Integrating Statistical Data Analysis and Data Art Creation at the High School Level

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Abstract

A picture is worth a thousand words, especially when that picture represents data. This paper dives into a high school cross curricular data visualization project that engaged students in data acquisition, analysis and representation through data art.

Introduction

Florence Nightingale is quoted as saying: "Printed tables and all-in double columns, I do not think anyone will read. None but scientific men ever look in the Appendix of a Report. And this is for the vulgar public." [3] Traditional statistics curricula focus on tabular and graphical representations of data to convey information, but these courses do not emphasize articulating the results of an analysis beyond these methods to create emotional representations. These skills are often assumed to be developed in other domains such as the fine arts or language arts. Our goal was to integrate procedural data analysis skills with artistic expression. The goal was accomplished by providing students an experience that combined data exploration and visualization with the creation of a data art project.

We created a unit of study that provided students with the opportunity to create their own data art. An introductory lesson on data visualization through an artistic lens was created and delivered by our visual arts teacher. Following this, lessons on data collection, tabulation, and analysis were presented by the math teachers following the Advanced Placement Statistics curriculum. Students next engaged in a project that gave them the opportunity to merge these two perspectives together resulting in a data art piece developed collaboratively by the students. This process was modified during a second iteration the following year that resulted in several additional data art pieces.

Background

The students in both iterations of this project were enrolled in an Advanced Placement Statistics course and were seniors in high school. The project was implemented during the unit of study which focused on the analysis of categorical data. In this unit, students focused on using the chi-square distribution [4] to complete hypothesis tests for goodness of fit, independence, and homogeneity. Prior to beginning the project, students were taught basic principles of data collection methods and survey design. Students had also previously completed an Art + Design or visual arts course during either their freshmen or sophomore years.

Project Description

Introductory Lesson

During the first iteration, a guest speaker with expertise in data analysis was invited to speak to students about data visualization and give them background in how data can be used in different ways to evoke meaning

and emotion from the audience. Several different visuals were presented in which data were represented in traditional graphical formats. The students then engaged in discussions regarding the messages being conveyed. Several of the visuals contained embellishments or were presented atypically to provide students with the opportunity to consider different modalities of visualizing data.

In a following class, Lee, the visual arts teacher, provided an in-depth look at how data could be integrated into artistic expressions. Students were shown examples of art that incorporated data starting with Florence Nightingale's rose chart [2] and progressing to contemporary works. As each example was projected, students were asked the following questions: What emotion did the art illicit? What information was conveyed? What point of view was the artist trying to showcase? The resulting discussion showed students the variation in their answers, depending on how the art impacted them. The students also reflected on what made a piece more effective. For their assignment, students were required to explore data art by conducting their own research. Then, the student groups presented to the class a piece that evoked a strong emotion and discussed the connection between the data and the visualization.

Due to the pandemic, outside speakers were not permitted on campus for the second iteration of the project. Therefore, rather than beginning from the data perspective, the second cohort began from the artistic perspective with an introductory lesson provided by Lee.

Data Collection and Analysis

The project's first iteration focused on using data collected from the NC Museum of Art. Students collected data on the art pieces in the museum's collection such as artist, year, and country of origin. The class was divided into four groups of five students. Each group was tasked with selecting two aspects of the data in order to allow the data to be structured as a 2-way table. The primary topics of analysis included: the medium used, the continent origin, the time period, and the age or gender of the artist. Table 1 illustrates an analysis of the data collected by one group who decided to analyze the museum collection by the continent and gender of the artist.

Table 1: *Results of data collection from one of the student groups*

|	Male	Female	Unknown	Group
Australia	0	1	17	0
Africa	10	4	49	6
Asia	14	0	31	1
Latin/South America	15	5	187	0
Europe	361	58	54	44
North America	650	239	5	2

Once the data were compiled, the students were tasked to summarize the information visually and verbally using the skills learned in their unit of study in their statistics course.

