# Creating Art as a Catalyst for Making Meaningful, Personal Connections to Mathematics

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## Abstract

Engaging in mathematically-inspired art projects in the mathematics classroom can encourage students to make meaningful connections between mathematics and their personal lives – connections which are unlikely to occur in a traditional mathematics classroom. Our view is that making these meaningful, personal connections plays a role in making more memorable aspects of the processes of mathematics learning. This report explores connections undergraduate students found between mathematics and their own lives, as realized through mathematically inspired art projects.

## Introduction

The prescriptive nature of the traditional mathematics classroom, where students are assigned problems for which they must determine a conventional solution, does not allow sufficient room for, and certainly does not encourage, students to develop personal meanings for their mathematical activity beyond their classroom experiences. Instructors often strive to make connections to the overall lives of their students by articulating the purpose and meaning of certain mathematical ideas. These connections, however, are often artificial and forced, with contrived story problems taking center stage. When students do find personal meaning in a mathematics class, it is often tangential to the mathematics – for example, a student may be fond of a particular number as it once served as their number on an athletic team.

Introducing art projects, for which there is no pre-conceived or "correct" solution, into the mathematics classroom, can allow students to explore broad personal meanings woven through their classroom mathematical activity. Rather than being pushed to accept stipulated meanings provided by instructors or textbooks, students can develop their own expressive realizations. In this preliminary report we analyze students' written and video reflections focused on their individually created art projects in a Foundations of Geometry course with an emphasis on Projective Geometry.

## Course and Art Project Descriptions

In traditional mathematics textbooks, applications for mathematical ideas are typically presented at the very end of a section or held until the final section of a chapter. Students are expected to apply the mathematics they have learned, and perhaps gain insight into the power and relevance of mathematics. In inquiry-based learning [1], as well as in realistic mathematics education [2], applications are used as a way for students to motivate or reinvent mathematical ideas. Whether applications are presented at the beginning or the end of learning mathematical ideas, applications are defined by the curriculum. In our undergraduate Foundations of Geometry course however, we extend the notion of what constitutes a mathematical application by engaging students in creating individual art projects. This alternative sense for what a mathematical application is, is less predefined by the mathematics curriculum and is instead inspired by students' imaginations, emotions, and interpretations.

In our course, students learn synthetic and analytic aspects of Projective Geometry through the use of physical devices and dynamic geometry software. Two of the primary tools students use are a physical and a computer version of what we call "Alberti's Window". The physical Alberti's Window consists of a 12x12 inch piece of clear acrylic that stands perpendicular to a table and a moveable eyepiece through which the students view drawings or objects (Figure 1). Students look through the eyepiece and trace on the window with a marker the drawing or object seen in front of them. The computer version of the window consists of a sketch in the dynamic geometry software Geometer's Sketchpad (GSP). This sketch shows a superimposed version of the physical Alberti's Window, where the tabletop plane is rotated up onto the vertical plane (Figure 2). Students construct an image on the tabletop plane then perform a transformation that results in the projection of the image onto the vertical plane. In addition, as these images are dragged to various locations on the screen, the projections move accordingly.

Twice during the course, students use the GSP version of the Alberti's Window to create a visual pattern or scene based on projecting geometric figures. In this way, the use of a mathematical instrument [3] to explore aspects of Projective Geometry gets extended to an artistic instrument, much like a paintbrush or a chisel. The intention of this project is for students to use the techniques of projective geometry for the sake of art creation. The result does not necessarily look like a canonical image of projective geometry. Thus while each design is required to fit within a 10 in. x 13 in. frame and include projected elements, other restrictions are not imposed. In describing how she created her design, one student stated, "I made a circle and then took a projection of that circle. I kept taking projections of the projected circle… I then moved my eye distance up past the baseline so that I could get the projected circle outside the original circle I began with. I wanted to make a circle within a circle, and knew that I could do that by projecting my original circle and then moving the eye distance." Stencils of each student's design are cut using a Craft Robo Pro, and students use the stencil in conjunction with an airbrush to paint their design in any way they desire.

