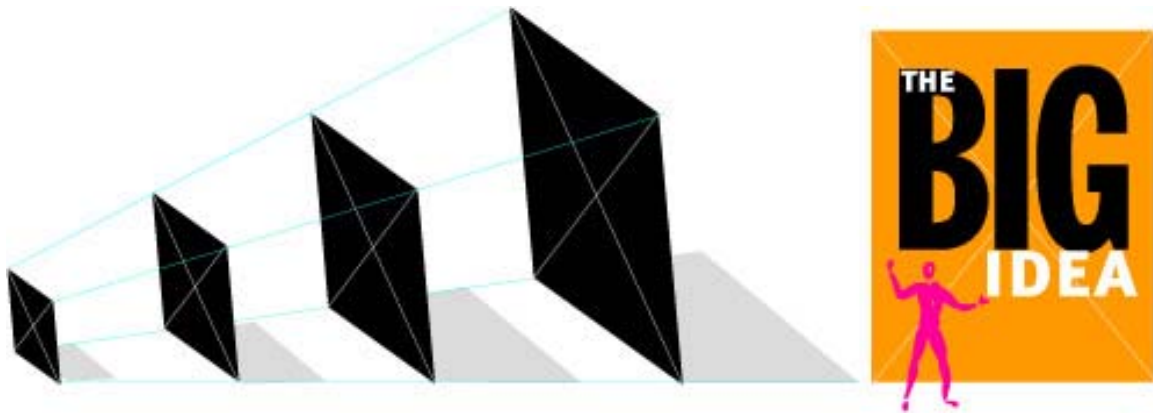


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## The BIG Idea Mural-making Project

Assessment Report  
**Nancy Daniels** and **Nina Weber**  
LDT Seminar 229D  
Daniel L. Schwartz

## **Abstract**

By providing students with an applied, problem solving activity we believe that students' performance and interest in math will increase. The arts-infused curriculum of the Big Idea Mural-making Project allows students of grades four through eight the experience of building a mural and contributing to a museum environment.

The process encompasses three contexts: classroom or after-school center, museum, and community, physical or virtual. Through a guided process in the classroom and exhibit space, students build a mural in which they apply mathematical concepts of ratio, scale, and proportion as well as artistic concepts of color and composition. Using KidPix, Adobe Photoshop, and direct manipulation SmartBoard technologies, the students are guided through a collaborative activity to construct a group, large-scale mural from their individual art pieces for a particular site within their school.

To determine whether this intervention was successful for students to learn about scale and proportion, fourteen written-questions were developed by the designers and then administered to the grade five 'experimental', grade five 'control', and grade seven 'benchmark' groups. Students also answered written survey questions about their interest in math. The results of our learning assessment show that the user group (n=24) out-performed both the control (n=19) and benchmark (n=19) groups in problem solving activities. 7<sup>th</sup> graders seemed less interested in math than 5<sup>th</sup> graders. There was no discernible correlation between either math performance or declining interest and gender of the students.

## **Introduction**

Our mural-making project addresses the need for students to have more collaborative problem solving activities to apply skills learned in the classroom. We intend that these activities will improve the performance of students in mathematics as well as sustain and increase their interest in math, especially that of girls. Throughout our project, we emphasize the process of learning

rather than the products of learning- we are interested in how students will organize and represent their ideas into a drawing and how they will enlarge this piece of work.

Studies such as Third International Mathematics and Science Study, TIMSS, (1999) and *Before It's Too Late: A Report to the Nation from the National Commission on Math and Science Teaching* (2000) show that the performance of students in math declines by the time they enter middle school. TIMSS benchmarking data show that there is higher mathematics achievement when teachers emphasize reasoning and problem solving activities. Also, research at the University of Michigan and TERC indicates that girls' interest in math declines during middle school. To increase girls' interest in math, the National Academy of Engineering recommends interventions such as making math more real and increasing collaborative activities.

Motivation also increases with an arts-infused curriculum, a curriculum in which the study of history and social studies is integrated with literature and writing. For example, researchers from UCLA in 1995 determined that the arts-infused curriculum of the Different Ways of Knowing Project, maintained or increased the levels of achievement and motivation of elementary students over time as compared to declining motivation for non-participating students.

From these findings, we conclude that middle school students in the United States may be performing below other students around the world in math because they lack applied projects in which they can experience authentic problem solving opportunities and work collaboratively. These same activities can also pique middle school girls' interest in math. As defined by the National Council of Teachers of Mathematics (NCTM), problem solving, an integral part of all mathematics learning, "means engaging in a task for which the solution is not known in advance."

The BIG Idea Mural-making project is an authentic problem solving activity. The students select a site in their community for their final product before it is designed. They approach local authorities to gain permission to "own" that special location for a significant period of time, or even permanently. Then their mural is designed specifically to the optimal scale, shape, and size for that location.

The main activity of our project is the creation, design, and production of a mural or large-scale artwork. Students use computer drawing programs and SmartBoard technology to compile their class mural. NCTM affirms that “(t)echnology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students’ learning.” An integral part of this project is the museum involvement in which the mural enlargement is simulated and manipulated using video projectors and other technology. Students participate in three contexts—classrooms, museum, and community, physical and virtual.

