Promoting Student Engagement in Science, Technology, Engineering, and Math:

An Evaluation of the Salvadori Center In-School and After-School 2018-19 Enrichment Programs

Evaluation Report

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Executive Summary

This report includes findings from Youth Studies Inc.'s (YSI) evaluation of the Salvadori Center's multi-day in-school residencies and after-school enrichment programs implemented at various sites throughout New York City during the 2018-19 school year. YSI's evaluation examined students' experiences in four different programs implemented across 12 different sites throughout New York City. Three different project-based curricula were taught across these programs, including a) *Bridges,* b) *Skateparks,* and c) *Landmarks, Monuments, and Memorials.* The goals of these curricula included:

- *Bridges*: Throughout the *Bridges* program, students investigate the different types of bridges and their functions, while learning about the history of some of the world's most prominent bridges. Students are also able to identify the structural parts that make up different types of bridges, and understand the forces that enable each bridge to support a load.
- *Skateparks*: The Skateparks program uses hands-on activities and design challenges to foster student learning and exploration of topics relating to skateparks – private versus public spaces, shape and form, scientific inquiry, friction, scale, energy, and materials.
- *Landmarks, Monuments, and Memorials*: In *Landmarks, Monuments, and Memorials,* students investigate the concepts behind and historical significance of landmarks, monuments, and memorials both in their local communities and around the world. Students design and build their own monument or memorial as part of a design challenge.

During the 2018-19 school year, Youth Studies, Inc. administered pre- and post-assessments to students participating in the following programs:

Skateparks After-School Program: 12-week after-school program, 90 minute sessions
Bronxworks Betances Cornerstone (NYCHA)
JCC at Richmond Terrace (NYCHA)
JCC Cornerstone at Todt Hill (NYCHA)
Manhattanville Cornerstone (NYCHA)
Seth Low Cornerstone (NYCHA)
St. Nick's Alliance (NYCHA)
Throggs Neck Boys and Girls Club
UAU Berry Homes (NYCHA)
Woodside Houses (NYCHA)
Bridges After-School Program: 12-week after-school program, 90 minute sessions
St. Nick's Alliance (NYCHA)
South Asian Youth Alliance
Bridges Starter In-School Residency Program: 8-week in-school residency, 45 minute sessions
Abraham Lincoln High School
PS/IS 217

Landmarks, Monuments, and Memorials After-School Program: 12-week after-school program, 90 minute sessions

Bronxworks Betances Cornerstone

JCC at Richmond Terrace

Throggs Neck Boys and Girls Club

Woodside Houses

A total of 419 assessments were completed by 275 students. The following are key highlights from YSI's evaluation of the Salvadori Center NYC Programs in 2018-19:

- A total of 275 students participated in YSI's assessment of the Salvadori Center's NYC Programs. Fifty-five (55) percent were female. Seventy-six (76) percent of surveyed participants self-identified as "Black or African American" or "Hispanic/Latino." Seven (7) percent of participants self-identified as "Asian," 6 percent as "White," 4 percent as "Native American," and 7 percent as "Other."
- Participants ranged in grade level from 3rd through 12th. The most common grade levels observed for NYC Salvadori participants included 4th Grade (39%), 5th Grade (23%), 6th Grade (16%), and 7th Grade (19%).
- The evaluation results reported below include evidence that Salvadori programs support several national math and science learning standards, including:
    - Common Core Math CCSS.MATH.CONTENT.HSG.MG.A.3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).
    - CCSS.MATH.CONTENT.3.MD.B.4: Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch.
    - Next Generation Science learning standard MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
- Salvadori participants in the *Bridges* program demonstrated a statistically significant increase in their understanding of various types of bridges, and the advantages and features of different bridge designs (See Page 10). Assessment results found that Salvadori participants improved their knowledge by 65 percent.
- Salvadori participants in the *Bridges* program demonstrated a statistically significant increase in their understanding of the effects of common forces on moving objects (See Page 12). Students in *Bridges* experienced an 18 percent improvement in their knowledge of common forces.
- Salvadori participants in the *Skateparks* program demonstrated a statistically significant increase in their understanding of scale, proportion, and measurement concepts (Page 17). Students in *Skateparks* experienced a 37 percent improvement in their knowledge of these concepts.

- Salvadori participants in the *Skateparks* program demonstrated a statistically significant increase in their understanding of the effects of common forces on objects (Page 20). *Skateparks* students experienced a 60 percent improvement in this area.
- Salvadori participants in the *Skateparks* program demonstrated a statistically significant improvement in their basic understanding of the rectangular three-dimensional form (Page 23). Students experienced a 75 percent improvement in their ability to recognize and analyze a rectangular three-dimensional form.
- Salvadori participants in the *Landmarks, Monuments, and Memorials* program demonstrated a statistically significant improvement in their understanding of concepts central to this subject, including what distinguishes landmarks, monuments, and memorials, and the properties of various building materials used in these structures (Page 25). Students experienced a 24 percent improvement in their understanding of these core concepts.
- Salvadori Center participants in all three programs – *Bridges, Skateparks, and Landmarks, Monuments, and Memorials* – demonstrated a significant increase in their confidence that they can be successful in math and science as measured by the Fennema-Sherman Attitudes Scale, a math and science attitude scale that has been used extensively in education research (See Page 25). YSI observed a 13 percent improvement in participants' STEM-related self-efficacy.
- Salvadori Center participants in *Bridges, Skateparks, and Landmarks, Monuments, and Memorials* demonstrated a significant increase in their motivation to pursue educational and career choices in science as measured by the assessment items from the Programme for International Student Assessment (PISA) (See Page 27). YSI observed a 24 percent improvement in students' future-oriented motivation to pursue STEM from pre- to post-test.

Background

A challenge facing many educational institutions, especially those in urban settings serving culturally and linguistically diverse populations, is the disconnect that often exists between schools and students' home communities. Science education researchers have argued that this disconnect between school and home/community life may result in students feeling that science is impractical, alien, and in contradiction with the beliefs and practices of their lives (Basu & Barton, 2007). Urban and low-income students, in particular, are more likely to hold negative sentiments about science, such as boredom, anxiety, confusion, and frustration. Bouillion and Gomez (2001) have argued that this decoupling leads to a disengagement in which some learners fail to see schooling as an avenue for life progress. With respect to science education, this phenomenon jeopardizes our nation's goal to become first in the world in science achievement among students (U.S. Department of Education, 1991).

In response to this challenge, many are advocating an instructional approach that emphasizes hands on activities and learning by doing. In fact, many of the recent national reports on the conditions of science teaching and learning in schools call for, "More active learning for students and less passivity; more hands-on, direct opportunities to 'make meaning'" (Schmieder & Michael-Dyer, 1991). To that end, science education standards set forth by the American Association for the Advancement of Science and the National Research Council now urge less emphasis on memorizing decontextualized scientific facts and more emphasis on students investigating the everyday world and developing deep understanding from their inquiries (Marx et al., 2004). These approaches to instruction challenge educators to transform students' experiences in science classrooms. For teachers who are used to using instructional methods based on recitation and direct instruction, inquiry teaching challenges them to develop new content knowledge and pedagogical techniques (Basu & Barton, 2007; Bouillion & Gomez, 2001).

This report includes recent (2018-19) findings from YSI's evaluation of various Salvadori Center programs implemented in sites across New York City. These programs were implemented as either a 12-week after-school program or an abridged, eight-week in-school residency. Three different Salvadori-designed curricula were utilized for these programs. They include: a) *Bridges*, b) *Skateparks*, and c) *Landmarks, Monuments, and Memorials*. All three programs represent an effort to engage disadvantaged students in math and science using a hands-on, project-based approach. Salvadori collaborates with providers including NYC Public Schools, New York City Housing Authority centers, and non-profit, community-based providers to implement these programs. The Salvadori Center uses the principles of architecture and engineering to help students in schools and out-of-school time programs to master mathematics and science concepts. All three programs aim to use investigations of the built environment to introduce and reinforce STEM concepts and skills. The program highlights engineering concepts and the design process through hands-on investigations of the built environment with an emphasis on collaborative learning.

