Between 1997 and 2003, the number of English language learners (ELLs) in U.S. schools nearly doubled, by some estimates reaching over five million students (Batalova, Fix, & Murray, 2005; U. S. Department of Education, 2004). By 2010-2011, 10% of U.S. public school students alone were ELLs, totaling an estimated 4.7 million learners (Center for Public Education, 2011; National Center for Education Statistics, 2013). Consequently, meeting the needs of ELLs is a major issue for public education.

The movement toward standardized testing has added to the concerns about educating ELLs. The Elementary and Secondary Education Act re-authorization of 2001 (No Child Left Behind Act, 2002) mandated that schools provide programs so that all children attain new, higher standards in English language arts and mathematics. Attainment of standards is traditionally measured through standardized tests, national assessments, and state examinations, a requirement that has been retained in the current re-authorization (U.S. Department of Education, 2013). Such tests, however, carry challenging language demands that can impact ELLs’ performance.

In order to ensure that all students are college and career ready upon graduation, new Common Core State Standards (CCSS) have also been implemented nationwide, focusing
initially on language arts and mathematics (Common Core State Standards Initiative, 2012). Like language arts, mathematics achievement presents special challenges for ELLs, particularly due to the specificity of language required and to the frequent lack of non-verbal clues to assist in understanding concepts and vocabulary that rarely occur in conversation. Much of the language of mathematics, indeed, occurs in word problems that require comprehension of formal operations, abstract thinking, and concept manipulation (Chamot & O’Malley, 1994). In fact, researchers have suggested that the lower math performance scores of ELLs may be related not only to their difficulties with mathematics instruction, but to the language demands of tests presented in English (Abedi & Dietel, 2004).

A promising path to mathematics achievement for ELLs may be instruction that uses the arts. Arts education can be motivating for students who are not easily engaged by conventional teaching (Dewey, 1934; Eisner, 2005), thus supporting instruction in challenging content areas such as science and mathematics. Indeed, research has demonstrated that students exposed to arts-based programs have outperformed their peers on mathematics achievement measures (Cuoco & Curcio, 2001; DuPont, 1992; Edens & Potter, 2007; Forseth, 1980; Gardiner, Fox, Knowles & Jeffrey, 1996; Goldberg, 2004). Moreover, the arts provide an avenue for non-linguistic learning, with studies discovering that arts-based programs tend to have a positive impact on skills development and/or uptake of content knowledge for ELLs (e.g., DuPont, 1992; Eisner, 2005; Jensen, 2002; Murphy, 2012).

To date, however, little research has looked at the impact of arts-based instruction on math achievement for ELLs. This article presents the results of a mixed-methods study designed to help fill this gap. We begin, however, with a brief review of literature on the achievement gap
between ELLs and native English speakers, the potential value of arts-based instruction in narrowing this gap, and the impact of arts-based programs on mathematics achievement.

**Literature Review**

Data from the National Assessment of Educational Progress (NAEP) have shown that Hispanic students, who make up 85.5% of the U.S. ELL population (Uro & Barrio, 2013), performed lower than their White counterparts on fourth and eighth grade mathematics tests (Abedi & Gandara, 2006). Examined from the standpoint of ELL proficiency groupings across the years 2002-2011, NAEP data show the equally disturbing statistic that the achievement gap between ELLs and native English speakers is wider in eighth (44 points) than in fourth grade (36 points) (National Center for Education Statistics, 2013).

Language based approaches, while still the most common response to this gap, do not always result in improved performance for ELLs (Slavin & Cheung, 2005). For example, in an analysis of data from the Los Angeles school system, fewer than 10% of ELLs in language-based intervention programs were re-designated as proficient after one year in school, and more than 50% took seven years or longer to attain this designation (Salazar, 2004).

By contrast, the arts can support ELLs in attaining both receptive and expressive skills. Arts involvement stimulates learning by encouraging the use of one’s imagination to enhance visualization, an important skill in improving reading comprehension. Consequently, arts-based
interventions have been found to assist students with reading (Eisner, 1998) and in developing vocabulary and writing skills (DuPont, 1992; Jensen, 2002).

Research also suggests that arts-based instruction can result in stronger math achievement. For example, in the first year of a two-year study with four experimental and four control first grade classrooms, Gardiner, Fox, Knowles, and Jeffrey (1996) found that the experimental group participants, who engaged in a music and arts program, attained statistically higher mathematical achievement than controls after seven months (75% compared to 53% at or above grade level). In another study, a group of over 600 students, parents, artists, and principals participated in a three-year Learning Through the Arts program (LTTA) (Smithrim & Upitis, 2005). By the third year, the LTTA sixth-grade students scored significantly higher in the mathematics test of computation and estimation than control students. Additionally, after three years of engagement in arts-related activities, students appeared to be more attentive, a crucial factor in attaining computational skills (see Boakes, 2009; Cuoco & Curcio, 2001; Edens & Potter, 2007).

**Method**

The study was designed to assess the impact of implementing a set of five grade specific and purposefully designed arts-based mathematics instruction lessons (“the intervention(s)”) with fourth and fifth grade ELLs. These grades were selected because the third grade is the level at which students first participate in standardized mathematics testing. Thus, the state’s mathematics exam for third grade was used as a pretest for the fourth grade, and the state’s
art-based instruction to support mathematics achievement for english language learners under the common core state standards

The mathematics test for the fourth grade was used as a pretest for the fifth grade. The interventions were designed with the goal of improving engagement with ELLs, many of whom do not engage easily through conventional mathematics teaching. To test this hypothesis, one class from each grade level was selected as the experimental group (those students receiving art-based instruction) and the other as the comparison group (those not receiving art instruction).

