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Margaret Adams
South Georgia State College

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Three Creativity-Fostering Projects Implemented in a Statistics Class

Margaret Adams

South Georgia State College, Waycross, Georgia, USA

`margaret.adams@sgsc.edu`

Synopsis

Undergraduate students enrolled in a statistics class at a rural college campus developed three creativity-fostering projects: a statistics vocabulary crossword puzzle, word wall, and graffiti math art poster. Given math anxiety and apathy toward mathematics in general, it seemed important to find ways of increasing interest and overall engagement. Crossword puzzles were designed individually by each student, but for the vocabulary word wall and graffiti art poster, they worked in pairs. A grading rubric contained scoring components related to statistics content, compliance, and originality. Rhodes's 4P's Model [1] guided the study. The final products were classified into three categories: developing, satisfactory, and outstanding. Post-hoc opinion surveys revealed benefits of social interactions, enjoyment using art supplies while working with their hands, and engaging in a meaningful process, in contrast to just taking notes and doing online homework. Math class art projects in both traditional and more adaptive curriculum settings can be utilized as authentic qualitative assessments of content knowledge in addition to traditional assessment methods.

1. Introduction

When many of us hear the word “creative”, we perhaps visualize the image of a big, abstract art painting. The more colorful, vibrant and/or abstract, the more creative it appears. Creativity extends well beyond the domain of paintings, though, but most people probably haven't given much thought to this matter. Yet, every individual performs or encounters a creative process,

product, or event without even realizing it. Therefore, my definition of creativity focuses on originality since all people have the ability to be original.

Examples are endless, but to name a few, how about the creative ways we organize our shelves, our desks, our pantries? How do we stage a home going up for sale? How do interior designers turn simple spaces into those elaborate and inviting? Ever buy a car and notice the different sales tactics used to persuade you into the sale? Sometimes we rely on creative strategies to get the best matched price for a retail item. These are just a few instances of creativity in action.

In spite of rampant high-stakes testing, aren't there still creative ways we foster learning in our classrooms? Well, creativity is evident within all of us but is subject to stifling by the current educational system, whereby teaching to the test means less authentic assessment and declining creativity [2, 3]. Over the past 50 years, creativity has been declining in the United States. In spite of IQ scores rising, creative thinking scores have declined. This decrease among students in kindergarten through third grade was actually the most significant [2, 4, 3]. Many educators and administrators think that universities drive curricular and instructional decisions at all level, but show no effort to intentionally support creativity [5]. Current cohorts of pre-service teachers graduating from teacher education programs are products of a highly conformist education system, and through no fault of their own, do not possess some of the skill sets to foster creativity. It is unfortunate that creativity, originality, and authenticity are not encouraged in this modern educational era.

2. Rationale

At the beginning of the semester, students in statistics typically appear unmotivated, unmindful, and uninterested. Math anxiety is an obstacle to success, and past history with high-stakes testing stifles creativity. Many students neither expect a satisfactory grade in the course nor expect to encounter an assignment creative and enjoyable in nature. Over time, I observed that students doodled in notebooks during lectures, so I decided to capitalize upon these natural tendencies, hence, developing the three projects to foster originality and creativity. In short, to spark enthusiasm and improve grades, I staged a "creative" intervention.

3. Background/Literature Review

Creativity is the ability to produce new, unique and useful ideas which correlates with expertise, imaginative thinking skills, a venturesome personality and intrinsic motivation. Shalley, Gibson, and Blum [6] defined creativity as the production, conceptualization, or development of a useful idea that may include processes and procedures, and serves as a major component in all aspects of human progress including the exponential growth of technological advancements.

In order to be creative, an individual must have some original ideas. There seem to be two routes to achievement: conformity and originality. Conformists follow the crowd whereas the original thinkers champion a set of novel ideas that go against the norm but ultimately make things better. Examples of conformists are public school teachers unquestioningly involved with high-stakes testing and No Child Left Behind [7]. On the other hand, many public school teachers find ways to insert their creative ideas into the curriculum within the constraints of their district. Charter school teachers might have even more freedom and flexibility to teach content with passion without the pressure of No Child Left Behind. Instead of teaching geometry because it's required, an original thinker, for example, might challenge whether or not geometry is necessary to be taught.