The rest of this report summarizes current findings from an evaluation of students' experiences in four different programs implemented across 12 different sites throughout New York City. Three different project-based curricula were taught across these programs, including a) Bridges, b) Skateparks, and c) Landmarks, Monuments, and Memorials. The goals of these curricula included:

- *Bridges*: Throughout the Bridges program, students investigate the different types of bridges and their functions, while learning about the history of some of the world's most prominent bridges. Students are also able to identify the structural parts that make up different types of bridges, and understand the forces that enable each bridge to support a load.
- *Skateparks*: The Skateparks program uses hands-on activities and design challenges to foster student learning and exploration of topics relating to skateparks – private versus public spaces, shape and form, scientific inquiry, friction, scale, energy, and materials.
- *Landmarks, Monuments, and Memorials*: In *Landmarks, Monuments, and Memorials,* students investigate the concepts behind and historical significance of landmarks, monuments, and memorials both in their local communities and around the world. Students design and build their own monument or memorial as part of a design challenge.

This evaluation was implemented by Youth Studies, Inc. (YSI), an evaluation firm that provides research and program evaluation services to a variety of youth-serving organizations, including schools and community-based youth programs. All three curricula are aligned to the Common Core Math Standards and the New York State Standards for Math, Science, and Technology. Each lesson uses a collaborative, hands-on, project-based approach. Activities in the earlier sessions focus on developing students' skills of measurement, observation, classification, and drawing conclusions based on the results of a controlled experiment.

Description of Evaluation Process

Participant Assessments

YSI developed pre- and post-participation student assessments that were administered by Salvadori instructors during the first and final sessions, at participating sites. In addition to basic background questions (e.g. gender, age, and ethnicity), the pre- and post-assessments included standardized measures of students' confidence in their ability to succeed in math and science, and their future-oriented motivation to pursue math and science careers. In addition to these general outcomes, YSI's assessments included tasks and measures of content and skills that were relevant to the specific program the participant was enrolled in: *Bridges, Skateparks, or Landmarks, Monuments, and Memorials*. These included:

Table 1: Program-specific content and skills evaluated

Salvadori Program	*Program-specific Content/Skills Assessed by YSI*
Bridges	• Students' familiarity with various types of bridges and their relative benefits • Students' understanding of the effects of common forces on objects • Students' ability to read and interpret a chronological timeline • Students' ability to generate measurement data using a ruler • Student understanding of the scientific inquiry process
Skateparks	• Students' comprehension of scale and proportion; • Students' understanding of the effects of common forces on objects • Students' ability to recognize and analyze three-dimensional shapes and forms
Landmarks	• Students' ability to define and differentiate landmarks, monuments, and memorials • Students' ability to read and interpret maps • Students' comprehension of scale and proportion

A total of 275 students participated in YSI's assessment of the *Bridges* program. Of those 275 students, 153 completed *both* a pre- and post-test assessment. The remaining 122 students participated in the pre-test only (110) or only submitted a post-test assessment (12). As seen in Table 2, Participants ranged in grade level from 3rd Grade through 12th Grade, although a large majority of participants (97%) represented students in grades 4th through 7th.

Moreover, 55 percent of participants assessed were female. Seventy-six (76) percent of surveyed participants self-identified as "Black or African American" or "Hispanic/Latino." Seven (7) percent of participants self-identified as "Asian," 6 percent as "White," 4 percent as "Native American," and 7 percent as "other."

Table 2. Background Characteristics of BRIDGES Participants

Demographic Characteristics	% of Students
Grade	
3rd	1
4th	39
5th	23
6th	16
7th	19
8th	1
9th	1
10th	0
11th	< 1
12th	<1
Gender	
Male	45
Female	55
Ethnicity*	
Black or African-American	55
Hispanic/Latino (of any race)	30
White	15
American Indian or Alaska native	14
Asian	8
Other	9

* *Participants were allowed to select as many ethnicities as they wanted. Hence, the percentages associated with these responses total to greater than 100.*

To assess how Salvadori participants' attitudes about math and science may have changed over the course of the program, YSI evaluators included survey items from the Fennema-Sherman Attitudes Scale, a math and science attitude scale that has been used extensively in education research. Using students' responses to questions from the Fennema-Sherman Attitudes scale, we constructed measures of students' personal *confidence* in their math and science ability . These attitudes were assessed prior to and after students participated in one of three Salvadori programs: *Bridges, Skateparks, or Landmarks, Monuments & Memorials*. More specifically, students were asked in both pre- and post-test surveys to agree or disagree with the following statements related to these attitudes. Students' responses to similar statements were averaged to form measures of students' confidence in math and science.

Table 3. Modified Fennema-Sherman Attitude Scales

Confidence Items
Math is hard for me
Science is hard for me
I know I can do well in math
I know I can do well in science
I am sure I can learn math
I am sure I can learn science
I think I could do advanced math and science

Three survey items from the Programme for International Student Assessment (PISA) were included to assess students' future-oriented motivation to pursue science education and careers (OECD, 2007). Those items are listed in Table 4.

Table 4. PISA Future-Oriented Science Motivation Scale

Future-Orientated Science Motivation
I would like to work in a career involving science.
I would like to study science when I go to college.
I would like to work on science projects as an adult.

Participant Outcome Findings

<u>Bridges In-School Residency and After-school Findings</u>

YSI assessed knowledge and skill gains among students who participated in the Salvadori Center's *Bridges* program in one of two formats:

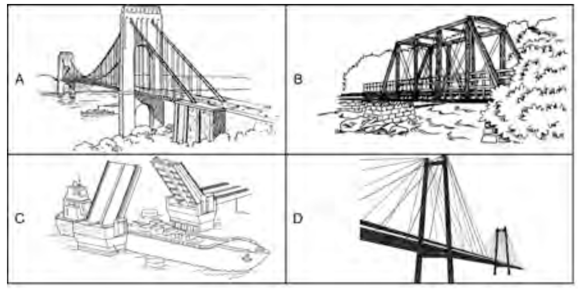
- Sixty (60) survey respondents participated in the *Bridges Starter* program which consisted of an eight-week in-school residency with Salvadori instructors incorporating lessons within 45-minute classroom sessions. These residencies took place at PS/IS 217 and Abraham Lincoln High School.
- Twenty-seven (27) survey respondents participated in the *Bridges After-school* program which consisted of a 12-week after-school program. In the after-school setting *Bridges* content was delivered in 90-minute weekly sessions. The *Bridge After*-school program was implemented in two after-school centers: The St. Nick's Alliance and the South Asian Youth Association (SAYA).

Salvadori participants were surveyed at the beginning and conclusion of their program. In addition to basic background questions (e.g. gender, age, and ethnicity), the pre- and post-assessments included standardized measures of: 1) **students' familiarity with various types of bridges and their relative benefits**; 2) **students' understanding of the effects of common forces on objects**; 3) **students' ability to read and interpret a chronological timeline**; 4) **student understanding of the scientific inquiry process**; 5) **students' confidence in their ability to succeed in math and science**; and 6) **students' future-oriented motivation to pursue math and science careers**.