Research Questions

The first research question was designed to be answered quantitatively and focused on student performance/achievement in mathematics. The remaining questions were to be answered qualitatively and focused on the appropriateness of the intervention in obtaining data relevant to the study’s objectives (questions two and three) and on obtaining a reflective practice perspective from the intervention instructor (question 4).

1. What impact, if any, did exposure to art-based instruction have on the mathematics achievement of fourth and/or fifth grade participants, as measured by grade and group (i.e., intervention vs. comparison) in terms of performance on pre- and post-tests?

2. How were the lessons in the intervention supportive of the learning needs of ELLs, as measured by alignment with the TESOL English Language Proficiency Standards Framework?

3. How were the lessons in the intervention supportive of learning needs in mathematics, as measured by alignment with the CCSS Mathematics Practice and/or Domain Standards?
4. What beliefs did the intervention instructor hold regarding the value of and/or appropriate methodology for implementing arts-based instruction in mathematics with ELLs? What were her impressions of the implementation of the intervention, and what can her reflective input contribute to the study’s findings?

Setting and Participants

The study was conducted in self-contained English as a Second Language (ESL) classrooms in a large urban elementary school in the northeastern United States. The school serves approximately 1,300 students in pre-kindergarten through fifth grade in a densely populated urban area where many recent immigrants reside. At the time of the study, 84.9% of the students at the school were Hispanic and 13.8% were of Asian ethnicity. Overall, 92% of the students came from homes in which English was not the first language, and 12.8% were considered recent immigrants (compared to an average of 8.8% across the city’s schools). Of these recent arrivals, 4.6% came from Mexico, 2.9% from Ecuador, 2.7% from the Dominican Republic, and 2.8% from China and other Asian countries. Additionally, 90.6% of the students’ families were at or near poverty, defined as qualifying for free school lunch, as compared to 73.9% citywide (New York City Department of Education, 2014).

In the fourth grade, 47 ESL students were randomly placed either in Class 4A (n=22)—the intervention group, which received arts education from a teacher who was certified in both art and ESL—or Class 4B (n=25), the comparison group, which received no arts education. In the fifth grade, 47 ESL students were also randomly placed in Class 5A (n=25), the intervention
group, or Class 5B (n=22), the comparison group. A power analysis indicated that the sample size was adequate for statistical analysis ($1 - \beta = .80$).

Overall, a slightly larger number of male than female students participated in the study; in the fourth grade, however, the female students outnumbered the males. Table 1 shows the distribution of male and female participants by grade and across the intervention and comparison groups. It also shows the total number of students receiving arts-based as opposed to no arts-based instruction in the study, which was the same (47).

Table 1

**Group Size and Gender Distribution Across Intervention and Comparison Groups**

<table>
<thead>
<tr>
<th>CLASS</th>
<th>STUDENTS</th>
<th>MALES</th>
<th>FEMALES</th>
<th>ART</th>
<th>NO ART</th>
</tr>
</thead>
<tbody>
<tr>
<td>4A</td>
<td>22</td>
<td>9</td>
<td>13</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>4B</td>
<td>25</td>
<td>12</td>
<td>13</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>5A</td>
<td>25</td>
<td>14</td>
<td>11</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>5B</td>
<td>22</td>
<td>15</td>
<td>7</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>TOTALS</td>
<td>94</td>
<td>50</td>
<td>44</td>
<td>47</td>
<td>47</td>
</tr>
</tbody>
</table>
**Intervention and Classroom Instructional Procedures**

The intervention for the study consisted of two series of five grade-appropriate, arts-based mathematics instruction lessons, designed by the classroom teacher who implemented them with the fourth and fifth grade students in the study’s intervention groups (i.e., groups 4A and 5A). Students in the comparison groups (4B and 5B) received no planned arts-based instruction during the study period. Table 2 provides a list of titles/topics for the lessons in the fourth and fifth grade interventions.

Table 2

*Arts-based Mathematics Instruction Lessons by Grade and Topic*

<table>
<thead>
<tr>
<th>Lesson number</th>
<th>Grade 4</th>
<th>Grade 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>wordless message</td>
<td>non-objective art</td>
</tr>
<tr>
<td>2</td>
<td>mosaic square quilts</td>
<td>non-objective art poems</td>
</tr>
</tbody>
</table>
The teachers of both the arts education and comparison groups, at both grade levels, followed a workshop model of instruction, as prescribed by the district, wherein each session began with a mini-lesson in which the teacher modeled a skill or strategy (Appendix A presents an excerpt from an intervention mini-lesson). Students then practiced the technique, and they continued to work on the skill/strategy during the independent work-time component of the model. While students worked, teachers engaged in conferences with individuals or small groups. Finally, students shared their work with the group.

During each mini-lesson, the teacher introduced technical and academic language relevant to the day’s topic. These words were written on the chalkboard and repeated many times as the lesson proceeded. During conferences and shared presentation times, students were encouraged and prompted to use the new vocabulary. Language-proficient students were allowed to translate meanings for new arrivals.

The mathematics textbook used was *Everyday Mathematics*, published by SRA/McGraw-Hill (University of Chicago, 2007). The art/ESL teacher used Internet resources and the *Adventures in Art* series of books (Chapman, 1998) to create her lessons. Students in the
intervention groups maintained art notebooks, in which drawings were kept, new words were listed, and commentaries about their artwork were written. At the front of the art classroom was a central, open area that was used for demonstration of the mini-lesson and for student presentation time. Students worked at four large, hexagon shaped tables in the middle of the room, or at large easels for painting. A library showcasing famous artists was housed at one side of the room, while the other side was dedicated to a *word wall*, where new vocabulary words were displayed.