In any event, originality starts with creativity by generating a concept, process, or product that is both novel and useful. In order to be original, radical risks and extending one's thinking beyond the day to day routines need to be taken. Original thinkers take risks in one arena while offsetting them with caution in another, and can ultimately make real world changes. To be original, something new has to be tried, which means taking on some measure of risk.

Teaching in the classroom requires a certain level of creative skill, whether overt and noticeable such as with using illustrative drawings in math lectures, or more covertly such as by offering suggestions on how to be resourceful with looking up information on certain math topics. Even though teachers often have to stick to scripted curricula, there are covert ways of importing some creativity without it being obvious, such as with enthusiasm in one's speaking style and smiling. Allowing students to work in collaborative groups on tasks to reinforce learnings is a more overt method of fostering creativity,

and it not only promotes deeper learning but develops the much needed social skills required for employment down the road.

In the classroom, creativity involves what students do as well as what teachers encourage in spite of the primary focus on high-stakes testing. Deviating from traditional homework assignments and designing interesting, hands-on tasks with wide open possibilities give students the chance to access various skill sets that remain otherwise repressed as a result of No Child Left Behind. The ability to be receptive to deviating from the traditional to the creative requires cognitive styles of flexibility and tolerance for ambiguity [8, 9]. Teachers and students alike need to extract these naturally occurring, human skill sets and foster them in them every day in the classroom.

Creativity helps prepare college students to become successful in future occupations which require innovative, collaborative teamwork and problem-solving. House [10] noted: “No matter how stable an industry is, today it is changing at least 10 times faster than 25 years ago,” organizations need to be creative to achieve high levels of productivity and to survive. “It is a question of innovate or die” [11]. Thus, creativity is a crucial capability that organizations need to foster in their employees; hence, in educational programs.

The theoretical framework for this study is Rhode’s 4-P’s model of creativity [1]. “Person” refers to physical constructs including personality, intellect, temperament, physique, habits, attitudes, self-concept, or value systems. “Process” includes different action-related constructs such as motivation, perception, learning, thinking and communication; “press” refers to the environment; and “product” pertains to the physical objects, ideas, systems, services, or processes [12]. Each of these components were involved in the creation of the crossword puzzles, word wall, and graffiti math art poster.

4. Design/Subjects/Methodology

Design: This was an explorative qualitative pilot study. All students designed their own crossword puzzles. The math word walls and graffiti art posters were done in pairs.

Subjects: A total of 62 freshman undergraduates participated who were enrolled in an introductory statistics course.

Methodology: Students were informed about an opportunity to pursue an additional homework assignment that would be fun and done with their friends. Samples were provided of each type of project and shown in person (Appendix A). Votes were collected and tabulated with yes/no about doing the projects. Unanimously all votes were in favor and so students and their partners wrote their names on a sign-up sheet. Being at a rural community, most students knew one another. Two students who did not have partners chose to work alone because they lived very far away and could not get together after class to meet with anyone. Flexibility was important in this case.

The following instructions were provided to students.

This semester, there are 3 special projects that count as homework assignments. You may work alone but it is recommended you work with one other person. A sign-up sheet will be provided so you can state your proposed topics. Each of the projects need to have a theme or framework, such as the history or founders of statistics, the notion of independence versus mutually exclusive events, probability and gambling, linear regression for business models, etc. and the framework must be clearly stated. A rubric for each is under construction and will be provided subsequently but for now, here is a description of the projects.

You can research various examples, but the project should reflect your own original ideas, and accompanied by a one page double-spaced typed paper explaining and describing how your project evolved, what sources you referred to and an explanation of what your project presents. Below are the descriptions.

1. Math/Statistics Crossword Puzzle – create a poster-size crossword puzzle of a single statistics topic or history of statistics. 15 word minimum.
2. Math/Statistics Vocabulary Wall – create a poster-size wall containing words from statistics with their definitions. A minimum of 20 words is required and designed in a way that definitions and picture examples are also attached. You can get these from your Vocabulary sheets.

