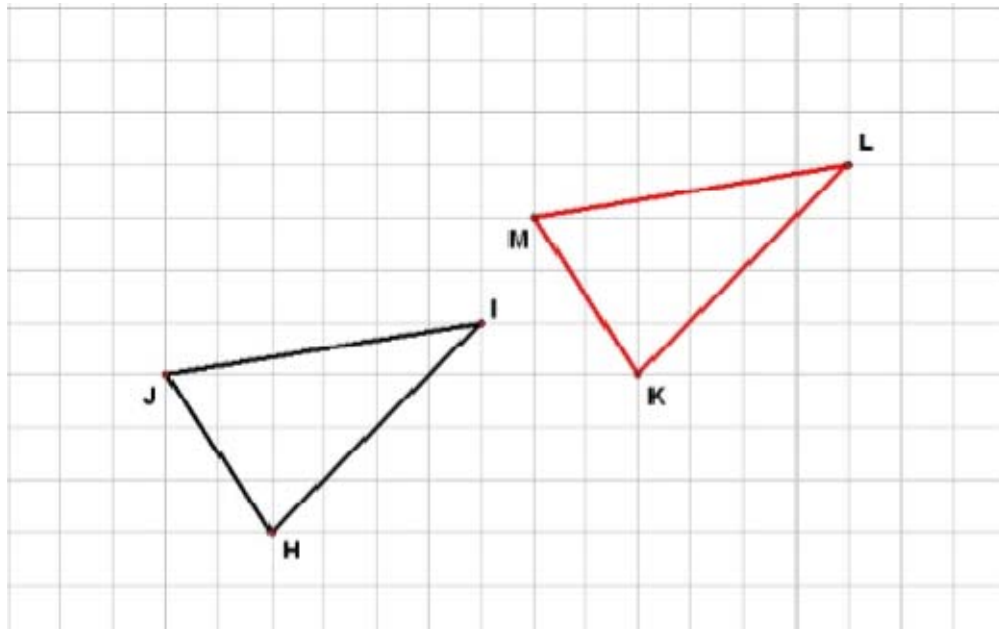
I'd also like to use a tape recorder to record what you and I talk about because the video camera doesn't always record sound very well.

This interview is part of my research and you do not have to do this if you do not want to. If you decide you want to stop this interview, you may do so, and we will stop right way. Also, your answers to these questions are private and will only go into my research. I will not be sharing any of this information about your individual feelings or ideas, though I will put everyone's comments all together into one big group and those grouped responses may be shared. If you have any questions for me, please ask.

Tell me what you think about...

### Mathematics Understanding (Pre and Post Interview Questions)

1. Tell me what you think reflections are.
  - a. What do you mean by reflect over?
2. Tell me about rotations.
  - a. What do you mean by turn?
3. Tell me what you know about translations.
  - a. What do you mean by slide?
4. Given the following picture, describe what is happening in the picture.
  - a. What type of movement?
  - b. Do you notice any properties?



Post: In your own words, describe how reflections, rotations, and translations are related.

Post: Describe how your understanding of transformations has changed.



### **Engagement (Pre and Post Questions)**

1. Tell me about the effort that you put into your mathematics work.
  - a. Can you expand on important/pointless?
2. Tell me how you work on your mathematics homework.
  - a. Why just get it done?
  - b. Can you think of a more effective way to approach homework?
3. Describe your attention level in your mathematics class.
  - a. Why bored/excited?
4. How do you feel about doing the best you can in your mathematics class?
  - a. Why/why not?
5. Describe your goals when working on your mathematics homework.
  - a. Why do you have to?
  - b. Why learn?
6. How do you feel when you do your mathematics homework?
  - a. Why frustrated/mad/glad/happy?
7. Describe your goals when working on your mathematics classwork.
  - a. Why do you have to?
  - b. Why learn?
8. How do you feel when you do your mathematics classwork?
  - a. Why frustrated/mad/glad/happy?
9. How do you feel about mathematics?
  - a. Why do you like it? Why don't you like it?
  - b. How would you classify mathematics in one word?
10. Describe how you use mathematics in your own life.
  - a. How do you apply it?
  - b. Why do you try to look for mathematics?
11. Beside being in school or doing homework, describe a situation that you thought of mathematics.

Post: Describe how your engagement in mathematics has changed.

Post: Would you recommend a friend to participate in a community service learning activity?