**Data Collection and Analysis**

*Pretest-Posttest*

To assess change in mathematics achievement in the intervention and comparison groups (i.e., to investigate Research Question 1), the study employed a pretest-posttest framework in which the state’s mathematics exam for third graders was used as a pre-test for the fourth graders and the state’s mathematics exam for fourth graders was used as the pre-test for the fifth graders. The equivalent test for participants’ current grade served as the posttest.

The state’s mathematics test consists of multiple choice, short-response, and extended-response questions. For the latter two types, students are allowed to take different paths to a solution and to use different strategies. Scores are reported as Level 1 (Below Standards), Level 2 (Partial Mastery of Standards), Level 3 (Meeting Standards), and Level 4 (Exceeding Standards). Specific reliability and validity data are not provided, although New York State Education Department (2012) states that extensive validation has been performed.
The fourth grade test was taken over three days, with session one taking approximately 50 minutes and sessions two and three approximately 45 minutes each. The fifth grade test was taken over two days, with session one taking approximately 45 minutes and session two took approximately 50 minutes (New York State Education Department, 2012).

The data from the pretest-posttest component of the study were analyzed by means of a 2 (arts-based instruction group versus comparison group) by 2 (pretest and posttest scores) analysis of variance (ANOVA), which was conducted separately for each grade level using the Statistical Package for the Social Sciences.

Observations and Alignment Criteria

To assess the extent to which the interventions could be considered potentially supportive of learning for ELLs (Research Question 2) and of grade-appropriate mathematics learning (Research Question 3)—a vital step in validating the study’s method and in supporting the relevance of the data generated in response to the other two research questions—the study’s first author conducted a series of classroom observations in the art room of the school. Each class was observed for a 45-minute period once per week for three months. The teacher’s lessons (table demonstrations), student work (drawings, painting, and notebooks), and the oral and written language produced by students were observed, recorded, and analyzed to assess the extent to which they aligned, on the one hand, with the TESOL Pre-K-12 English Language Proficiency Standards Framework (Teachers of English to Speakers of Other Languages, 2006) and, on the other hand, with the CCSS in mathematics (Common Core Standards Initiative, 2012). The five standards of the TESOL Framework are listed in Appendix B, and an account of the points of alignment identified in the interventions is presented in the Results section. The
identified points of alignment of the interventions with the CCSS for mathematics are summarized in Appendix C and presented narratively in the Results section.

Teacher Interview

To further the understanding of alignment issues (Research Questions 2 and 3) and to investigate Research Question 4, the art/ESL teacher, Ms. Sanders (all names are pseudonyms), was interviewed using the protocol presented in Appendix D. Ms. Sanders had taught art at the school for six years and had recently obtained certification in ESL. The interview took place after the observations in her classroom and was designed to capture the teachers’ perspectives on the relationship between art and mathematics, as well as to further the understanding of her efforts to enhance comprehension for ELLs during instructional activities.

The qualitative data from the observations and interview were analyzed using the constant-comparative method, which involves examining key issues and recurring events, patterns, or activities that might relate to the research questions (Bogdan & Biklen, 2007). To enhance validity and reliability, moreover, the results of these analyses were triangulated against data from other sources, including the lesson plans and student artifacts examined by the researchers, as well as the pretest-posttest results.

Results

Research Question 1
What impact, if any, did exposure to arts-based instruction have on the mathematics achievement of the fourth and/or fifth grade students in the study, as measured by grade and group (i.e., intervention vs. control) in terms of performance on pre- and post-tests?

To investigate this question, a 2 (arts-based instruction group versus comparison group) by 2 (pretest and posttest scores) analysis of variance (ANOVA) was conducted for each grade level. Table 3 presents the mean scores and standard deviations as determined by this analysis.

[Insert Table 3 approximately here.]

The fourth grade sample included 22 ELLs in a class (4A) that received arts-based instruction and 25 students in a class (4B) that received no arts-based instruction (see Table 1). On the mathematics exam for grade 4, a significant multivariate effect was observed (Wilks’ lambda = .151, p < .007 for the effect of time, and Wilks’ lambda = .235, p < .001 for time by group interaction). In other words, the students on the whole performed better on the posttest than the pretest. The within subjects effect was significant (F=8.011, p < .000) and the interaction effect was also significant (F=13.814, p < .001). The test for between subjects effect for group (arts-based instruction and comparison) was also significant (F=7.689, p < .008), indicating that the students who received arts-based instruction, as a group, performed better on the posttest than those who did not (see Table 3).

The fifth grade sample consisted of 25 ELL students in a class (5A) that received arts-based instruction and 22 students in a class (5B) that received no arts-based instruction (see
Table 1). On the mathematics exam for grade 5, a significant multivariate effect was observed (Wilks’ lambda=.223, p < .001 for the effect of time, and Wilks’ lambda=.393, p < .000 for time by group interaction). These results showed that both groups improved from pretest to posttest. The within subjects effect was significant (F=12.936, p < .001), as was the interaction effect (F=29.171, p < .000). The test for between subjects effect for group (arts-based instruction and comparison) was also significant (F=10.280, p < .000), again revealing relatively larger gains for the students who participated in the arts-based instruction (see Table 3).

Research Question 2

How were the lessons in the intervention supportive of the learning needs of ELLs, as measured by alignment with the TESOL English Language Proficiency Standards Framework?

The observations showed that the TESOL Proficiency Standards (see Appendix B) were embedded into each of the lessons provided to the ESL classes. An illustration of art activities that addressed each Standard is provided below.