For the second iteration, students were given a choice in their data topic. Each group created a topic of interest and used surveys to collect their own data by surveying a random sample of the student body and faculty. Therefore, each group in the second iteration of the project had created a unique data set to form the basis of their data art projects. The data analysis steps were implemented as they were the first year.

Data Art Construction

During the first year, Lee engaged the students in a discussion regarding how they could take their findings and create a data art piece that engaged the user in a meaningful way. Using principles of design thinking, she led the class in a collaborative ideation session on how to represent their findings artistically in a cohesive narrative.

The students decided to create four separate sculptures, one for each group's dataset, that would come

(a)

(b)
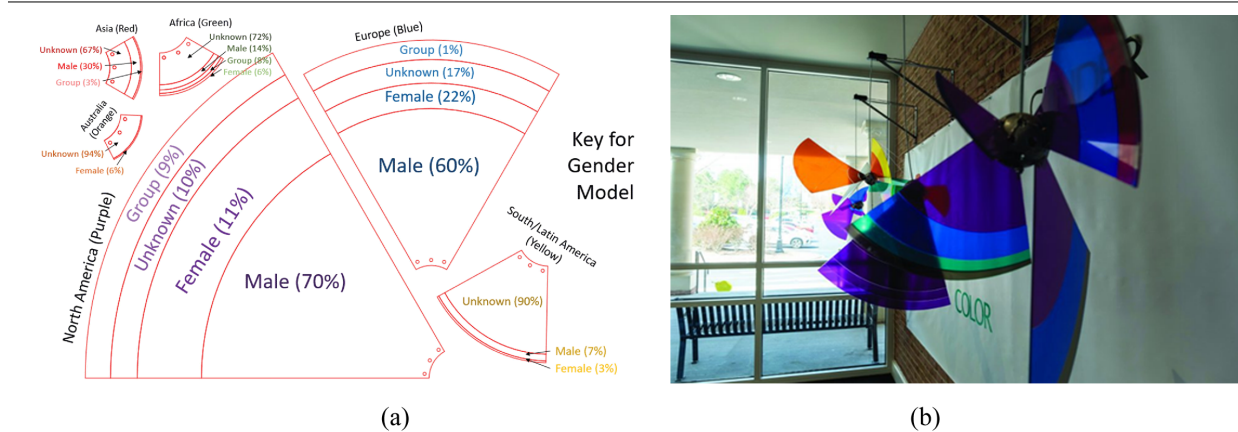
Figure 1: *(a) Data art product blueprint and (b) Final Data Art Product*

together as a cohesive unit. Inspired by Nightingale's rose graph, students decided to use pie wedges in which
the size of each sector would represent the proportionality of the specific qualitative union within the data as
shown in Figure 1(a). Colored vinyl adhesives were used to illustrate a different aspect of the data depending
on the groups' analyses as shown in the final product illustrated in Figure 1(b).

Students wanted each of these wedges to protrude out from a center source, creating a three-dimensional
prism of color. Lee had the ingenious idea to use silver spray painted whiffle balls and fishing line to affix
each groups' set of Plexiglass, using programmed holes from the laser cutter. The result was a radiant and
kinetic sculpture that flourished with the natural lighting of the space.

The second iteration of the project, Lee preselected the medium of the data art product to be vinyl
adhesives that would be used to create "stained-glass" installations. Students were provided with a wide
variety of colors and were tasked with developing 11x13 inch data art pieces that illustrated their data in a
creative way. Construction of the pieces was conducted over two 4-hour periods during which our entire
cohort of students could come to campus and work on their own time as needed. Instead of groups, students
worked in pairs, since the data art product was smaller in scale.