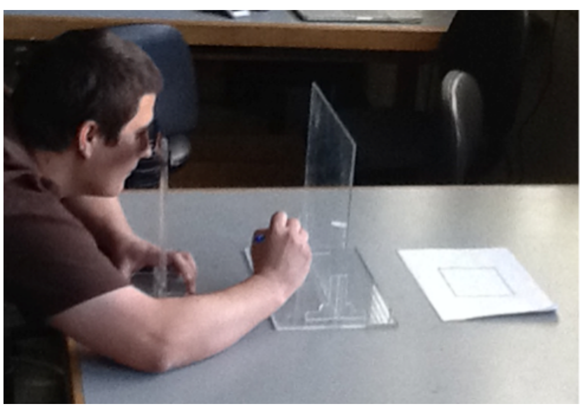

**Figure 1**: *Physical Alberti's Window*

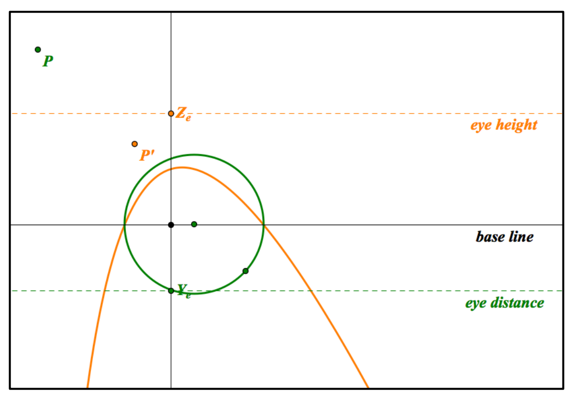


**Figure 2**: *Geometer's Sketchpad Alberti's Window*

## Examples

Analysis of students' reflections indicate that, through their art projects, students often created pieces expressing diverse personal meaning. These personal meanings ranged across hobbies, religion, relationships, life interests, as well as everyday playfulness with shapes, colors, and occlusion. In this section we provide several examples for how students projected personal meaning into their art projects.

**Life Experiences.** Carla's design was inspired by an experience in which the meshing together of her classroom mathematical activity and her activity outside of the classroom became salient (Figures 3 & 4).

> "The inspiration for my design is based on a very important day in my life, the day I took maternity pictures for my pregnancy with my second son. I remember that the instant I stepped under the pier for my first shot and looked out into the ocean I immediately thought of

Geometry. I turned to my husband and said, "I know what I am going to do for my final project." The view was gorgeous, but what really captured my concentration was the horizon and how when under the pier you could easily see how the parallel lines created by the columns seemed to become diagonals that met at the horizon. This was important to me not only because it reminded me of the class lecture, but because it was my most important and first interaction with projective geometry. The class discussion on parallel lines and their projection, was at first mind boggling, yet the standing under the pier made the lecture extremely clear, something that I could truly never forget."

**Figure 3**: *Carla's painting, entitled 'The Pier.'*

**Figure 4:** *Inspiration for 'The Pier.'*

**Connection to other subjects.** As a chemistry major, Candace was frequently being questioned regarding her motivation for taking a geometry course. She used her art project as an opportunity to interconnect her interest in chemistry and in mathematics by creating an abstract piece representing water molecules (Figure 5). Candace's choice in color represented what people often associate with water, while her shading was chosen to bring forth the polarity and density of a water molecule. She notes, "I decided to do shading because the design itself was simple and I wanted to challenge myself. This can also describe the polarity of the molecule. The dipole moment is going to be directed to the bottom of oxygen. For visual effects I also decided to shade the grey part, which represents the hydrogen atoms, and I chose to shade the part not connected to the oxygen because that is where the atom would be more dense."