Standard 1: English language learners communicate for social, intercultural, and instructional purposes within the school setting. After completing their “Non-objective Art” pictures (Fifth Grade-Lesson 1), students created poems to describe their work. Ms. Sanders began this lesson (Fifth Grade-Lesson 2) by reading a poem. She emphasized the words tapping, tipping, and rapping. Together with the students, she generated a list of imaginative words, such as plunging, diving, swooping, twisting, gliding, and soaring. Students paired up and described each other’s pictures using words from the list.
Ms. Sanders wrote down all the key words—twisting, colorful, whirling, wind, mixing, drooping, creeping—on a sheet of paper for the boys. Wen and Luis then worked together to write the following poem about Wen’s picture:

Like the wind

Just blowing about

Clothes twisting and moving around

Colorful bubbles flitting on top

As the washing machine is

whirling around.

Each student created a poem about his or her picture and shared the poem with the class. The pictures were then displayed with the poems in the hallway outside the classroom.

**Standard 2: English language learners communicate information, ideas, and concepts necessary for academic success in the area of language arts.** Ms. Sanders often read to the students from *Adventures in Art*. In the lesson on “Non-objective Art” (Fifth Grade-Lesson 1), as students looked at images of works by Oscar Howe, a Native American artist, Ms. Sanders read the following: “Howe’s painting is dominated by curved lines and shapes that imply swirling motion. The movement in his painting comes from his feelings about the beauty of curves in nature. He likes to observe the motions of birds in flight, leaping flames, and wind-swept clouds” (Chapman, 1998, Grade 5, p. 20). She then wrote the following words on the board: Wiggle, Curving, Circular, Colorful, Twisting, Combination. This method of introducing
vocabulary, known as “frontloading” (Beers, 2003), was used in all of the intervention lessons. Figure 1 shows an example from a student journal in which the student has recorded vocabulary introduced at the beginning of the lesson.

Figure 1. Example of frontloading vocabulary in journal.

In the fourth grade class, students were introduced to still life painting in Lesson 3. Ms. Sanders compared both abstract and realistic art and, related each to mathematics. The students then created their own still life pictures using fruit as models. In fifth grade Lesson 5, the students created still lifes using primary colors and values. First, the students were introduced to vocabulary words: still life, values, shadows, contrast. On the board, Ms. Sanders wrote: darkness and lightness, light-tint, and shade-dark. She modeled contour lines, and later emphasized contour lines and value. For example, when one student drew flowers, Ms. Sanders encouraged him to use contour lines and different values. After modeling the value scale, Ms. Sanders asked, “Why do you think I am asking you to make a value scale?” A student answered, “You use it so you know what different values to use in your picture.”
Standard 3: English language learners communicate information, ideas, and concepts necessary for academic success in the area of mathematics. For Lesson 2 in the fourth grade, students created quilt squares with mosaic tiles that displayed geometrical shapes and symmetry. In fact, within several of the lessons, students were asked to define the shapes that they created and to combine curved and straight lines. For example, in both fourth grade Lesson 1 (wordless messages) and the lesson on still life for the fourth grade (Lesson 3), students solved problems involving measurement and classified shapes by properties of their lines and angles.

Standard 4: English language learners communicate information, ideas, and concepts necessary for academic success in the area of science. This standard was represented in a fourth grade lesson in which students created “Mechanimals’ (Lesson 5). The lesson was based on a work by artist Murray Tinkelman entitled “Mechanimal” (Adventures in Art Grade 4, p. 50). Ms. Sanders told the students to think of ways in which animals and machines are similar and different, and then to use their imaginations to create their own “Mechanimal” drawings. As the students worked on their drawings, Ms. Sanders reminded them that they would have to explain them to the class. She asked Juan, “Who would benefit from your machine?” Juan had drawn a “Mechanimal” with the head of an elephant on top of a tank-like body. He stated that junk yards could benefit because the machine could dig deep holes to bury junk. The students asked Juan if his machine needed gas. He said, “No, because the animal part would do the work.” He laughed and added: “You would have to feed the elephant part!” Juan wrote the following about his machine:

What my mechanimal does [is] that he could dig deep holes with his horn. If the constortion [construction] worker wants to dig a deep hole he could use mechanimal and did deep into the hole. If I want something deep underground, I
could use my mechanimal to dig through the dirt to get what I want. If the
constortion [construction] worker needs to make a new street and they need a
really big hole, they could use my mechanimal. They can make a street for our
town. If you need to dig holes, use my machine.

In this lesson, students were involved in evaluating their own machines and in evaluating the
work of the other students.

Standard 5: English language learners communicate information, ideas, and concepts
necessary for academic success in the area of social studies. Through the Adventures in Art
books and other resources, the students learned about artists with a wide range of ethnic
backgrounds, including Chinese, Spanish, Irish, French, and Native American. The students
created art that imitated the styles of many of the artists, including Picasso, Van Gogh, and
Georgia O’Keefe. To supplement the instruction, Ms. Lin, a Chinese ESL teacher, taught the
students about calligraphy, and each child learned to write his or her name using this system.

Research Question 3

How were the lessons in the intervention supportive of learning needs in mathematics, as
measured by alignment with the CCSS Mathematics Practice and/or Domain Standards?

The Mathematical Practices observed in the intervention included the following: 1) Make
Sense of Problems and Persevere in Solving them; 2) Reason Abstractly and Quantitatively; 3)
Construct Viable Arguments and Critique the Reasoning of Others; 4) Model with Mathematics;
5) Use Appropriate Tools Strategically; 6) Attend to Precision; 7) Look for and Make Use of
Structure; and 8) Look for and Express Regularity in Repeated Reasoning. Applications of these
practices in the arts-based lessons are summarized in Appendix C and described here.
In each of the arts-based lessons, students were observed to be immersed in *Making Sense of Problems* or building new mathematical knowledge through monitoring and reflecting on the mathematical process. Among the numerous instances of problem solving observed were the following:

- In a lesson on creating a design that expressed movement and shape (Fifth Grade-Lesson 3) students were asked to refer back to a lesson on illusions, using what they already knew to solve the problem at hand. For example, one student indicated that illusions could be used to create movement in and out.