3. Math/Statistics Graffiti Art Project – this can be a poster or other creative artifact that depicts prominent themes from descriptive or inferential statistics. Examples are history of statistics through art, statistics word and symbol art, probability in gambling, Central Limit Theorem, relationship of Chebyshev's Theorem to the Normal Distribution, binomials and tree graphs, relationship of the normal curve to that in calculus, the field of education, biology, psychology, information technology or other.

In addition to detailed instructions, grading rubrics related to originality were provided for each of the three projects so students would know what was expected of them. A sample of a crossword puzzle on cardstock with the answer key was brought to class and shown to everyone there. Similar examples were brought in for the vocabulary word wall and graffiti math art poster. Pictures of these samples were also posted in the course management system for future reference.

According to the rubric, blank probability-statistics vocabulary crossword puzzles with clues were required to be submitted on large decorative cardstock. Students were asked to draw the puzzle lines with rulers and attach the clue key separately, either on the back or on the front if there was room. Submitting a computer-generated version was not acceptable, as one main purpose of the assignment was for students to get away from the computer and use their hands. A minimum of 15 words were to be used from a particular topic in either probability or statistics. Table 1 contains the grading rubric for the crossword puzzle.

Large poster-size vocabulary word walls were designed, which utilized words from a particular topic in the textbook. Included were definitions with examples, sometimes underneath a flap of paper or sticky note. Fifteen words were required. Since the word walls could be used to teach others, definitions and examples were required. Table 2 below depicts the word wall grading rubric.

The third and most artistic project was to design a graffiti math art poster. Students used paint, brushes, paint samples from retail stores, corkboard, push pins, stencils, markers, colored pencils, pattern cutting machines, glue, glitter, melted crayons, and objects such as dice, playing cards and marbles. The magnitude of creativity on these ranged from using one set of colored

Table 1: Grading Rubric for the Crossword Puzzle.

Criteria	20 points	15 points	5 points	0 points
Words	15+	12-14	8-11	less than 8
Words specific to content area	15+	12-14	8-11	less than 8
Quality	neatly written and used ruler for lines	neatly written but no ruler used for lines	partly neat but lines appear uneven	total rush job on the fly; messy
Clues & Answers submitted	On or before due date & complete	1-3 days late and complete	4-7 days late and/or incomplete	not submitted or more than 7 days late
Submission	On or before due date	1-3 days late	4-6 days late	more than 6 days late

pencils to combinations of several artistic tools such as markers, paint, glitter and objects. Students were asked to place a title on top emphasizing the poster's theme, and they also were required to type a one-page paper describing their poster was all about, including why they chose the particular topic or theme. Table 3 on the next page displays the grading rubric for this project.

Table 2: Grading Rubric for the Vocabulary Word Wall.

Criteria	20 points	15 points	5 points	0 points
Words	15+	12-14	8-11	less than 8
Definitions	15+	12-14	8-11	less than 8
Poster Size	large poster	small-medium poster	8×11 cardstock	plain paper
Words specific to content area	15+	12-14	8-11	less than 8
Submission	On or before due date	1-3 days late	4-6 days late	more than 6 days late

Table 3: Grading Rubric for the Graffiti Math Art Project.

Criteria	20 points	15 points	5 points	0 points
Original Authorship	used markers, pens, paints, etc. (time commitment notable)	printed out personalized images and glued down	evidence of Googled images printed out or drew mundane image like “pi”	no evidence of original authorship or time commitment
Theme/Title	unambiguous theme and title presented	theme apparent, but title not on front	ambiguous theme, no title	clearly no theme
Quality	colorful, lots of packed detail	colorful, but hardly any detail	simple figure or graph, not original art	no detail, not colorful, not artistic
Poster Size	large poster	small-medium poster	8×11 cardstock	plain paper
Submission	On or before due date	1-3 days late	4-6 days late	more than 6 days late

5. Results

The final project products are classified into three categories: developing, satisfactory and outstanding. Noticeable differences across projects occurred, suggesting distinct levels of originality and compliance with rubric guidelines. Below are snapshots of several projects, including crossword puzzles, vocabulary word walls and graffiti art posters. Though actual scores on the projects are not disclosed, all of them were ranked according to rubric scores: column 1 outstanding, column 2 satisfactory and column 3 or 4 developing.