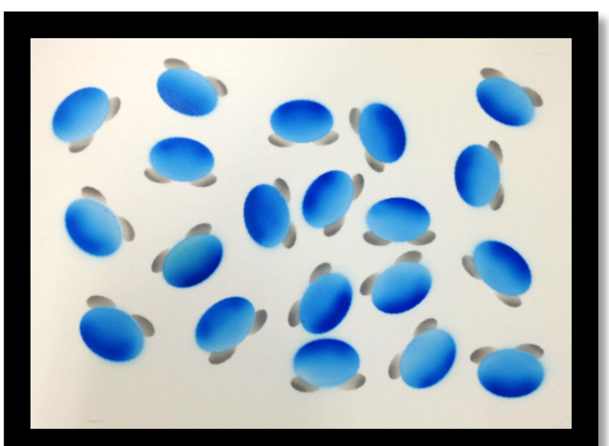

**Figure 5:** *Candace's painting, entitled 'Whatta.'*

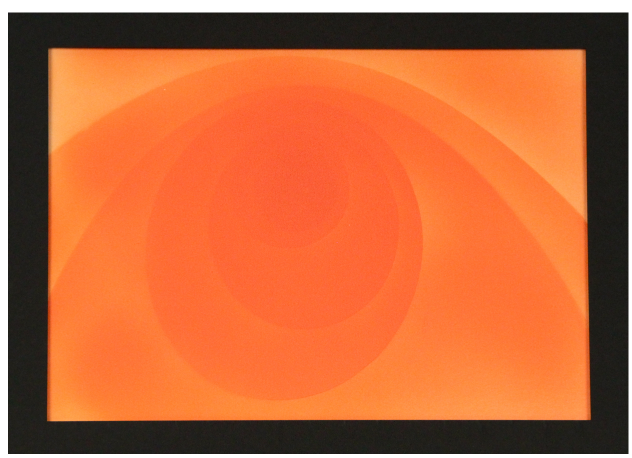

**Figure 6:** *Trisha's painting, 'Sunrise and Swirls.*

**Life passions.** Trisha is an avid dancer. She has an interest in spirals and they remind her of dancing. She wanted to create a painting that was spiral-like and showed depth dimension (Figure 6). Trisha writes in her reflection, “I have always liked spirals because they remind me of dance. In dance my favorite thing to do is turn. I love doing pirouettes (spinning on one leg). The spiral makes me think about dance and the movements of dance.” In addition to her interest is spirals and dance, Trisha made a connection to her passion for nature, “I chose the color orange because I also love nature and thought about a rising sunshine. Not only do I see a swirl image when I see my design, I also see a sun rising in the early morning. The movement of the sun rising sometimes creates different shades of orange.”

## Discussion

Our conjecture is that personal meanings play a major role in making more memorable aspects of the process of mathematics learning. While a student may not be able to remember every detail of their mathematical activity, by having a meaningful, personal connection to the mathematics, they may feel a deeper relationship to the mathematics, and in turn be able to evoke particulars of their mathematical activity or associated feelings. This is similar to the way in which an individual may not recall the exact details of an event, but may recall the melody of a song that was playing during the event. As the individual thinks about this melody, details of the event begin to come to the fore, such as the people, the smells, and the personal emotions. So too may personal meanings in mathematical artwork draw the student back to the mathematics classroom, calling to mind aspects of her previous mathematical activity. For example, Carla, as she thinks about her maternity pictures, may recall the beauty of the day, her feelings about her son, and the look of the pier, in ways that may have become inseparable from her memories about her mathematical experiences with projective geometry and how projected parallel lines meet at the horizon line.

In addition to encouraging students to establish meaningful, personal connections with mathematical ideas, we speculate that asking students to engage in open-ended artistic projects in a mathematics course can expand students’ notions of what it means to do mathematics. In the traditional classroom, students are assigned problems for which they must determine a solution to be assessed by conventional criteria. We think that part of practicing flexibility in mathematical work is to use mathematical instruments to open up surprising possibilities that students would be unlikely to achieve otherwise. For example, one student, Jerry, in trying to achieve a particular design, moved the eye distance line on the GSP version of Alberti’s Window above the baseline. This led him to wonder about a particular arrangement of the components of the physical window that he had not tried previously. While reflecting on creating his artwork, Jerry explored this new situation and worked to develop his understanding of how the projections would occur. Within the traditional from of school mathematical activity, and without having engaged in constructing his artistic design, Jerry’s exploration would have been unlikely to occur. By engaging in the open-ended art project, Jerry had the opportunity to become more flexible and imaginative in his mathematical thinking, thus reinserting some creativity back into his mathematical activity.

## References

[1] Cobb, P., & McClain, K. (2006). Guiding inquiry-based math learning. In K. Sawyer (Ed.), *Cambridge handbook in the learning sciences* (pp. 171-186). New York: Cambridge University Press.

[2] Gravemeijer, K., & Doorman, M. (1999). Context problems in realistic mathematics education: A calculus course as an example. *Educational Studies in Mathematics, 39*(1/3), 111-129.

[3] Nemirovsky, R., Kelton, M. L., Rhodehamel, B. (2013). Playing Mathematical Instruments: Emerging Perceptuomotor Integration With an Interactive Mathematics Exhibit. *Journal for Research in Mathematics Education, 44*(2), 372-415.