- In the lesson on creating “Mechanimals” (Fourth Grade-Lesson 5) students had to discover how they could create something that was part animal and part machine, indicate a use for their creation, and answer questions about it from the teacher and from their peers.

- In a lesson on drawing a still life (Fifth Grade-Lesson 5) the students were challenged to add more value to their still life pictures by using dark colors. In art work, values are the differences in the lightness and darkness of colors. Ms. Sanders showed the students where the light came through the window and how it created a shadow (see Figure 2).
Students created seascapes (Fourth Grade-Lesson 4) using tints, shades, and various brush strokes. The students mixed colors to create the sea in their pictures. Ms. Sanders modeled the painting of a wave and then asked students to explain how she had produced it. One student noted that she used different brush strokes. Ms. Sanders then encouraged the students to experiment with using different brush strokes to create their own waves.

In a lesson on building bridges with wood pieces and toothpicks (Fifth Grade-Lesson 4) students began the process by reading a passage about bridge basics taken from the Internet (Bridges & Tunnels of Allegheny County & Pittsburgh, PA, 2008). The students used this selection as a model to draw blueprints on graph. Noticing that one student had made two blueprints, Ms. Sanders stimulated direct application of mathematical reasoning (see Limitations and Suggestions for Future Research below) by suggesting
that he combine his blueprints into a final bridge design with either one or two levels (see Figure 3).

• Figure 3. Brant’s first blueprint of his bridge

Table 3

Mean Scale Scores and Standard Deviations for Students at Pre-test and Post-test on the Mathematics Assessments

<table>
<thead>
<tr>
<th>GRADE Group</th>
<th>Pretest M</th>
<th>Pretest SD</th>
<th>Posttest M</th>
<th>Posttest SD</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRADE 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Art Instruction Group</td>
<td>2.86</td>
<td>.899</td>
<td>3.45</td>
<td>.596</td>
<td>+0.59</td>
</tr>
<tr>
<td>Comparison Group</td>
<td>2.68</td>
<td>.627</td>
<td>2.60</td>
<td>.707</td>
<td>-0.08</td>
</tr>
</tbody>
</table>

GRADE 5
The *Reason Abstractly and Quantitatively Standard*, defined as making and investigating mathematical conjectures and developing and evaluating mathematical arguments, was also evident in many of the lessons. In one lesson (Fourth Grade-Lesson 3), students created flowers using watercolors and discussed whether their flowers represented abstract or figural art. After reviewing these schools, students explained their own styles, using evidence to justify the type of painting their flowers represented. In “Mechanimal” (Fourth Grade-Lesson 5), students demonstrated how their machines would work and presented a rationale for their inventions.

Regarding the *Construct Viable Arguments and Critique the Reasoning of Others* standard, the use of mathematical language to express ideas precisely and critically was evidenced in many of the lessons and was taught explicitly. The teacher explained her focus on reasoning during the instructional process as follows:

Books are read aloud about an artist or a period of time in which an artist lived…. [T]echnical and academic vocabulary are abstracted from readings, written on chalkboard, rehearsed, and an art word-wall is constructed…. [F]or new immigrants, translation of new words occurs by second-language proficient peers…. In their art notebooks, students keep drawings and [lists of] new vocabulary introduced in the lesson…. They write about their sketches or the art work they have completed that day in the notebooks…and critique the work and reasoning of their classmates….

The lesson that related most directly to this standard was the one entitled “Mechanimals” (Fourth Grade-Lesson 5), in which students explained their creations both orally and in writing and then

<table>
<thead>
<tr>
<th>Art Instruction Group</th>
<th>2.80</th>
<th>.763</th>
<th>3.48</th>
<th>.714</th>
<th>+0.68</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparison Group</td>
<td>2.54</td>
<td>.800</td>
<td>2.40</td>
<td>.734</td>
<td>-0.14</td>
</tr>
</tbody>
</table>
answered questions from the teacher and other students, defending the rationale for their inventions. In this and the other lessons, the teacher encouraged students to use the newly-introduced vocabulary (see Figure 4).

![Figure 4. Example of mathematics vocabulary words in journal](image)

Relevant to the Model with Mathematics standard, students made connections between mathematical ideas and art. In a lesson on creating quilts using mosaic square tiles (Fourth Grade-Lesson 2) students added to the patterns in their designs after observing teacher modeling. As Ms. Sanders stated, “Repetition and patterns in art go hand and hand with mathematics…. [The biggest connection exists between art and geometry…. [S]ymmetry and balance [are] evident in both…. [A]nd students…replicate…designs based upon models.”
The *Use Appropriate Tools Strategically* standard was evidenced in the mechanimal drawing that Juan created using pen, markers, and crayons on paper. Maria made use of rulers to create straight lines, used color pencils, and operated a protractor and compass to create her drawing.

The *Attend to Precision* standard was observed in Juan’s careful explanation of the meaning of the symbols in his drawing. Maria’s picture was very precise, and her commentary included detailed explanations of colors and geometric shapes.

The *Look for and Make Use of Structure* standard focuses on the creation and use of representations to organize, record, and communicate mathematical ideas. The best examples of this standard were the blueprints created by the students in designing their bridges (Fifth Grade-Lesson 4). The students created and relied on representations (blueprints) to organize, record, and communicate mathematical ideas that resulted in physical structures.

The eighth standard, *Look for and Express Regularity in Repeated Reasoning*, was highlighted most notably in students’ written explanations of their “Mechanimals” drawings. The presentations revealed that the students understood and could explain the function of each animal/machine. Additionally, students encouraged each other to rethink the purpose of their inventions and challenged each other to determine who would benefit from these creations.