We envision that our mural-making project will be implemented within after-school or in-class programs as supplementary, replacement, or enrichment units for students of grades four through eight. This is an interdisciplinary project since the mural can represent a topic, chosen by the instructor, from language arts, science, social studies, or art.

Our experimental design includes fourteen questions. This learning assessment was administered after completion of the project to three subject groups— the user group of 24 5<sup>th</sup> grade students, the control group of 19 5<sup>th</sup> graders, and the benchmark group of 19 7<sup>th</sup> graders. Ten of the fourteen questions of the learning assessment are graphical, algorithmic, and social discourse problems. The graphical problems ask the student to draw or indicate his/her answer non-numerically. The algorithmic problems require more abstract symbolic representation. The social discourse problems are open-ended and designed to assess flexibility in the subjects' understanding and application of the math concepts. One question focuses on artistic composition to measure whether our project promoted this area. Four of the fourteen questions survey the students about their attitudes about math and museums.

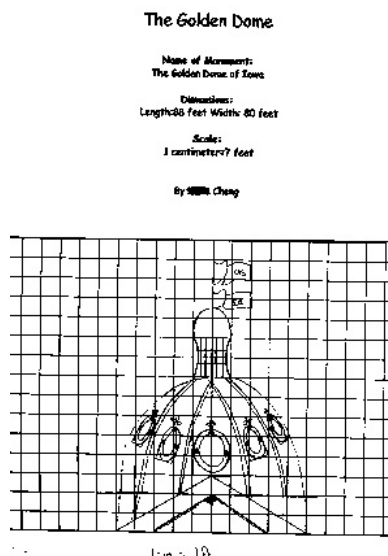
## **General Description of Tool**

The BIG IDEA mural-making project includes three major phases in various contexts. They are (1) the pre-museum introduction and artwork preparation in the classroom or after-school program site; (2) the museum experience; and (3) the implementation of the murals—physically on-site and virtually, online.

## 1. In the Classroom

We prepared two online curriculum components before interacting with the user group. The first is an introductory unit that includes materials for the teacher and/or project leader. This unit contains suggestions for subject content for the murals or large-scale artwork. Our curriculum in this area serves as points for departure or inspiration for the teachers. We keep the content open-ended so that the project leader can tailor it to his/her classroom's needs. The teacher chooses the content of the mural, which can encompass social studies, science, art, or language arts. We inform the teacher as to the process of The BIG Idea project and the mathematical concepts that are covered in our activities.

Between late March and May 2002, we participated almost weekly in the user group's classroom, meeting with teachers and implementing a curriculum to prepare the students for the primary mural-making simulation activity. Because a typical 5th grade curriculum includes individual 'state reports' as a core social studies unit, the teacher Sue Oberg, chose state landmarks as the topic for her class's mural. The students selected the state they wanted to study and found an interesting physical landmark during their research activity. As homework and classwork, they determined the **size** of their respective landmark structure, which required varying degrees of math activity and complexity. For example, if they chose a vertical structure like a tower or statue, often they were given the height but not width. They then needed to perform **measurement operations to estimate** its overall size. The students then sketched with paper and pencil their landmarks on **gridded paper, to scale**. The following is an example of this activity:



The next session took place in the school's computer lab. The students drew their landmarks again, this time on iMac computers using KidPix, a simple drawing software program. They focused on drawing the landmarks in correct **proportion** with details such as windows in **correct scale**. This class (and all classes within Glorietta School) has worked weekly in the computer lab since Kindergarten. The technology teacher, Tre Frane opted to use KidPix for the students to recreate their landmarks since most students were both comfortable and competent using it.. Furthermore, KidPix is a bit-mapped format that would provide the correct format of graphic imagery to be utilized in the final mural-making activity.



The next activities involved learning about large-scale artwork and beginning to experience what mural-making was all about. In the computer lab the students participated in an activity where they experimented with combining a group of landmarks into one composition. They each selected five of the class's images to produce a 'mini-collage' document. They were concerned with maintaining a **generally true scale relationship** between the forms and in making a **pleasing composition**. After this computer-based activity we returned to the classroom for lessons.

We participated in a presentation and discussion of large-scale artwork via a website called 'An Illustrated Survey of BIG IDEAs' created for this project. The website is a pictorial introduction

to five topics of large scale art: including frescoes, the Mexican muralists, and urban murals. In addition to the works of art, simple notations (presented in rollovers) about **scale, composition** and theme are available for the students.

The students worked in groups of three for a period of twenty minutes exploring the website. Then we reconvened as group for discussion and reflection. Our discussion included the **scale and impact** that large murals have.

While referring to an art book of Americana we also discussed **artistic elements such as composition**, placement of titles, and color palettes. During our fifth class session another important mathematical component of the mural-making project was resolved. The class needed to find the location where their final mural would be installed and displayed. They had to come to consensus about where they would most like to view it and, then, procure administrative approval. During our participation we **measured the location**. Then in the classroom we discussed the **general shape and proportion** of the mural and what **implications its shape** may bring to its composition. The students settled on a title 'Landmarks Across America' and a specific background and border- elements which would guide the final layout effort.

The final classroom activity was a discussion of the museum exhibit space. In a final version, the mural-making simulation would occur in a custom exhibit space within a museum. Since our user-testing would occur in the iRoom (interactive room) at Stanford and not a museum, the designers built a **scale model** of the exhibit space to present and discuss with students. The researchers discussed the size of the exhibit space with human figures made to scale to help the students understanding of scale and **ratio** in three-dimension.