Students' Familiarity with Various Bridge Types

The pre- and post-test questionnaires included a performance task designed to assess students' familiarity with different types of bridges, and the advantages and features of different bridge designs. The specific items included the following:

Table 5. Bridge Type Assessment Items

Question #	Assessment Item
24	Match the following types of bridges with the correct name. ***Bridge Type*** Suspension Bridge Draw Bridge Truss Bridge Cable-Stayed Fan Bridge 

YSI created an overall measure of student comprehension that summarizes how well students performed on these tasks. Possible values for this measure ranged from 0 (indicating 0 correct responses) to 100 (indicating that the students answered all questions correctly).

As seen in Table 6 below, *Bridges* participants demonstrated a significant increase in their recognition and understanding of different types of bridges. A paired-samples t-test was conducted to compare students' knowledge of bridge types and functions at the beginning of the *Bridges* program and after the module was completed.

There were significant improvements in measured pre-test vs. post-test knowledge observed for students participating in the *Bridges* program. At the participating *Bridges* sites, the mean pre-test score was 49% (M=49.3, SD=32.7). After the program was completed, Salavdori participants scored an average of 81% (M=81.1, SD=34.5) on the post-test assessment. This represents an average improvement of 32% observed over the course of the 8 or 12-week intervention ($M_{difference}$=31.8, SE=38.1); t (147)=5.75, $p <$ .0001.

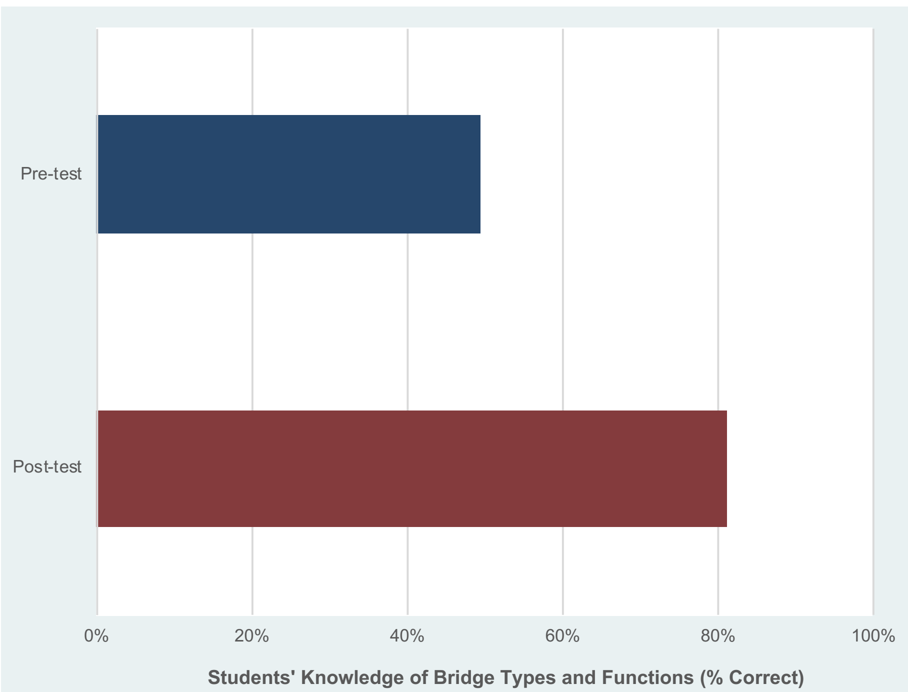
These findings represent a 65 percent improvement from pre- to post-test for Salavdori Center students participating in either the *Bridges* in-school residency or the *Bridges* after-school program. Figure 1 below presents a visual representation of the pre-test vs. post-test comparison for all participating sites.

Table 6. Pre- vs. Post-test Assessments of Students' Familiarity with Bridge Types and Functions

	Student Knowledge of Bridges
Mean (range 0-100)	
Pre-test Score	49.3
Post-test Score	81.1
Change	+ 31.8[#]

[#] Statistically significant change from baseline to follow-up (p<.0001)

Figure 1. Pre- vs. Post-test Assessments of Students' Knowledge of Bridge Types and Functions



This assessment finding offers evidence that the *Bridges* program supports student learning for the following New York State Standards for Math, Science, and Technology:

Standard 7, Key Idea 1

Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

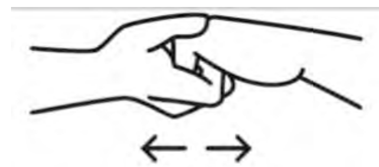
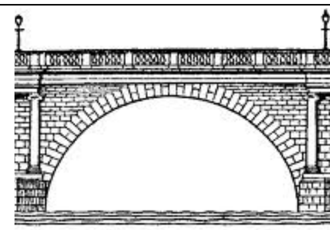
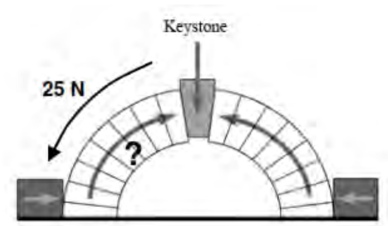
- Make informed consumer decisions by applying knowledge about the attributes of particular products and making cost/benefit trade-offs to arrive at an optimal choice
- Design solutions to problems involving a familiar and real context, investigate related science concepts to determine the solution, and use mathematics to model, quantify, measure and compute

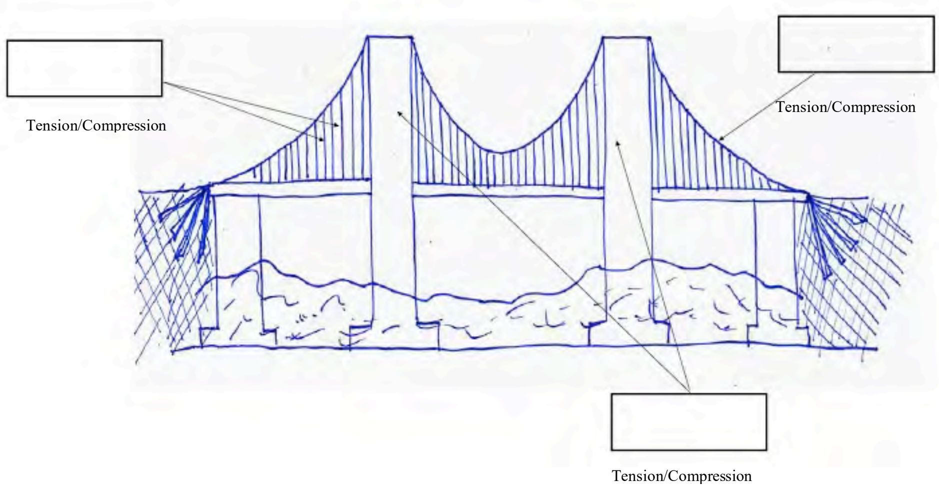
Students' Understanding of the Effects of Common Forces on Objects

The pre- and post-test student questionnaires included several items to assess students' understanding of the effects of common forces on moving objects. More specifically, these items required students to distinguish between the forces of tension and compression and to interpret Newton's Third Law of Motion. These concepts are central to the *Bridges* curriculum.

The specific assessment items included the following:

Table 7. Common Forces Assessment Items

Question #	Assessment Item
25	Label which force is being used in each picture below. ☐ Tension ☐ Compression  
26	When all other things are equal, which of the following is true about a beam bridge? ❑ The shorter the main span, the stronger the beam bridge. ❑ The longer the main span, the stronger the beam bridge.
29	If a truck weighing 500 pounds crosses this bridge, how will the weight of the truck be distributed? Fill in the blanks below: ____ pounds will be distributed to the right side of the arch and____ pounds will be distributed to the left side of the arch. 
30	Newton's Third Law states that for every action there is an equal and ____________ reaction. ❑ opposite ❑ perfect ❑ stable ❑ positive
31	If a pile of snow pushes down on the keystone of an arch bridge so that 25N are distributed to the left side of the bridge, how much force will the ground "push back" with on that side of the bridge? ___________Newtons 

32	Label each box in the diagram below to show which force is applied on that part of the bridge: TENSION or COMPRESSION. 