(a)   (b)   (c)   (d)
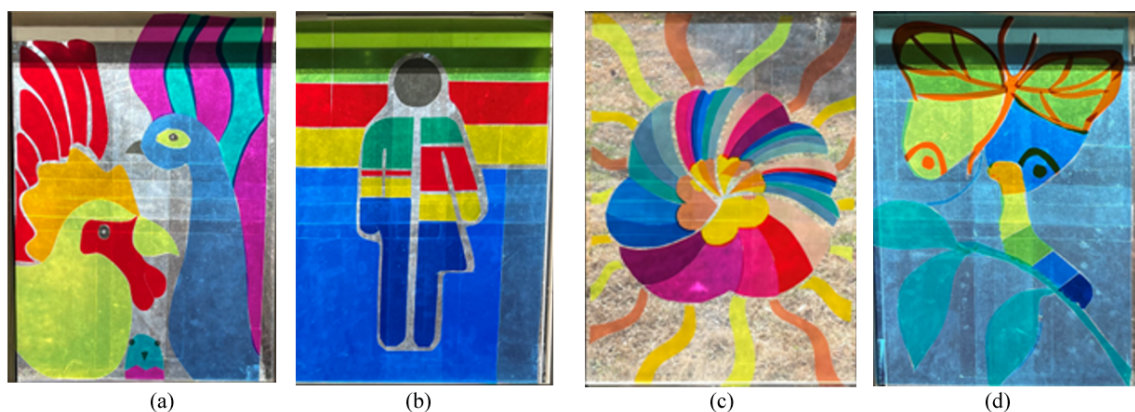
Figure 2: *Examples of the students' final product in the second year*

Each group created window panel coverings that depicted the data they had collected. Some students chose
a humorous path; for example, one group asked in their survey which bird was most favored from either
chickens, flamingos, or pigeons. Their data art piece depicts bird heads that were scaled by size based on the
survey results as shown in Figure 2(a). Another group displayed their data by using a human figure shown

in Figure 2(b). Their data divides the human body with the left side containing male responses while the right side are female. The color gradient within represents the grade level, and the background color gradient represents the faculty responses. The group that created Figure 2(c) analyzed responses to the question "Which of the following is most important to you when trying to create an empathetic question with another person?" The design was a flower pattern with petals colored and scaled to indicate responses. The last example is a group that asked whether the pandemic had made the person more depressed. This pertinent mental health data was represented with a developing caterpillar in Figure 2(d) representing student responses and a fully formed butterfly representing the faculty responses.

Summary and Conclusion

The first iteration of the project provided students with a meaningful way to communicate ideas beyond static tables and figures. Students were able to use creativity and mathematical skills to produce an eye-catching piece of art. Further, this data art piece was installed in a prominent location on campus and created conversation regarding the connection between mathematics and art [1].

Ironically, the pandemic forced the options available to the student to be limited, but resulted in providing the students more creative freedom. While the second data art installation was limited to two dimensions, students had a blank canvas to tell their story. As a result, the products themselves were more creative in nature and provided an outlet to exhibit the students' voices. The first iteration was confined to mathematical properties of scale and proportion in terms of geometric shapes, but the students in our second iteration took more liberty in how they applied these skills to their products.

The introductory lesson played a critical role in influencing student data art products. With the first iteration, the focus was on modifying traditional graphs, the result was a reinterpretation of an existing graph. With the second iteration, the focus was from the artist's perspective, the products were more varied and took on more nuanced traits. In future iterations, we will want to make sure that the introduction is focused on a voice other than mathematics as the intended outcome was to provide students with different perspectives. Our conclusion is that while both projects helped students appreciate data art and learn techniques of expressing data in more than a tabular form, the second version was more successful. The pieces the students created were more unique and were more customized to their data. The narrative expressed in the windowpanes achieved our goal of developing the students' abilities to communicate about data in meaningful ways.

Our goal was to increase students appreciation of both art and mathematics and understand how they could be used collaboratively to convey meaning and messages. Comments from our students indicate realization of this goal. Specifically, one student noted "I have always thought that math is beautiful, but I was excited to present it beautifully!" The end of course survey also reflected the impact this project had on our students. Students mentioned their data art products as one of the most substantial learning experiences of the course.

References

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