Discussion of the exhibit model

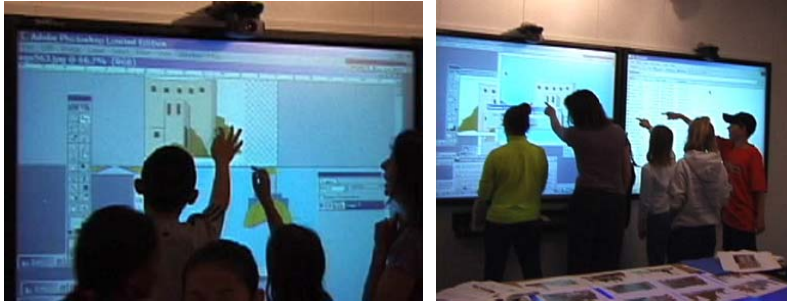
## 2. The iRoom mural simulation- User Study

On April 27<sup>th</sup> 2002, fourteen of the class's twenty-four students traveled to the Stanford campus to test our design using the three SmartBoard touchscreens in the iRoom. The iRoom (interactive room) is part of the human/computer interaction program at Stanford. Several different types of interaction scenarios are installed within the room to aid in experimental research and in the development of effective interfaces. The features of the iRoom that our user study took place in are shown below-- three adjacent touchscreen 'SmartBoards.



The iRoom in the Gates Building at Stanford University

The goal is for students to produce a digital simulation (in scale) of their mural by dragging, dropping, and manipulating their individual landmark images. The students worked in small groups for almost two hours on the three screens collaborating on different tasks, bringing the pieces into the middle board for final adjustment and **composition**. Guided by us, (a museum staff member or artist in the real exhibit) the students participated in a dynamic activity of **enlarging**, manipulating and simulating their artwork. For example, while the group on the middle workspace was adjusting the placement of landmarks on the overall artwork, students working on the mural title experimented with typestyle and color of the typography before dragging it with their finger to the main screen.



the user study in the iRoom

We observed collaborative efforts among the students and the working groups as they constructed their class project. The activity was full of open-ended exploration, discussion, and discovery as the students worked in new ways with technology.

After the user study, the researchers developed an experimental design to assess the learning of the concepts of scale and proportion. Questions that we sought to answer were ‘did they and could they comfortably use the language’ of these topics, so we designed some of the questions to ask the students’ approach to solving the problem. Then, could the users go beyond the concrete drawing and gesturing to enlarge or deal with proportion, to make judgments about relative scale in an environment (would this be noticeable?), or with an object (computer screen size). Finally in getting more abstract, we sought to see if our users could link numerical symbolic processes to the types of problems they had encountered.

### **3. Implementation in the community**

To finish the mural meant completing a digital Photoshop file which was to be sent to a company for full-size output in vinyl. We returned to Glorietta School a few days later to finish the project in the computer lab with the class. The final full-scale mural arrived in Orinda two weeks later for installation in the main school office.

## **General Description of Experiment**

The goal of our learner test was to determine if our participants learned about scale and proportion through participation in our project design. We wanted to determine whether the

students demonstrated strong conceptual knowledge about these important mathematical topics. We developed several types of questions to assess the learning.

The design consisted of fourteen questions. The first ten were content focused. The last four surveyed student attitudes toward math and museums. We designed the math assessment problems to include a wide spectrum of problem types and to appeal to different levels of learning. They ranged from graphical concrete problems in which the student was asked to draw or indicate the answer graphically to non-graphical, algorithmic problems. The assessment included a few multiple-choice questions because we anticipated that there would be some students who are inarticulate verbally but understand the concepts or procedure for problem solving. And, for students who would benefit by some scaffolding, a multiple-choice problem could help guide them. Some problems required computation while some were open-ended, asking the students to describe how they would go about solving the problem. Overall we sought a variety of questions that represented proximal and distal outcomes: some that were very similar to the activities and subject matter that the users encountered with our curriculum and some that would seem to require additional intervention or extrapolated reasoning beyond what they encountered. In addition, we included a question about visual composition of a photograph to see if our users knew more about the artistic qualities of mural-making than our other experimental groups.

*See Appendix 1 for the experimental design*

The learning that we measured was of the underlying mathematical concepts of scale, ratio and proportion. We did not assess whether students learned other content concepts from other subjects. The assessment is very important to see if the math actually got through to the students or got buried in the artistic and/or collaborative activities. In addition to assessing the math learning, we included some questions that asked the users their opinions as to how much math they thought the project included, whether they liked math, and whether they thought math was relevant to their lives. If it is shown that students are learning math while undertaking this artistic and creative activity, our mural-making project may be adopted by a school district or classroom, especially in these times of budget cuts when arts programs are often among the first programs to be eliminated.

## **Methods**

### **Subjects**

The student group closest to our informant user group was another Glorietta School fifth grade class. This class has the same math and social studies curriculum which includes individual state reports but without our intervention. Sue Oberg, our user group teacher, contacted the other two fifth grade teachers. One agreed to have us administer our assessment at the proposed time. The teacher was not familiar with our study.