YSI created an overall measure of student comprehension of common forces that summarizes how well students performed on the assessment items listed above. Possible values for this measure ranged from 0 (indicating 0 correct responses) to 100 (indicating that the students answered all questions correctly).

As seen in Table 8 below, *Bridges* participants demonstrated a small increase in their ability to recognize and analyze the effects of common forces on objects. A paired-samples t-test was conducted to compare students' knowledge at the beginning and conclusion of the *Bridges* program.

There were significant improvements in measured pre-test vs. post-test knowledge observed for students participating in the *Bridges* program. At the participating *Bridges* sites, the mean pre-test score was 55% (M=55.2, SD=28.1). After the program was completed, Salavdori participants scored an average of 72% (M=72.1, SD=30.2) on the post-test assessment. This represents an average improvement of 17% observed over the course of the 8 or 12-week intervention ($M_{difference}$=16.9, SE=4.79); t (147)=3.53, p = .0006.

This assessment finding offers evidence that the *Bridges* program supports student learning for the following New York State Standard for Math, Science, and Technology:

Standard 4, Key Idea 5
Energy and matter interact through forces that result in changes in motion.

Describe the effects of common forces (pushes and pulls) of objects, such as those caused by gravity, magnetism, and mechanical forces

For every action there is an equal and opposite reaction

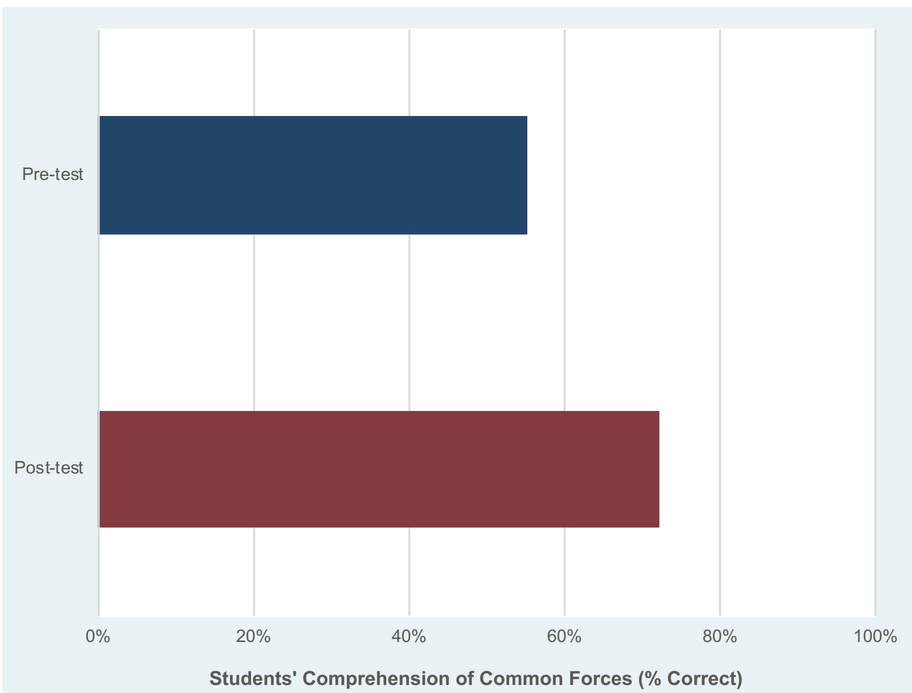
These findings represent an 18 percent improvement in students' understanding of the effects of common forces from pre- to post-test for Salavdori Center students participating in either the *Bridges* in-school residency or the *Bridges* after-school program. Figure 2 below presents a visual representation of the pre-test vs. post-test comparison for all participating sites.

Table 8. Pre- vs. Post-test Assessments of Students' Understanding of the Effects of Common Forces

	Student Understanding of the Effects of Common Forces
Mean (range 0-100)	
Pre-test Score	55.2
Post-test Score	72.1
Change	+ 16.9[#]

[&] This result was not found to be statistically significant.

Figure 2. Pre- vs. Post-test Assessments of Students' Comprehension of Common Forces

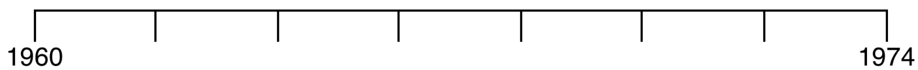


Students' Ability to Read and Interpret a Timeline

The pre- and post-test questionnaires included two items that asked students to correctly read and interpret a chronological timeline. The specific items included the following:

Table 9. Chronological Timeline Assessment Items

Question #	Assessment Item
21	Which of the following is the missing year that belongs in the timeline below? 1927 1940 1953 1966 1979 ? ❑ 1994 ❑ 1992

	❑ 2005 ❑ 1953
22	The timeline below includes a starting and end year, but the years in between are not labeled.  What is the correct scale for this timeline? ❑ 3 years ❑ 5 years ❑ 14 years ❑ 2 years

YSI created a measure of students' ability to correctly interpret a chronological timeline using the items above. Possible values for this measure ranged from 0 (indicating 0 correct responses) to 100 (indicating that the students answered all questions correctly).

As seen in Table 10 below, Salvadori participants demonstrated a small, but not statistically significant increase in their ability to read and interpret a timeline. A paired-samples t-test was conducted to compare students' knowledge at the beginning and conclusion of the *Bridges* program.

A paired-samples t-test was conducted to compare students' timeline interpretation skills at the beginning and conclusion of the *Bridges* program. At the participating *Bridges* sites, the mean pre-test score was 58% (M=58.1, SD=29.1). At the conclusion of the *Bridges* program, Salvadori students scored an average of 65% (M=65.1, SD=28.4) on the post-test assessment. This represents an average improvement of 7% observed over the course of the *Bridges* intervention ($M_{difference}$=7.0, SEM=4.8); t (147)=1.47, p = .1426.

The magnitude of the observed improvement in timeline reading skills among *Bridges* participants was *not* sufficient to conclude that the program led to a significant improvement in students' ability to read and interpret a chronological timeline.

Table 10. Pre- vs. Post-test Assessments of Students' Ability to Read and Interpret a Chronological Timeline

	Students' Ability to Interpret a Timeline
Mean (range 0-100)	
Pre-test Score	58.1
Post-test Score	65.1
Change	+ 7.0[&]

[&] This result was not found to be statistically significant.

<u>Skateparks After-school Findings</u>

YSI assessed knowledge and skill gains among students who participated in the Salvadori Center's after-school *Skateparks* program. In total, YSI's evaluation of the *Skateparks* program included assessments from 142 participants. These students spanned nine different program sites, including 8 New York City Housing Authority community centers and one Boys and Girls club. The full list of centers that participated in YSI's evaluation of *Skateparks* includes: Bronxworks Betances Cornerstone, the JCC at Richmond Terrace, the JCC Cornerstone at Todt Hill, Manhattanville Cornerstone, Seth Low Cornerstone, St. Nick's Alliance, Throggs Neck Boys and Girls Club, UAU Berry Homes, and the Woodside Houses.