Figures 1, 2, and 3 display three examples of crossword puzzles.

An example of minimal effort appears in Figure 1. Although clues and answers are displayed, the content does not focus exclusively on statistics. Spelling errors occur and there are less than the required 15 words. Written on lined paper with pencil and squares drawn without a ruler, the rubric guidelines were not followed. Creativity is limited to jotting ideas down on paper without transforming them into a subsequently more polished product.

Figure 1: Evidence of not conforming to rubric criteria - Developing.

In Figure 2, hand-drawn lines and different colored words suggest more thought was given to the assignment compared to that in Figure 1.

Figure 2: Evidence of conforming to rubric criteria - Satisfactory.

This puzzle has the required number of words and was done on the correct size poster board, rather than on a single sheet of writing paper as with the previous example. While it is evident that the rubric was closely followed and that there was creativity involving the design and color, no clue key was provided to show what the statements were for down and across. Creativity was limited to the arrangement and colorful display of words.

In Figure 3, there is evidence of having followed the rubric guidelines. The purple circle cutouts constituted a novel idea of displaying the letters. The clues were supplied at the top. Even though there is no evidence of ruler use, overall, the original creative ideas in designing this crossword puzzle resulted in a unique product of exceptional quality.

Next, snapshots of some vocabulary word walls are provided in Figures 4, 5, and 6. These also appear in order, ranked from developing to outstanding. It should be noted that each of the projects involves some very interesting and original ways of displaying the words.

Figure 3: Evidence of following rubric criteria - Outstanding.

In the student project shown in Figure 4, while original creativity emerges with visual appeal, as the mean, median, and mode are, arguably, in the correct places on the skewed distribution, the axes are not correctly labeled. The x-axis appears numerical but the y-axis is, at best, nominal, and unrelated to the values on the x-axis. Also, the mean is a number less than 1, whereas the median is illustrated as a range between 1 and 3, while the mode appears as a range between 4 and 6. Although this is an interesting word wall showing the relationship between mean, median, and mode, it does not follow the grading rubric, which required 15 or more words.

Furthermore, as it is using the relationship out of its correct context, a skewed distribution with numerical values, this project resulted in a rating of developing.

Figure 4: Math Word Wall – Developing.

The poster in Figure 5 illustrates various colors, sizes and patterns. It contains a title and appears very decorative, containing all words from statistics. Since it does not contain definitions and examples as required, this poster received a satisfactory rating.

The word wall in Figure 6 is brilliantly designed into a pinwheel. Bright pastel colors in the background with dark letters made the project very attractive. The definitions that match the words are correct, and there are more than the required 15 words which suggests enthusiasm and enjoyment behind the scenes. The unique design of placing the definition beneath each word rather than covering it up with sticky notes makes this particular project receive an outstanding rating.

Figure 5: Math Word Wall - Satisfactory

Figure 6: Math Word Wall - Outstanding.

Last, the graffiti math art posters snapshots are displayed. Given these seemed to be the most favored of the three projects, additional snapshots of these projects are included.

The graffiti math art project in Figure 7 has interesting descriptive statistical figures but does not constitute graffiti art. There are no descriptions or labels on any of the figures. It appears that the topic may have been associated with displays of data. If that were true, then perhaps the same data could have been used and displayed different ways. A one-page paper describing the them was not included. Hence, this project received a rating of developing.

Figure 7: Graffiti Math Art Poster 1 - Developing.

Figure 8 depicts a unique attempt to display words with definitions in the form of graffiti art using ice cubes. The title does not represent a topic in statistics though. Moreover, within each cube the sub-topics don't all align. For instance, in the bottom cube, references are made to "skewed" with definitions while an adjacent side references a definition of "placebo".