We decided to conduct our experiment with a seventh grade class as a benchmark. There is only one middle school in Orinda; Glorietta and three other elementary schools feed into Orinda Intermediate. We contacted the math department chair and he directed us to a seventh grade math teacher. We requested a non-accelerated seventh grade pre-algebra class. The teacher offered us a choice of two and we selected the class with the most convenient schedule. We expected that the seventh graders would be competent at the content included in assessment. All of the topics are covered in a more traditional manner in sixth and seventh grade textbooks.

### **Procedural Design**

The assessments were administered to the three groups of students on May 23<sup>rd</sup> (three weeks after the iRoom activity) by the project designer. The students were not given a time limit for completing the fourteen questions. The students in each class finished in ten through thirty minutes with the estimated average of twenty minutes. There was no discernable difference in the time it required the seventh graders versus the fifth graders.

Both the control group (5th grade- non-users) and the benchmark group (7th graders) consisted of nineteen students. May 23<sup>rd</sup> was the Friday before Memorial Day weekend and four students were absent from each class. The user group had full attendance of twenty-four students.

### **Coding**

The sixty-two assessment forms were first analyzed in a cursory overview and then in a detailed manner to note reasonable answers. Since many of the questions were open-ended and looking

for conceptual understanding and not a numerical answer, the researchers were sensitive to interpret whether the intention of the response showed a feasible approach to the problem solving.

## **Results**

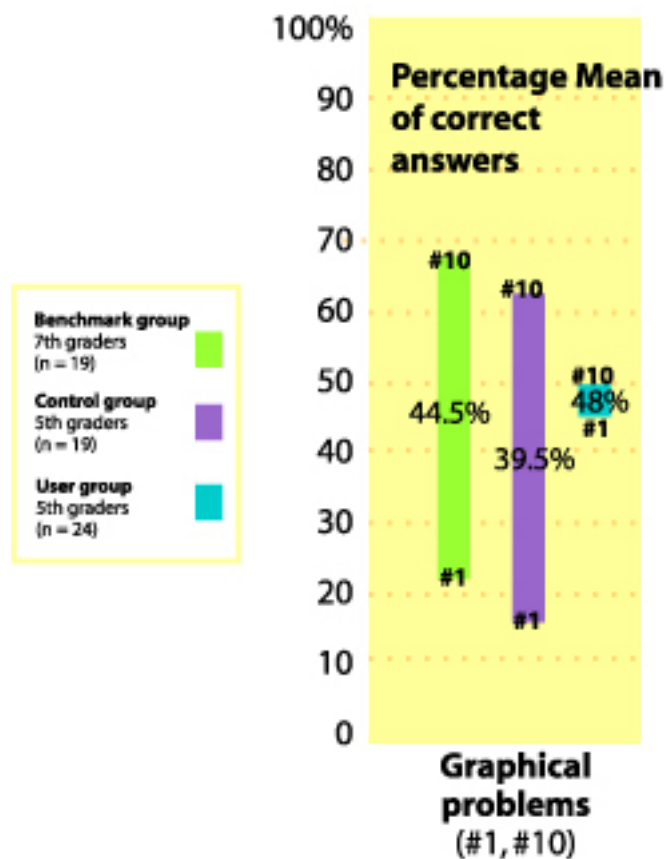
### **Overview**

The fifth grade user group outperformed the other fifth graders and the seventh grade benchmark group in all of the math categories. The seventh graders did considerably better on the composition question than either fifth-grade group. From the attitudinal questions about attitudes towards math, we found that the seventh graders had less interest in math than the fifth graders. There was no discernable gender difference in any of the questions.

### **Details and Graphs**

After reviewing our data, we decided to eliminate the responses to two questions. Many students misinterpreted the wording of questions #7 and #8. They misunderstood the meaning of ‘enlarging to 110%’, many students believing that it meant that the measurement was more than doubled. With that misunderstanding they could not respond to the question appropriately. In question #8 about the proportion of a computer screen, the wording: ‘will it fit on the screen without being stretched or squished’ many students didn’t understand that we were asking for them to enlarge the image. The students simply responded, sure it will fit—it’s smaller than the screen, thus avoiding the concept of proportional enlargement,