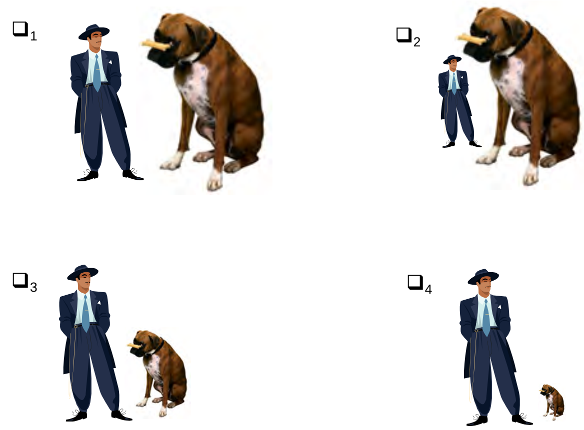
Salvadori participants were surveyed at the beginning and conclusion of the 12-week after-school program. In addition to basic background questions (e.g. gender, age, and ethnicity), the pre- and post-assessments included standardized measures of: 1) **students' comprehension of scale, proportion, and measurement concepts**; 2) **students' understanding of the effects of common forces on objects**; 3) **students' ability to recognize and analyze three-dimensional shapes**; 4) **students' confidence in their ability to succeed in math and science**; and 5) **students' future-oriented motivation to pursue math and science careers**.

Students' Comprehension of Scale and Proportion

The pre- and post-test questionnaires included two performance tasks that were designed to assess students' understanding of scale and proportion concepts central to the *Skateparks* curriculum. The specific items included the following:

Table 11. Scale and Proportion Assessment Items

Question #	Assessment Item
30	Use the Architect Scale Ruler to measure the objects in the pictures below. (Scale: ½" = 1') This skateboard would be ______' long. 

32	Which picture below shows the dog and his owner in correct proportion?	

YSI created an overall measure of student comprehension that summarizes how well students performed on these four tasks. Possible values for this measure ranged from 0 (indicating 0 correct responses) to 100 (indicating that the students answered all questions correctly).

As seen in Table 12 below, Salvadori *Skateparks* participants demonstrated a significant increase in their comprehension of scale, proportion, and measurement concepts. A paired-samples t-test was conducted to compare students' knowledge of scale and proportion at the beginning of the *Skateparks* program and after the *Skateparks* module was completed.

There was a significant improvement in measured pre-test vs. post-test knowledge observed for students participating in the *Skateparks* program. At the participating *Skateparks* sites, the mean pre-test score was 46% (M=46.3, SD=33.1). After the program was completed, Salavdori participants scored an average of 63% (M=63.2, SD=29.2) on the post-test assessment. This represents an average improvement of 17% observed over the course of the 12-week intervention ($M_{difference}$=16.9, SE=5.63); t (179)=3.00, p = .0031.

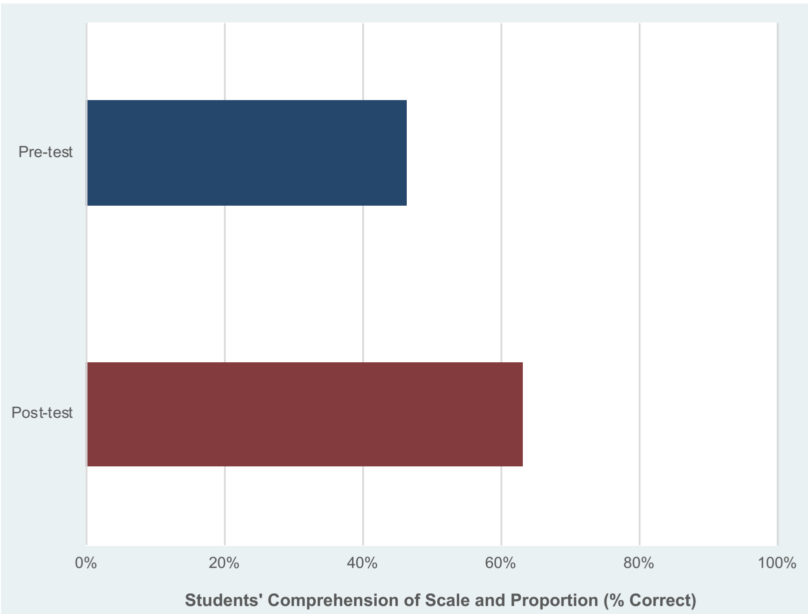
These findings represent an 37 percent improvement in students' understanding of scale, proportion, and measurement from pre- to post-test for Salvadori Center students participating in the *Skateparks* after-school program. Figure 3 below presents a visual representation of the pre-test vs. post-test comparison for all participating sites.

Table 12. Pre- vs. Post-test Assessments of Students' Comprehension of Scale and Proportion

	Student Understanding of Scale, Proportion, and Measurement
Mean (range 0-100)	
Pre-test Score	46.3
Post-test Score	63.2
Change	+ 16.9#

Statistically significant change from baseline to follow-up (p=.0031)

Figure 3. Pre- vs. Post-test Assessments of Students' Comprehension of Scale and Proportion

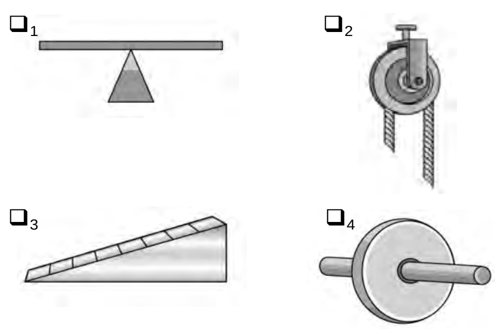


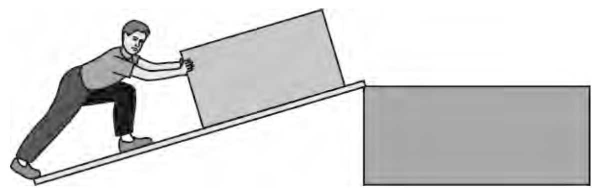
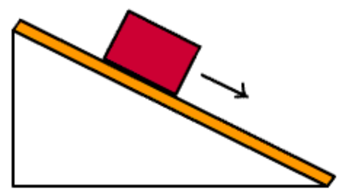
Students' Understanding of the Effects of Common Forces on Objects

The pre- and post-test student questionnaires included seven items to assess students' understanding of the effects of common forces on moving objects. More specifically, these items required students to recognize an inclined plane, to understand how the length of an inclined plane impacts the force needed to move an object, how friction impacts movement, and how to calculate the amount of work done when moving an object. These concepts are central to the *Skateparks* curriculum.

The specific assessment items included the following:

Table 13. Common Forces Assessment Items

Question #	Assessment Item
25	Which of the pictures below shows an inclined plane? 
26	Which units are used to measure **Force**? ❑1 Meters ❑3 Inches ❑2 Newton-meters ❑4 Newtons

27	Which units are used to measure **Work**? ❑1 Meters ❑3 Inches ❑2 Newton-meters ❑4 Newtons
28	Look at the picture below of a box being pushed up a ramp. This man will need **less** force to push the box if he … ❑1 uses a shorter ramp ❑3 uses a longer ramp ❑2 gets someone to encourage him ❑4 does not use a ramp at all 
29	A heavy block is released at the top of a rough wooden ramp, and slides down to the bottom (see picture below). The ramp is then covered with a strip of smooth wax paper, and the same block is then released from the top. Which of these **best** explains the motion of the block as it slides down the smooth wax paper? ❑1 The block will move faster. ❑2 The block will move slower. ❑3 The block will move at the same speed on the smooth surface as it did on the rough surface. ❑4 The block will not slide down since there is no force acting on it. 
33	If a shopper pushed a cart 5 meters down the aisle with a force of 20 Newtons, how much work did he do? Please show your work. Answer: __________ Newton-meters 
34	Which of the following best describes the force being placed on the spring scale below? ❑1 The force is a little less than 5 Newtons ❑3 You cannot measure force with a spring scale ❑2 The force is a little more than 5 Newtons ❑4 I don't know 

YSI created an overall measure of student comprehension of common forces that summarizes how well students performed on the assessment items listed above. Possible values for this measure ranged from 0 (indicating 0 correct responses) to 100 (indicating that the students answered all questions correctly).