*The mathematics standards by domain*

The Mathematics Standards by Domain observed in the intervention included the following topics: 1) Numbers and Operations in Base Ten; 2) Geometry; and 3) Measurement and Data. Knowledge of such operations as how to add, subtract, and make estimates was needed to construct the bridge blueprints (Fifth Grade-Lesson 4), and adding or subtracting color
was used when determining the value of lightness and darkness in the lesson on still lifes (Fifth Grade-Lesson 5). For geometry, students used vertical, horizontal, and diagonal lines to create wordless messages (Fourth Grade-Lesson 1). Here, the students were asked to create artworks using curved lines and shapes (circles, ovals, etc.) or using straight lines and shapes (squares, triangles, etc.). Moreover, in the Mechanimals lesson (Fourth Grade-Lesson 5) the students were asked to include geometrical shapes in their drawings and to explain their function. Maria described her Mechanimal in writing as follows:

In my picture I drew a hippopotamus picking up with his tongue coconuts and then they come out from the back. By then its [sic.] all crushed. Through the mechanical animal the coconuts are being crushed, cleaned, and separated in the bin. In my drawing I used geometric shapes such as circles, squares, and rectangles. I used calm colors like blue, gray, and white. I noticed that as I looked at the picture I could imagine what is going on in the mechanical animal. As I look at the picture I feel happy because this mechanical animal is making the coconuts easier for people to eat.

Other lessons focused on the use of measurement and data. In building bridges, students created precisely-measured blueprints that they then used to construct bridges out of Popsicle sticks and other materials. In creating still lifes, finally, students made value scales on the sides of their drawings, an activity that embodied both mathematical operations and precise measurement.

**Research Question 4**

*What beliefs did the intervention instructor hold regarding the value of and/or appropriate methodology for implementing arts-based instruction in mathematics with ELLs?*
What were her impressions of the implementation of the intervention, and what can her reflective input contribute to the results of the study?

This section follows the Interview Protocol provided in Appendix D.

What connections do you see between mathematics and art?

Ms Sanders noted numerous connections to mathematics processes and topics, including the following:

- Repetition and patterns in art go hand in hand with mathematics;
- [She sees] the biggest connection between art and geometry.... [A]rtists draw shapes...and repeat them over and over.... [S]ometimes they draw or paint non shapes.... Picasso used shapes, but in a different way.
- Symmetry is also very evident in artwork.... Artists must make sure that their pictures or paintings are balanced.
- When artists make designs they have to measure, [and her students had] to make sure their measurements were accurate when they designed bridges.

Among the Mathematics Process Strands of the Standards, the above responses indicate incorporation of Model with Mathematics. Among the Strands by Domain, the teacher touched on Geometry and Measurement in her responses.

How do you implement ESL strategies utilizing the content areas?

Ms. Sanders stated that she uses several ESL strategies when teaching art and that she differentiates instruction according to students’ individual needs. For example, she often reads
books about an artist to supplement the students’ prior knowledge, and she sometimes reads books about the period in which the artist lived. She introduces technical vocabulary of the subject area, writes the words on the board, and repeats them throughout the lesson. When the students share their work at the end of the lesson, she encourages them to use the new words. She also drew attention to her use of an “Art” word wall and to her practice of having students translate for their less-proficient peers. She emphasized that it sometimes takes many art periods before the students start to use English, but that their faces light up when they speak their first words: “These words can be simple—such as ‘stroke’ or ‘light’—but they are the words of an artist.” These strategies—and the practice of having students keep art notebooks, which Ms. Sanders also noted—are consistent with several of the Mathematics Standards, particularly the Processes of Communication, Connections, and Representation.

How can you specifically target your instruction to meet the needs of English Language Learners?

Ms. Sanders stated that she grouped students according to their needs and met with students individually as they worked on their art creations: “As I walk around the room as the students work, I pick out a piece of student work and make comments about it using the vocabulary from the mini-lesson.” She noted that this method is another way to differentiate instruction for ELLs.

What ongoing evaluation is conducted to ensure that students are meeting their goals?

To this question, Ms. Sanders replied that she assigns homework to her students, such as asking them to complete a piece of artwork or directing them to do research. Other homework
assignments include writing in their notebooks. Since many of the students’ artworks are not completed during one class, conferences are held with students on their next steps. Ms. Sanders often asks questions to guide students in creating their artwork, and their responses help her to evaluate whether the student has understood the lesson.

*How do you transfer students’ initial enthusiasm in art into everyday math performance?*

Ms. Sanders believed that students’ enthusiasm could be transferred by making them aware of the connections between art and math. “If they can figure out the pattern in their own artwork, then they should be able to see the pattern in math,” she said. She added that when students were aware that they had created a piece of art, she reinforced the idea that they were problem solvers and that they could replicate the problem solving process in mathematics. These comments suggested her awareness of the importance of the mathematics processes of *Making Sense of Problems and Persevering in Solving Them*.

*How do you think art training can result in improved mathematics performance for your students?*

Ms. Sanders said that artists have to be problem solvers. “In any work of art, you must solve several problems as you create it. What makes it your ‘own’ is how you solve these problems.” She explained, “The students have to be problem solvers to answer the questions, and they must show their work. They can draw diagrams as well as use numbers and words to explain their answers.” She emphasized that if we can teach our students to be problem solvers in any subject, then we are “teaching them how to survive in life, not just how to take a test.” Ms. Sanders’s response was related to the *Reason Abstractly and Quantitatively* component of
the Process Strands, as well as to the standard *Construct Viable Arguments and Critique the Reasoning of Others.*

**Discussion**

The ELL students in both fourth and fifth grade who received arts-based instruction from an ESL-certified teacher performed better on the state mathematics exam than the ELL students who did not receive art instruction. On the fourth grade mathematics exam, the scores of students in the intervention group increased from a mean of 2.86 to 3.45, a gain of .59 points, whereas the scores in the comparison group declined .08 points (see Table 3). In the fifth grade, the scores of students participating in arts instruction rose .68 points, from a mean of 2.80 on the pretest to a mean of 3.48 at the posttest. The scores of the comparison group, however, decreased by .14 points (see Table 3).