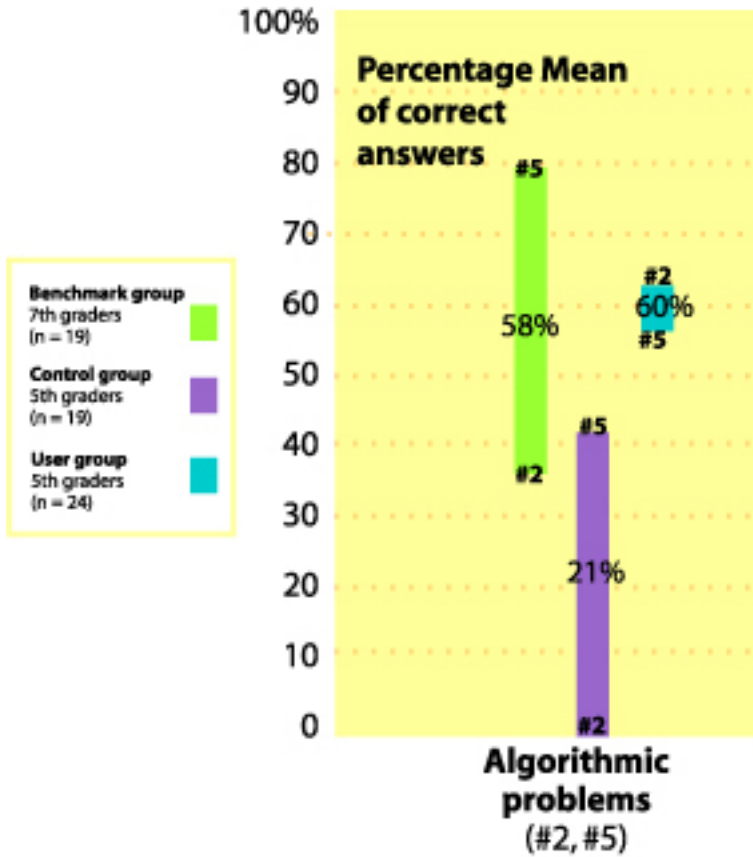
We grouped the remaining questions based on the type of problem- graphical, algorithmic, or demonstrating social discourse. Questions 1 and 10 were both graphical problems. That is, they asked the student to draw or indicate his/her answer on the provided grid or diagram. Graph 1 shows the results of the three groups. The control and benchmark groups showed relatively poor results on one question (#1) and relatively strong showings on the other, (#10). The mean percentage of correct answers is shown in the middle of the respective color bars. Our user group, shown in blue, had very little variation in performance on the two questions. Their mean percentage correct (48%) was higher than either control group.



Graph 1

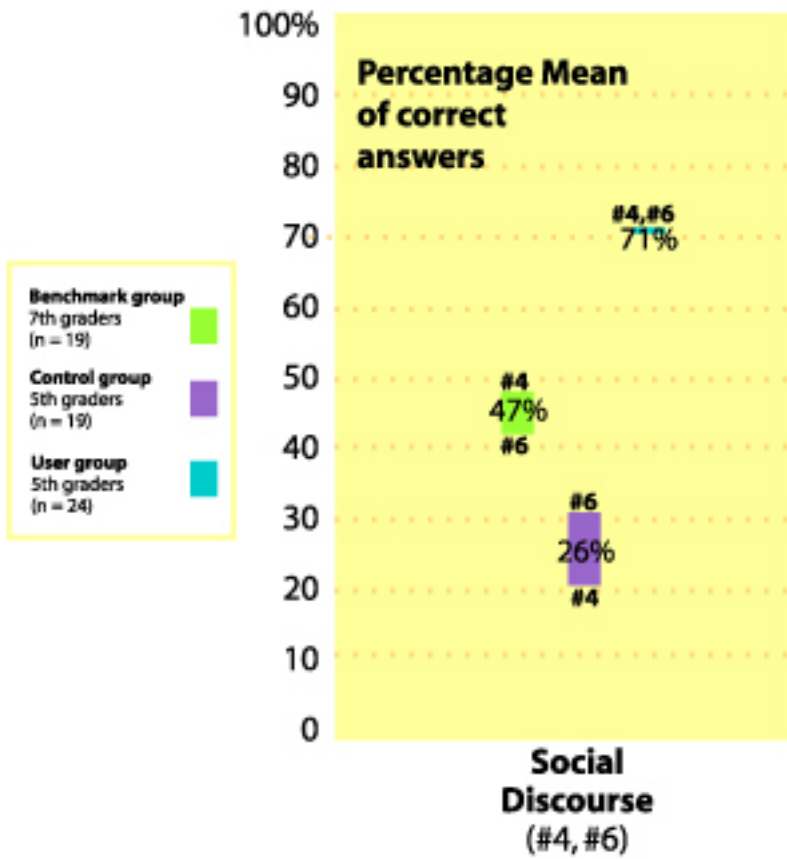
Graph 2 shows the results of questions #2 and #5. which are both algorithmic problems. They ask the student to tackle the problem using more abstract symbolic representation. Again, the control and benchmark groups showed a wide variation in success with the two questions. Not one student of the 5th grade control group successfully solved question #2, which is typically covered

in 6th or 7th grade math textbooks. The user group however, answered an average of 60% of the algorithmic problems. Again their variation between the two problems was slim. And again, their average exceeded that of the 7th graders and the other 5th graders.