As seen in Table 14 below, Salvadori *Skateparks* participants demonstrated a significant increase in their ability to recognize and analyze the effects of common forces on objects. A paired-samples t-test was conducted to compare students' knowledge at the beginning of the *Skateparks* program and after the *Skateparks* module was completed.

There was a significant improvement in measured pre-test vs. post-test knowledge observed for students participating in the *Skateparks* program. At the participating *Skateparks* sites, the mean pre-test score was 31% (M=30.8, SD=24.3). After the program was completed, Salavdori participants scored an average of 49% (M=49.2, SD=22.1) on the post-test assessment. This represents an average improvement of 18% observed over the course of the 12-week intervention ($M_{difference}$=18.4, SE=4.16); t (179)=4.43, p < .0001.

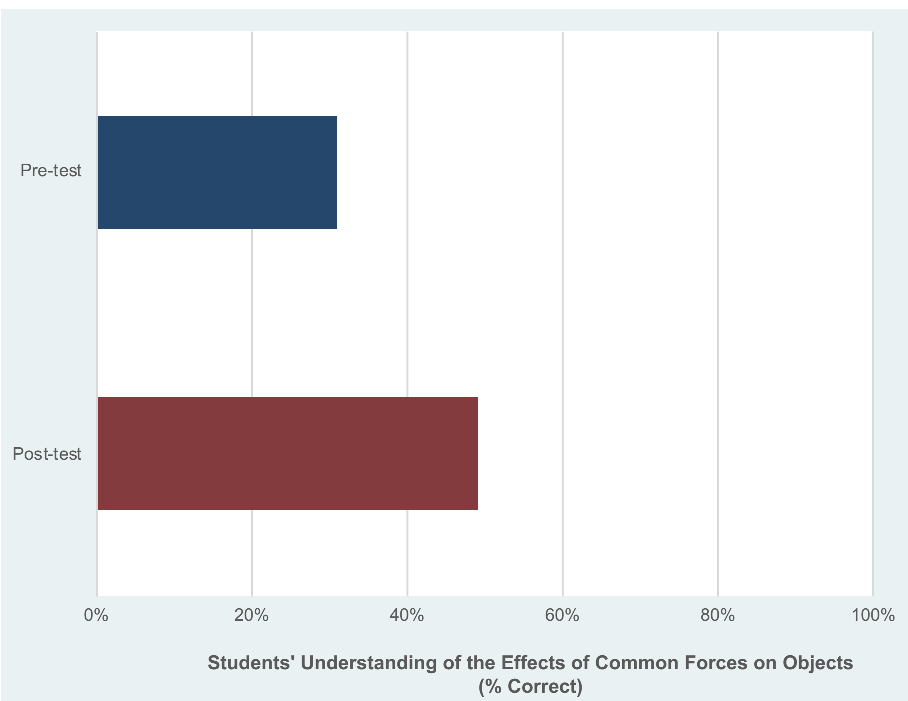
These findings represent a 60 percent improvement in students' understanding the effects of common forces on objects from pre- to post-test for Salavdori Center students participating in the *Skateparks* after-school program. Figure 4 below presents a visual representation of the pre-test vs. post-test comparison for all participating sites.

Table 14. Pre- vs. Post-test Assessments of Students' Comprehension of Common Forces

	Student Understanding of the Effects of Common Forces
Mean (range 0-100)	
Pre-test Score	30.8
Post-test Score	49.2
Change	+ 18.4[#]

[#] Statistically significant change from baseline to follow-up (p<.0001)

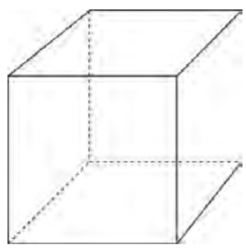
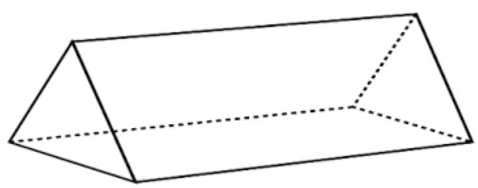
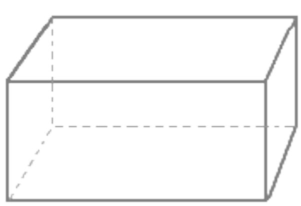
Figure 4. Pre- vs. Post-test Assessments of Students' Comprehension of Common Forces



Students' Ability to Recognize and Analyze Three-Dimensional Forms

The pre- and post-test questionnaires included three items that asked students to identify the faces, vertices and edges on a rectangular form. The specific items included the following:

Table 15. Understanding Three-Dimensional Forms Assessment Items

<table>
<tr><th>Question #</th><th>Assessment Item</th></tr>
<tr><td>22</td><td>How many vertices does the cube have?

❑ 6 ❑ 12 ❑ 8 ❑ 7</td></tr>
<tr><td>23</td><td>How many faces does the triangular prism have?

❑ 6 ❑ 12 ❑ 8 ❑ 7</td></tr>
<tr><td>24</td><td>How many edges does the form have?]

❑ 6 ❑ 12 ❑ 8 ❑ 7</td></tr>
</table>

YSI created an overall measure of students' ability to correctly analyze the properties of the 3-dimensional form above. Possible values for this measure ranged from 0 (indicating 0 correct responses) to 100 (indicating that the students answered all questions correctly).

As seen in Table 16 below, Salvadori *Skateparks* participants demonstrated a significant increase in their ability to recognize and analyze a three dimensional rectangular form. A paired-samples t-test was conducted to compare students' knowledge at the beginning of the *Skateparks* program and after the *Skateparks* module was completed.

There was a significant improvement in measured pre-test vs. post-test knowledge observed for students participating in the *Skateparks* program. At the participating *Skateparks* sites, the mean pre-test score was 28% (M=27.8, SD=22.2). After the program was completed, Salavdori participants scored an average of 49% (M=48.7, SD=24.6) on the post-test assessment. This represents an average improvement of 21% observed over the course of the 12-week intervention ($M_{difference}$=20.9, SE=5.25); t (179)=5.25, p < .0001.

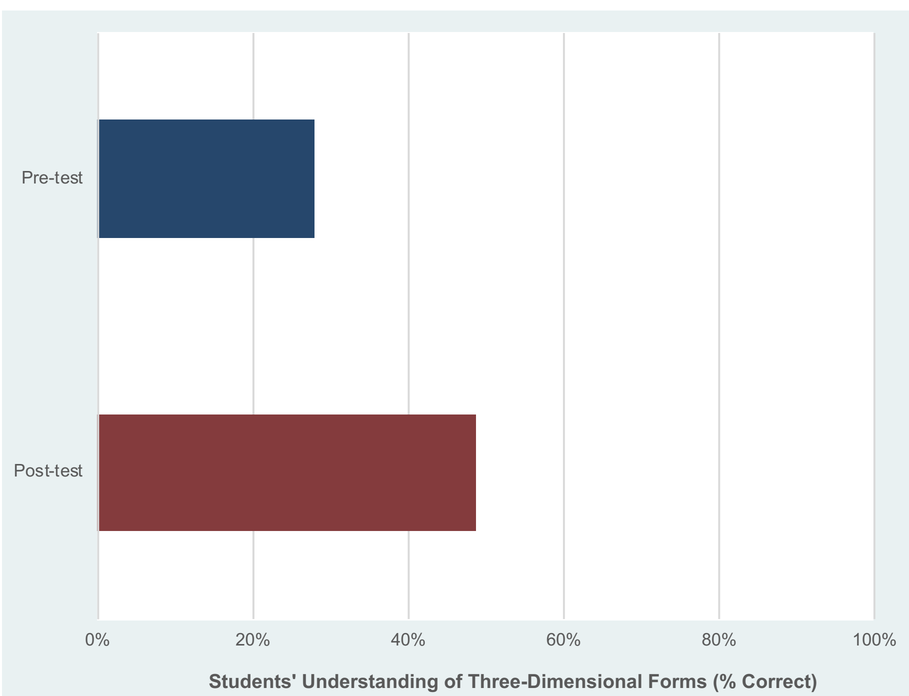
These findings represent a 75 percent improvement in students' basic understanding of the rectangular three-dimensional form from pre- to post-test for Salavdori Center students participating in the *Skateparks* after-school program. Figure 5 below presents a visual representation of the pre-test vs. post-test comparison for all participating sites.