Research has shown that the language demands of tests that measure performance in content disciplines negatively influence the performance of ELLs (Abedi & Dietel, 2004: Abedi & Lord, 2001). This impact may be due to the complexity of academic language, which becomes more difficult to learn when it is not supported by the rich array of nonverbal and contextual clues that characterize the language of face-to-face interaction (Chamot & O’Malley, 1994). Observational findings from the arts instruction classroom in this study indicated that there were numerous instances in which students received support in mathematics concepts and language acquisition by engaging in visual arts-related activities. These activities, as structured
by the teacher and implemented through the workshop model, provided a context in which mathematical connections could be made.

In order to enhance their facility with the English language, moreover, it is important to create a learning environment in which ELLs feel comfortable expressing themselves in English (Cummins, 1981; Goldberg, 2004; Krashen, 1982). Such an environment was established and maintained in the intervention, in which discussions, presentations, journal writing, and student-teacher and peer-peer interaction provided support for learning of both language and mathematical skills by encouraging reasoning and communication.

The quantitative and qualitative findings confirm the literature-based hypothesis that visual art concepts can be linked to mathematics standards and mobilized to enhance student understanding. The language development activities in the intervention used specific mathematics vocabulary as well as mature words (Beck, McKeown, & Kucan, 2002) in ways that helped the students to express reasoning and problem-solving processes through speaking, drawing, and writing. Additionally, the art lessons incorporated many higher-order thinking concepts, as described in the CCSS for mathematics, emphasizing measurement, geometry, function, and problem solving. Overall, the data demonstrate that a targeted arts education class can provide numerous opportunities for ELLs to develop academic language and improve mathematical understanding and achievement.

Conclusion
Through interaction between teacher and student, presenter and peer, the ELL students who received arts instruction successfully integrated the language and conceptual processes of mathematics into their repertoire of skills, as evidenced by the increase in performance scores. The study further suggests that the attentiveness that is needed to engage successfully in arts activities influences mathematical skills and concept acquisition, which supports the findings of previous research (Cuoco & Curcio, 2001; DuPont, 1992; Edens & Potter, 2007).

The present study suggests that there may be a role for visual arts education in providing an environment in which students are given the opportunity to improve both their mathematics and language skills. The observational findings support the view that standardized test scores in mathematics can increase significantly for such students participating in arts-based education in which mathematical and language concepts are reinforced. Practitioners should also consider integrating the arts and art related activities into other content disciplines (Reeves, 2007), thus providing students with motivation and with non-linguistic means to participate and to interact with their teacher and peers. Implications for implementing programs similar to the one described in the present study include the need for teachers to emphasize and align the CCSS with language development goals and exercises during arts activities. This can be accomplished through the use of specific academic development activities such as vocabulary building, journal writing, and tasks that encourage problem solving and analysis.

Limitations and Suggestions for Future Research
This study was somewhat limited in that it included only one intervention and one control classroom each for fourth and fifth grade. Future research could extend the study across the elementary and middle school grades, using more groups from each grade and including intervention and control groups consisting of non-ELLs as well as ELL students. Furthermore, future studies might find ways to use a more contrived framework for these groupings, in which the number of students and gender distribution would be equal across the intervention and comparison groups, providing a more robust basis for conclusions. In addition, the present study was conducted over three months, with weekly observations, but future studies could increase the observation frequency and extend the study term, perhaps to encompass the entire academic year. Moreover, the arts education teacher in this study was also certified in ESL, which is not always the case, even in districts with large ELL populations. Hence, similar experiments should be performed using educators both with and without such training.

The use of the state testing for pretest/posttest enabled the study to generate a quantitative response to Research Question 1 that was not limited by potential teacher bias or test creation problems. However, the administration of such tests over a period of days allows for outside influences (such as home issues and amount of rest) to impact the results. Moreover, state tests typically evaluate facility in applying mathematical concepts, making them an indirect measure of the impact of arts education on mathematical critical thinking skills and vocabulary. Thus, future studies might look not only at final test scores but also at more sensitive measures of mathematics achievement, beginning with an examination of test items passed and failed by participants, in order to pinpoint specific areas of benefit from arts education.
Researchers might also seek to develop ways in which to qualitatively evaluate the application of mathematical principles and reasoning demonstrated while students are engaged in arts lessons, as in the example noted in connection with the bridge building project described under Research Question 3 in the Results section of the present study. Clearly, students can become absorbed in computations and could be described as mentally and physically acting out word problems as they decipher and mobilize applications related to their arts projects. A better understanding of how this process unfolds and of what educators can do to enhance learners’ ability to apply concepts to practical and creative tasks would be invaluable in assessing the potential impact of arts-math fused classroom lessons on students’ academic and career success.

References


Appendix A

Excerpt from a Mini-lesson Conducted with Group 5A

The aim is written on the chalkboard: *How can we create a design that expresses movement by using various lines and shapes?*

At the beginning of the period, the students are gathered together in the meeting area at the front of the room. The teacher is showing the students a picture from *Adventures in Art* (Chapman, 1998).