In the middle cube, there is reference to “mutually exclusive” with “outlier”. No attachment describing the math art project was attached making it unknown what the ice cubes mean and how they relate to statistics. Difficulty exists with deciphering most of the hand-written entries and the overall combining unrelated topics within each cube, though definitions of each word were provided. The title could be more specific, containing words such as “descriptive measures” or “probability” and a description should have been provided to explain the theme and details. A generous satisfactory rating was given.

Figure 8: Graffiti Math Art Poster 2 - Satisfactory.

Below are four outstanding examples, presented together with the written descriptions.

Figure 9: Graffiti Math Art Poster 3 with Description - Outstanding. Part I: The poster

Figure 9 above presents words embedded within the first four letters of the word “statistics”, a procedure referenced in the student’s description below as “micrography”. Although a title is lacking and there are some repeated words, the project appears to have been thoughtfully planned and carried through, and contains the required attached description of the theme; see Figure 10 below.

This poster received an outstanding rating. More generally, the posters in Figures 9-10, 11, 12, and 13 were all beautifully done, and contained the required description of the theme. In addition to paint and markers, students glued on playing cards (Figure 12) and paper paint samples (Figure 13).

For my art project I put my own spin on the graffiti examples. In the examples only one word is used but I wanted to incorporate more. In my art class ~~the~~ last year we ~~did~~ experimented with an art style called micrography. For this style you use just words to draw your picture. I decided to use a combination of regular bubble letters and micrography. I chose to use a combination because I wanted the words to be more defined. To fill in my bubble letters which spelled Stat (which is the abbreviation for statistics) I use statistics related words. Some of the words are sentences that are from my notes giving instruction or definitions. I thought ~~that~~ that this was a unique way to combine art and what we've learned in class and through the homework. For the back ~~green~~ ground I didn't want to leave it blank. I decided to put math symbols scatter around in the back ground. I used plus signs, subtraction signs, multiplication, ~~signs~~ division, equal, and percent signs. I ~~thought~~ believe I achieved my goal of showcasing what I've learned through math words, and signs creatively in an art project.

Figure 10: Graffiti Math Art Poster 3 with Description - Outstanding. Part II: The description.

Given the depth of originality, thought, planning and time which resulted in conforming to the rubric guidelines, ratings of outstanding were in my opinion, fully justified.

After having the Calculus Math Art project behind us, it was much easier to create this project. We knew exactly what we wanted to accomplish, and how to accomplish it in the best way. We were able to make this project very personalized. We drew all of our inspiration from our notes and did not use Google as a resource because of the volume of information that we had available to us from our notes. We started by including major vocabulary words and topics from the notes such as probability, types of data, and mathematicians. Then we covered all of our graphs by including dot plots, bar graphs, histograms, pie charts, and many different types of curves. We covered skews on curves, the Empirical curve, and Cheby Chev's curve. We also included important formulas and equations. We included z-score, conditional probability, mean, standard deviation, as well as permutations and combinations. In addition, we added the binomial and Poisson distributions. We included factorials by putting an exclamation mark at the end of our title. This time we completely created our own graphics for our project in order to further express our individual creativity. We created two characters to represent our project. First, we have the Gaussian Cowboy created by utilizing the curve as a hat/sombrero, pie charts for eyes, a percent sign as a nose, and the symbol for sum as ears. Our other graphic is Venn the Robot. He was created by turning a proper Venn Diagram into eyes in order to bring to life our cute, metal friend Venn. In summation, this project was a great outlet for our left brain to shine. The creation process was very smooth and we were able to create a very well put together, colorful, informative project.

Figure 11: Graffiti Math Art Poster 4 with Description - Outstanding.