Table 16. Pre- vs. Post-test Assessments of Students' Understanding of Three-Dimensional Forms

	Student Understanding of Three-Dimensional Forms
Mean (range 0-100)	
Pre-test Score	27.8
Post-test Score	48.7
Change	+ 20.9#

Statistically significant change from baseline to follow-up (p<.0001)

Figure 5. Pre- vs. Post-test Assessments of Understanding of Three-Dimensional Forms



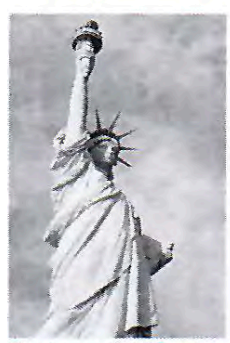
<u>Landmarks, Monuments, and Memorials After-school Findings</u>

YSI assessed knowledge and skill gains among students who participated in the Salvadori Center's after-school *Landmarks, Monuments, and Memorials (LMM)* program. In total, YSI's evaluation of the *LMM* program included assessments from 46 participants. These students spanned four different program sites, including 3 New York City Housing Authority community centers and one Boys and Girls club. The full list of centers that participated in YSI's evaluation of *LMM* includes: Bronxworks Betances Cornerstone, JCC at Richmond Terrace, Throggs Neck Boys and Girls Club, and the Woodside Houses.

Salvadori participants were surveyed at the beginning and conclusion of the 12-week after-school program. In addition to basic background questions (e.g. gender, age, and ethnicity), the pre- and post-assessments included standardized measures of: 1) **students' comprehension of scale, proportion, and measurement concepts**; 2) **students' map interpretation skills, and** 3) **students' ability to distinguish landmarks, monuments, and memorials and other urban planning concepts.**

Students' Comprehension of Landmarks, Monuments, and Memorials

The pre- and post-test questionnaires included several items designed to assess students' understanding of core concepts in the *LMM* curriculum, including what distinguishes a landmark, monument, or memorial, and the properties of building materials. The specific items included the following:

Question #	Assessment Item	
21	Label each of the pictures below indicating if they are a Landmark, a Monument, or a Memorial.	 Brooklyn Bridge  9/11 Memorial Lights  Statue of Liberty  Ghost Bike

26	Properties of a material are used to describe:	❑ How much land the material can occupy. ❑ The features/characteristics of the material. ❑ The mineral breakdown of the material. ❑ Ownership of the material.
25	Which of the properties below applies to **brick?**	❑ Smooth ❑ Hard ❑ Flexible ❑ Transparent
31	A licensed professional who is trained in developing economical and safe solutions to practical problems by applying mathematical and scientific knowledge is called …	❑ an architect ❑ a project manager ❑ an engineer ❑ an urban planner

YSI created an overall measure of student comprehension that summarizes how well students performed on the above tasks. Possible values for this measure ranged from 0 (indicating 0 correct responses) to 100 (indicating that the students answered all questions correctly).

As seen in Table 17 below, Salvadori *LMM* participants demonstrated a significant increase in their comprehension of core concepts from the *LMM* curriculum. A paired-samples t-test was conducted to compare students' knowledge of scale and proportion at the beginning of the *LMM* program and after the *LMM* module was completed.

There was a significant improvement in measured pre-test vs. post-test knowledge observed for students participating in the *LMM* program. At the participating *LMM* sites, the mean pre-test score was 52% (M=51.6, SD=20.9). After the program was completed, Salavdori participants scored an average of

64% (M=63.9, SD=18.7) on the post-test assessment. This represents an average improvement of 12% observed over the course of the 12-week intervention ($M_{difference}$=12.3, SE=4.29); $t(84)=2.87$, $p = .0052$.

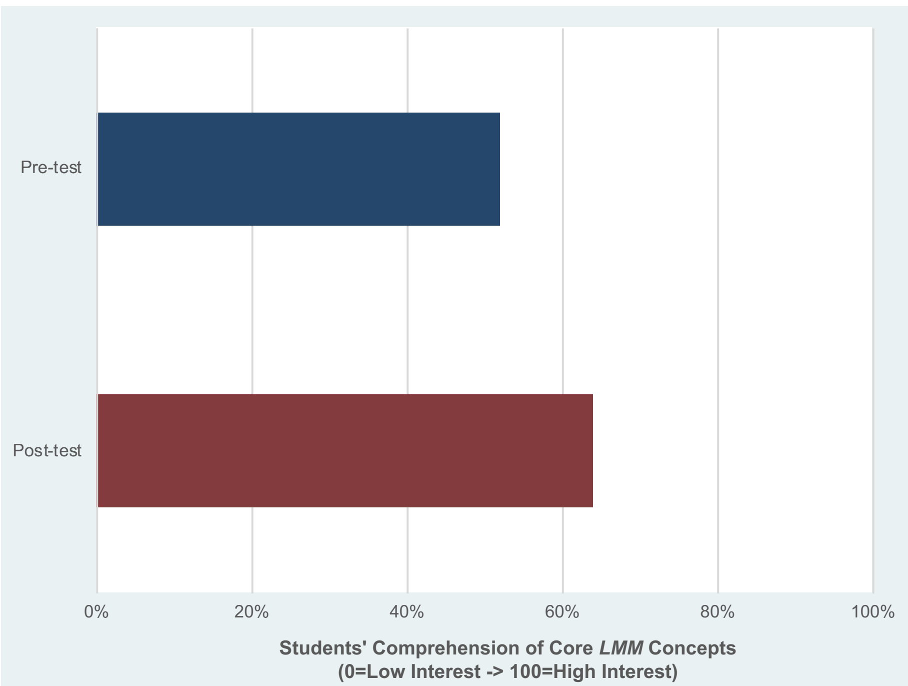
These findings represent an 24 percent improvement in students' understanding of core concepts in the *LMM* curriculum, including what distinguishes landmarks, monuments, and memorials, and the properties of various building materials. Figure 6 below presents a visual representation of the pre-test vs. post-test comparison for all participating sites.

Table 17. Pre- vs. Post-test Assessments of Students' Comprehension of LMM Core Concepts

	Student Understanding of Core *LMM* Concepts
Mean (range 0-100)	
Pre-test Score	51.6
Post-test Score	63.9
Change	+ 12.3#

Statistically significant change from baseline to follow-up (p=.0052)

Figure 6. Pre- vs. Post-test Assessments of Students' Comprehension of Scale and Proportion



<u>STEM-Related Attitudinal Changes for Participants in Bridges, Skateparks, and Landmarks, Monuments, and Memorials</u>

This section of the report discusses YSI's assessment of the impact of Salvadori Center programs on participants' STEM-related attitudes. YSI's assessments include measures of participants' confidence in their ability to be successful in math and science tasks and their future-oriented motivation to pursue math and science-related education and careers. The findings below encompass all three Salvadori programs: *Bridges, Skateparks, and Landmarks, Monuments, and Memorials.*

Students' Confidence in their Ability to Succeed in Math and Science

To assess how Salvadori Center students' attitudes about math and science may have changed during the year they participated in the program, evaluators administered a modified version of the Fennema-Sherman Attitudes Scale (see description above). Responses to this assessment were used to develop a measure of students' personal *confidence* in their ability to do math and science. These attitudes were assessed prior to and after students participated in their Salvadori program. The assessment items included:

Table 18. Student Confidence Items

Question #	**Confidence Item** (Answer Choices: Strongly Disagree, Disagree, Agree, Strongly Agree)
6	I am sure I can learn math
7	I know I can do well in science
8	I think I could do advanced math and science
9	Math is hard for me
10	I know I can do well in math
13	Science is hard for me
15	I am sure I can learn science

YSI created an overall measure of students' math and science self-efficacy. Possible values for this measure ranged from 0 (indicating the lowest possible confidence) to 100 (indicating that the students answered reported the highest possible confidence).