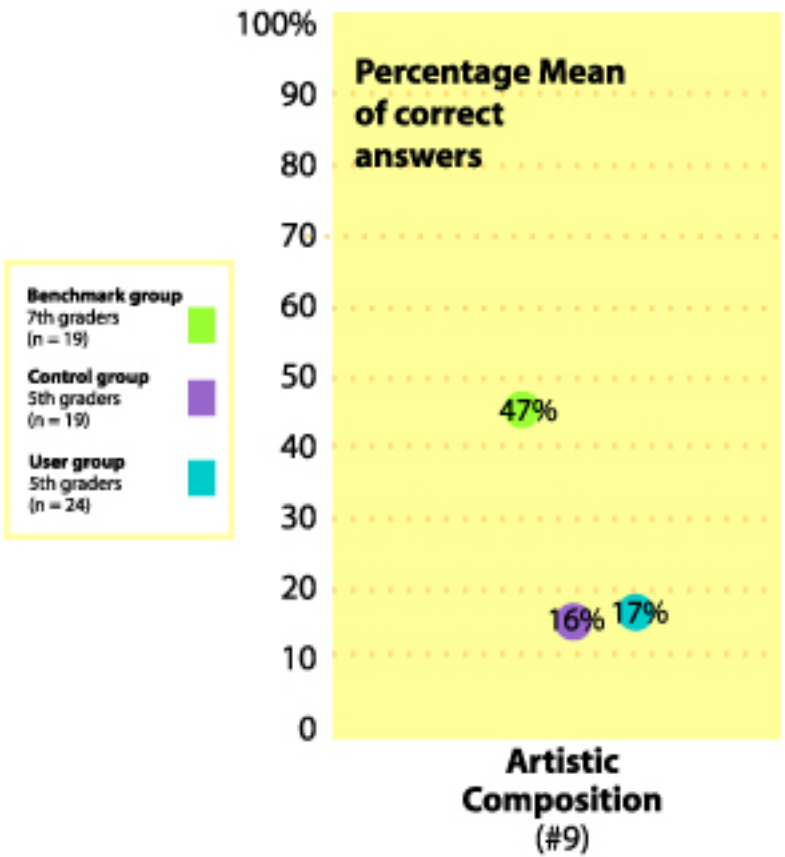
Graph 2

A third pair of problems, (#4 and #6) are termed 'social discourse' and are designed to assess some flexibility in the subjects' understanding and application of the math concepts. They are open-ended in that they ask the student to write how they would go about solving this problem, as opposed to requesting a numeric answer. Graph 3 shows the findings for these problems. The user group out-performed the other two groups by 24 - 50%.



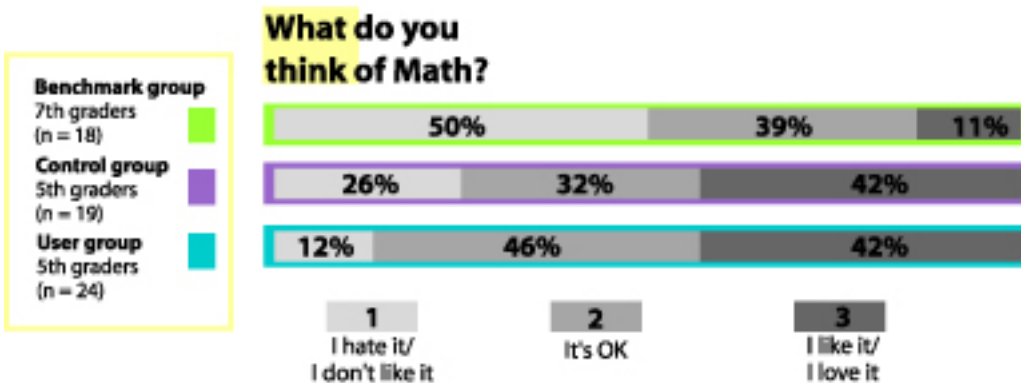
Graph 3

Finally, we included one question that asked about artistic composition. Two similar photos were displayed and we sought to see if the students could identify which one was better compositionally. In this case, all of the 5th graders, including the user group, performed poorly. The 7th graders did considerably better.



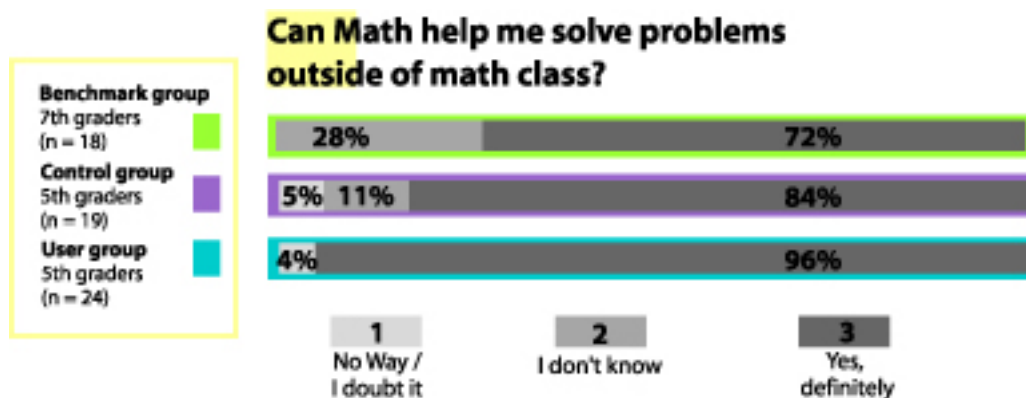
Graph 4

In the questions surveying the students' attitudes, two issues are notable. In line with the prevalent research, the middle school students asserted that they dislike math more than the 5<sup>th</sup> graders (see graph 5). Only 11% of the benchmark group stated that they like or love math as compared to a significant 42% of the 5<sup>th</sup> graders.



graph 5

Regarding the students' perceived relevance of math in their daily lives, the vast majority of the experimental groups definitely believed math to be vital and important (see graph 6). The user group is the most adamant at 96%. There is however an indication that perhaps that belief is waning as there is more than 20 percentage points difference between the older and younger students.