Teacher: I see a triangle. Here are some other words to describe your painting:

- Wiggle
- Curving
- Colorful
- Twisting
- Combination

Think of words to describe your picture. Remember this is non-objective Art. I don’t want you to think of shape. Why does color matter? Do you see movement? I don’t want to see circles or triangles!
The teacher writes these words on the chalkboard:

*Nonobjective, implied movement, diagonal, vertical, horizontal, advance, recede.*

Students return to seats at the tables in the center of the room. They are using crayons, colored pencils, and markers to create their pictures. At one table the teacher discusses the use of color with the students, saying: “Complementary colors are opposite colors…. Do you notice it gives illusions? We [covered] illusions already [i.e., in another lesson]. They can be used to create [visual] movement.”

At a second table, students are looking at the cover of *Blok Bots* magazine. One student tells another that his picture looks similar to the cover. He says, “Maybe that is where you got the idea.” At another table, the teacher comments: “This reminds me of Georgia O’Keefe. It looks like a flower ready to bloom.” The students consider this observation “Cool.”

Another group is engaged in shading their pictures, and the teacher remarks: “What did Justin do with the color? Think [about the] ‘value’ of color....”

Subsequently, the teacher hangs some of the students’ pictures on the white board and reinforces the day’s vocabulary words.
Appendix B

TESOL Pre-K-12 English Language Proficiency Standards Framework

( Teachers of English to Speakers of Other Languages, 2006 )

Standard 1: English language learners communicate for social, intercultural, and instructional purposes within the school setting.

Standard 2: English language learners communicate information, ideas, and concepts necessary for academic success in the area of language arts.

Standard 3: English language learners communicate information, ideas, and concepts necessary for academic success in the area of mathematics.

Standard 4: English language learners communicate information, ideas, and concepts necessary for academic success in the area of science.

Standard 5: English language learners communicate information, ideas, and concepts necessary for academic success in the area of social studies.
## Appendix C

Alignment of the Arts-based Mathematics Lessons with the Common Core State Standards in Mathematics: Mathematical Practice and Standards by Domain

(Common Core Standards Initiative, 2012)

<table>
<thead>
<tr>
<th>Mathematical Practice or Domain</th>
<th>Arts-based Lesson(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCSS. MP.1: Make Sense of Problems and Persevere in Solving Them</td>
<td>Fourth Grade Lesson 3: Still Life</td>
</tr>
<tr>
<td>Mathematically proficient students start by explaining to themselves the meaning of a problem. They analyze givens and constraints about the form and meaning of the solution. They monitor and evaluate their progress.</td>
<td>Fourth Grade Lesson 4: Seascapes</td>
</tr>
<tr>
<td></td>
<td>Fifth Grade Lesson 3: Movement &amp; Shape Design</td>
</tr>
<tr>
<td></td>
<td>Fifth Grade Lesson 4: Building Bridges</td>
</tr>
<tr>
<td></td>
<td>Fifth Grade Lesson 5: Still Life</td>
</tr>
<tr>
<td>CCSS. MP.2: Reason abstractly and quantitatively</td>
<td>Fourth Grade Lesson 5: Mechanimals</td>
</tr>
<tr>
<td>Mathematically proficient students make sense of quantities and their relationships.</td>
<td>Fifth Grade Lesson 1: Nonobjective art</td>
</tr>
<tr>
<td>CCSS. MP.3: Construct viable arguments and critique the reasoning of others.</td>
<td>Fourth Grade Lesson 1: Wordless Messages</td>
</tr>
<tr>
<td>Mathematically proficient students understand and use stated assumptions and previously established results in constructing arguments. They justify conclusions, communicate them to others, and respond to the arguments of others.</td>
<td>Fourth Grade Lesson 5: Mechanimals</td>
</tr>
<tr>
<td></td>
<td>Fifth Grade Lesson 2: Non-objective Art Poems</td>
</tr>
</tbody>
</table>
Art-Based Instruction to Support Mathematics Achievement for English Language Learners Under the Common Core State Standards

CCSS.MP.4: Model with mathematics

Mathematically proficient students can apply the mathematics they know to solve problems everyday life. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.

CCSS. MP.5: Use appropriate tools strategically.

Mathematically proficient students consider the available tools when solving a mathematical problem.

CCSS. MP.6: Attend to precision

Mathematically proficient students try to communicate precisely to others. They try to use clear definitions in discussion with others and in their own reasoning

CCSS. MP.7: Look or Make Use of Structure

Mathematically proficient students look closely to discern a pattern or structure.

CCSS. MP.8: Look for and express regularity in repeated reasoning

Mathematically proficient students notice if calculations are repeated and look both for general methods and for shortcuts.

Standards by Domain: Numbers & Operations In Base Ten

Use place value understanding and properties of operations.
Fifth Grade Lesson 5: Still Life
Standards by Domain: Geometry

Draw and identify lines and angles and classify shapes by properties of their lines and angles.

Fourth Grade Lesson 1: Wordless Messages
Fourth Grade Lesson 2: Mosaic Square Quilts
Fourth Grade Lesson 5: Mechanimals
Fourth Grade Lesson 3: Still Life

Standards by Domain: Measurement & Data

Solve problems involving measurement and conversion of measurements.

Fourth Grade Lesson 1: Wordless Messages
Fourth Grade Lesson 3: Still Life

Appendix D

Teacher Interview Protocol

1. What connections do you see between mathematics and art?
2. How do you implement ESL strategies utilizing the content areas?
3. How can you target your instruction specifically to meet the needs of English Language Learners?
4. What ongoing evaluation is conducted to ensure that your students are meeting their goals?
5. How do you transfer students’ initial enthusiasm for art to everyday math performance?

6. How can visual art training result in improved mathematics performance for your students?