As seen in Table 19 below, *Salvadori Center* participants demonstrated a significant increase in their confidence that they can be successful in math and science. A paired-samples t-test was conducted to compare students' self-efficacy at the beginning and completion of the Salvadori program. There was a significant improvement in pre-test (M=72.1, SD=12.1) vs. post-test (M=81.8, SD=14.2) conditions ($M_{difference}$=9.7, SE=7.41); t (417)=7.4, $p < .0001$.

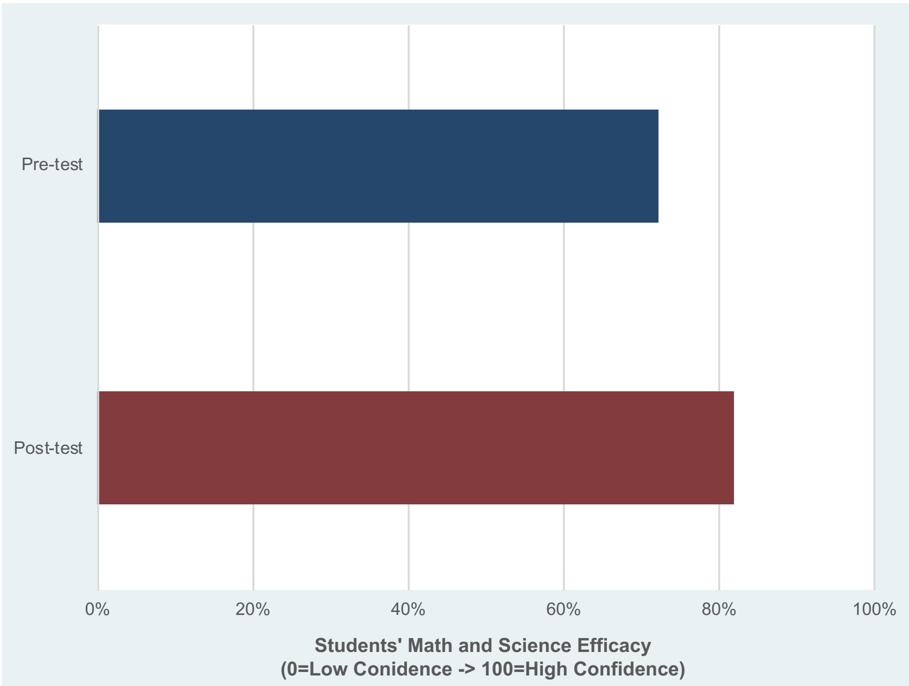
These findings represent a 13 percent improvement in students' confidence in their math and science abilities from pre- to post-test for Salavdori Center students participating in the *Skateparks* after-school program. Figure 7 below presents a visual representation of the pre-test vs. post-test comparison for all participating sites.

Table 19. Pre- vs. Post-test Assessments of Students' Confidence in their Ability to Succeed in Math and Science

	Math and Science Confidence
Mean: range 0 (low) - 100 (high)	
Pre-test Score	72.1
Post-test Score	81.8
Change	+ 9.7#

Statistically significant change from baseline to follow-up (p<.0001)

Figure 7. Pre- vs. Post-test Assessments of Students' Confidence in their Ability to Succeed in Math and Science



Students' Future-oriented Motivation to Pursue Science Careers

YSI's assessments also included three items to measure students' motivation to pursue future education and careers in math and science. These items included:

Table 20. Future-Oriented Motivation Assessment Items

Question #	**Motivation Item** (Answer Choices: Strongly Disagree, Disagree, Agree, Strongly Agree)
11	I would like to work in a career involving science.
12	I would like to study science when I go to college.
14	I would like to work on science projects as an adult.

YSI created an overall measure of students' motivation to pursue STEM-related careers. Possible values for this measure ranged from 0 (indicating the lowest possible motivation) to 100 (indicating that the students answered reported the highest possible motivation).

As seen in Table 21 below, Salvadori participants demonstrated a significant increase in motivation to pursue educational and career choices in math and science. A paired-samples t-test was conducted to compare students' future-oriented motivation to pursue math and science as measured at the beginning and completion of their Salvadori program. There was a significant improvement in pre-test (M=47.0, SD=18.6) vs. post-test (M=58.3, SD=19.3) conditions ($M_{difference}$=11.3, SE=1.9); t (417)=5.91, p < .0001).

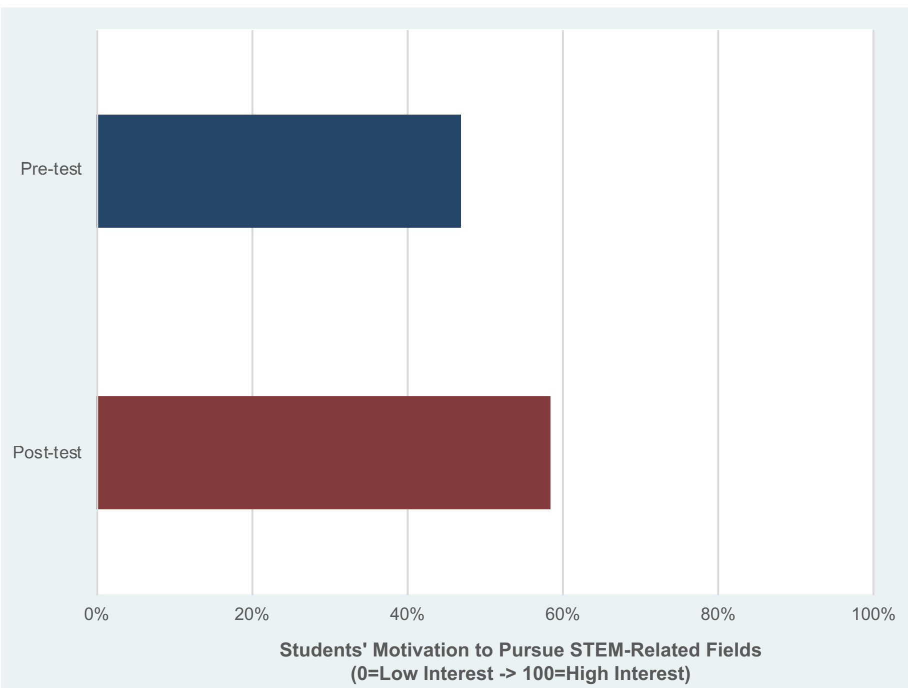
These findings represent a 24 percent improvement in students' future-oriented motivation to pursue STEM from pre- to post-test for Salavdori Center students participating in the *Skateparks* after-school program. Figure 8 below presents a visual representation of the pre-test vs. post-test comparison for all participating sites.

Table 21. Pre- vs. Post-test Assessments of Students' Future-Oriented Science Motivation

	Science Motivation
Mean (range 1-4)	
Pre-test Score	47.0
Post-test Score	58.3
Change	+ 11.3[#]

[#] Statistically significant change from baseline to follow-up ($p<.0001$)

Figure 8. Pre- vs. Post-test Assessments of Students' Future-Oriented Science Motivation



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