## Discussion

The user group showed impressive results in the math problem solving. The fact that the variation in their scores was much narrower than the other groups suggests that they learned the topics deeply and were able to successfully tackle these concepts in a variety of forms and representations. The most striking instance of this is found in Graph 2. Question #2 is an algorithmic equation that is typically covered in a 7<sup>th</sup> grade traditional textbook. Not one student of the 5<sup>th</sup> grade control group guessed (it was multiple choice) correctly. Thirty-five percent of the 7<sup>th</sup> graders were correct. But, 62.5% of the user group had the correct response. So while we would not expect the 5<sup>th</sup> grade user group to be able to construct the algebraic equation themselves, a majority of the students were able to connect the concepts and identify which of the three answers seemed to be the right one.

The user group did better on the social discourse questions than the other groups. The results of question #4 are also worth noting. Seventy-one percent of the students had a reasonable answer to a question that required judgment based on understanding, not procedural knowledge. The other two groups scored 47% (benchmark) and 21% (control). It is difficult to know how to attribute this difference. However, the constructivist nature of the activities that were part of the project may be responsible. The students collaborated in small groups, discussed the concepts within the classroom context and conducted personal explorations (with their mini-collages) as part of their experience. The type of problem solving skills they cultivated in the activities could come into play when being asked to 'put it all together' in the assessment question.

The artistic composition question was problematic. It was deemed difficult by adults and children who reviewed it. So it is difficult to ascertain whether the students did not learn some basic fundamentals about composition or whether the question was unreasonable. However, the fact that almost half of the 7<sup>th</sup> graders did get it correct seems to suggest that the 5<sup>th</sup> graders did not learn it. In future development of the curriculum we recommend more emphasis, time, and effort should be placed in this area. Also, there may be a developmental advantage that an older child possesses relating to visual comprehension. This issue is worth further study.

The attitudinal questions were consistent with studies cited earlier in this paper. Student attitudes toward math seem to decline as they work their way through middle school. There were no significant differences in the enjoyment of math with 5<sup>th</sup> graders who participated in our project vs. the group who did not. In contrast to the research, however, we did not find any statistically significant differences in the responses comparing boys and girls either in performance or in attitude.

## **General Discussion**

The BIG Idea mural-making project addresses the need for students to have more collaborative problem solving activities to apply skills learned in the classroom. We expect that these activities will improve the performance of students in mathematics and hope that these activities will also sustain and increase their interest in math. Throughout our project, in the classroom, interactive

room, and back in the school community, we emphasize the process of learning rather than mere products of learning.

The primary challenge we have in continuing the project is the technology, specifically the software. We do not believe that it will be difficult to develop a suitable graphics program for the students. However, this assessment did not broach the role of technology in the learning, an issue we are very interested in. In our iRoom user study, the Photoshop technology interfered with the activity. The collaborative interaction, spontaneous problem solving were seriously hindered by a buggy, cumbersome software program. So, as the appropriate software is being designed, it is important to conduct evaluation of the interface and to assess the learning that may or may not be attributable to the gesture based activities.

All in all, the results are very encouraging. However, there are clearly some improvements that should be made to the assessment tool when administered the next time. The two questions that we eliminated because of students' miscomprehension of the wording should be revised. It would be worth continuing the study also to see if the results are consistent. The fact that there was no gender difference is pleasing yet curious, as it conflicts with current research. Overall, we believe that the development of a multi-disciplinary program for making art, using new technology yet also learning important math concepts is an innovative and worthwhile endeavor.

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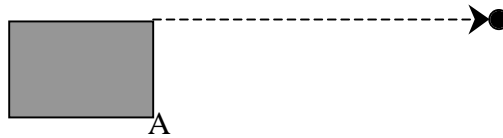
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<http://www.nae.edu/>

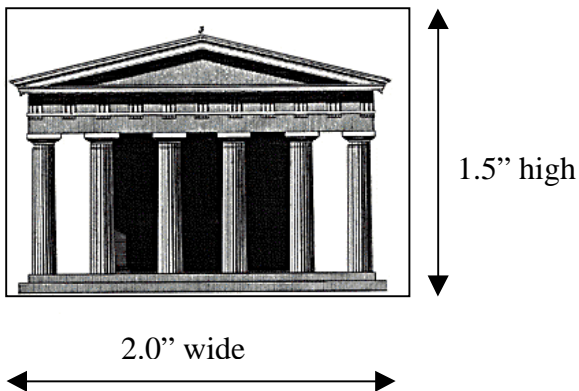


**Part A: Circle your final answer and please show all of your work.**

1. A student creates a computer drawing in the shape shown here. She then wants to enlarge it to the width shown by the black dot. Where will the bottom right corner will end up? **Draw a dot to show where it will be.** (“A” shows the bottom right corner before enlargement).



2. This drawing needs to be enlarged to fit a layout space of 5 inches wide. What is the correct expression to determine its scaled height (x)?

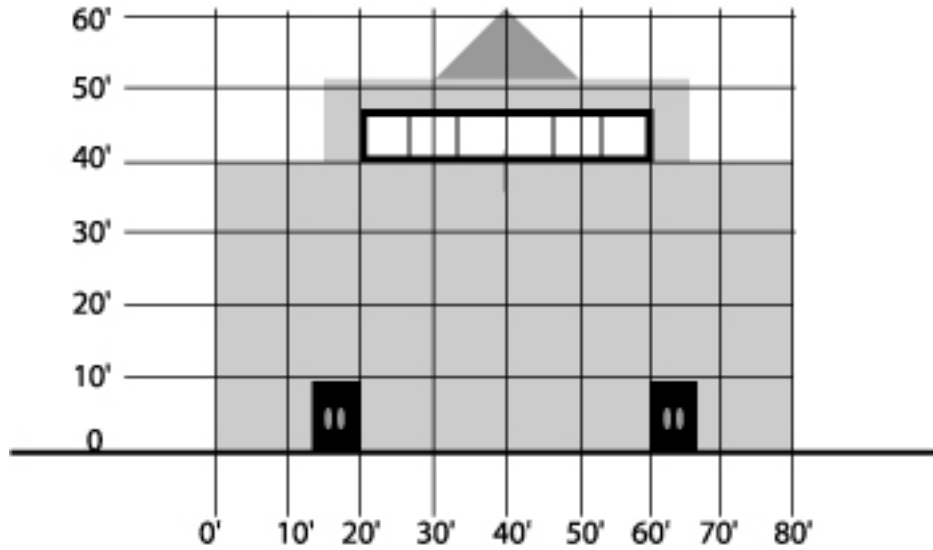


Question 2:

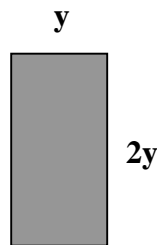
A:  $\frac{2.0}{5} = \frac{x}{1.5}$

B:  $\frac{2.0}{1.5} = \frac{5}{x}$

C:  $\frac{1.5}{5} = \frac{x}{2}$



3. Above is a drawing (called an elevation) of the front of a new community center building. A collaboration of local artists has created a tile mural that they plan to install on the front of the building. If the mural is shaped like this, with the height twice as tall as the width, what is the largest **height** it could be?



Answer 3:

\_\_\_\_\_

4. Refer back to the diagram above. While the tile mural is being designed, a billboard advertisement that is 10' wide by 10' high is posted on the front of the building. Do you think it is noticeable? Why/why not?

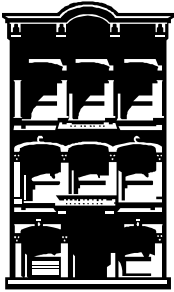
\_\_\_\_\_

\_\_\_\_\_

5. An official state flag has the width to length ratio of 1 : 2.0. If you want to make an official US flag that is 5.5 feet wide, what will its length be?

Answer 5:

PART B: Short Answer- complete sentences not necessary



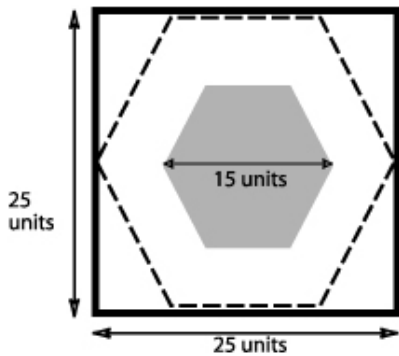
Question 6. Here is a building front. Its actual height is 44 feet. How would you go about calculating its width?

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Question 7. A student working on a brochure layout wants to make the gray polygon shown in below fit tightly within the square, as shown with the dotted line. If he increases the **scale** of the polygon to 110% will he be successful? Why or why not?



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Question 8. Your computer screen measures 640 x 480 pixels. You want to design a web page using a full-screen photograph for the background that is currently 320 x 300 pixels. Will it fit without being squashed or stretched? How do you know?

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A

Question 9. Which of the photos on the left has the **worse** layout or composition? Why do you think so?

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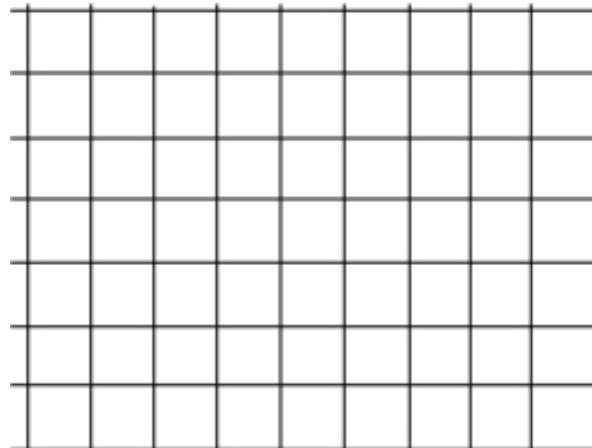
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B

Question 10: This star should be 5 units high. Draw it to scale on the grid below.



**PART C: Your Opinions: Circle the number that represents your feelings:**

Question 11.

What do you think of Math?

- 1: I hate it
- 2: I don't like it
- 3: It's OK
- 4: I like it
- 5: I love it

Question 12.

Can Math help me solve problems outside of math class?

- 1: No way
- 2: I doubt it
- 3: I don't know
- 4: Yes
- 5: Definitely

Question 13:

- 1: No way!
- 2: Not much

Do you like going to museums?

Question 14:  
What is your gender?

1: Girl
2: Boy

Thank you very much for completing this survey!

*For Mrs. Oberg's class ONLY:*

Question 15:

The Mural-making activity had \_\_\_\_\_ in it.

- 1: A lot of math
- 2: A little math
- 3: No math