Our project represents the probability of a randomly shuffled deck of cards. The primary deck of 52 playing cards in use today and includes thirteen ranks of each of the four French suits, diamonds, spades, hearts, clubs, and face cards. Each suit includes an ace, depicting a single symbol of its suit; a king, queen, and jack, each depicted with a symbol of its suit; and ranks two through ten, with each card depicting that many symbols of its suit. Two (sometimes one or four) Jokers, often distinguishable with one being more colorful than the other, are included in commercial decks but many games require one or both to be removed before play ... A deck often comes with two Joker Cards that do not usually have hearts, diamonds, clubs or spades, because they can be any card in certain games. In most card games, however, they are not used.

Playing cards involves probability. The better you understand probability, the better you will play. What is the probability of picking up an ace in a 52 card deck? The probability of picking up an ace in a 52 deck of cards is $4/52$ since there are 4 aces in the deck. The odds of picking up any other card is therefore $52/52 - 4/52 = 48/52$. What is the probability of picking up an ace or king in a 52 card deck? The probability of picking up an ace or a king is $8/52$ since in a deck of 52 cards there are 4 aces and 4 kings, which totals 8. The probability of not picking up an ace or king is simply $52/52 - 8/52 = 44/52$. What is the probability of picking an ace in five consecutive attempts in a 52 card deck? In order to determine this probability, first you must determine the probability of not picking up an ace in 5 attempts; removing a non-ace after each attempt. The probability of not picking up an ace in the first attempt is $48/52$. The probability of not picking an ace in the second attempt is $47/51$. This is the case because you had previously removed one of the non-aces in the first attempt reducing the non-aces from 48 to 47. Also, the total amount of cards also dropped after the first attempt reducing the total number of cards from 52 to 51. Continuing with this logic on the third attempt the probability of picking a non-ace is $46/50$. You can see that the numerator and denominator are both being reduced by 1 with each attempt. On the fourth attempt the probability of picking a non-ace is $45/49$ and on the fifth attempt is $44/48$. So, the total probability of picking a non-ace in 5 consecutive attempts removing the card after each attempt is the product of each individual attempt. The product of each individual attempt is $48/52 * 47/51 * 46/50 * 45/49 * 44/48 = 0.66$. Multiplying this value by 100 will give you 66 percent. There is a 66 percent chance of not picking up an ace in 5 consecutive attempts.

<https://www.pdx.edu/tutoring/sites/www.pdx.edu/tutoring/files/Probability%20-%20Playing%20Cards.pdf>

Figure 12: Graffiti Math Art Poster 5 with Description - Outstanding.

Fishing for Data

Statistics is the branch of mathematics that deals with the collection, organization, analysis, and interpretation of data. Throughout the collection of data, patterns are created based upon probability. We decided to incorporate patterns, which is associated with probability, in our project by using ombré on the fish and water. We were inspired by the colors and contrasts of paint tiles, so we decided to use them in our project to create the patterns in the water and the fish itself. Using ombré on the water and the fish is reasonable because water has many shades and colors, depending on how far the water is from the surface and fish are also composed of many different shades and colors. We wrote statistics formulas on the water tiles surrounding the fish to correlate with just like how the fish is surrounded by water, we are surrounded by numbers and formulas in our everyday lives. It does not matter what type of lifestyle you chose to live you are always going to use math and sometimes without even knowing it. We chose the title "Fishing for Data" because it is ambiguous, meaning that it takes a little bit of thought to grasp the meaning of the project. Our project evolved through the analysis of our lecture notes and we got our inspiration for the project through our mutual love of water. We referred to the online textbook, lecture notes, and Galileo to come up with ideas and create our project. Statistics plays an integral role in our everyday lives from patterns in the water to the probability of catching a fish. Thus, the theme for our project in "Fishing for Data".

Figure 13: Graffiti Math Art Poster 6 with Description - Outstanding.

6. Discussion

My attempt to foster originality and creativity in my statistics course was successful, as each project turned out to be quite unique. Being an exploratory endeavor, the goal was to simply observe what students were capable of producing and if they followed the rubric guidelines.

It should be noted that though there were 62 crossword puzzles, 34 word walls, and 35 graffiti art posters, I only selected a handful to use as examples here due to space limitation. Though there was no formal method for selecting them, each one selected was classifiable into one of the three levels: outstanding (rubric column 1), satisfactory (rubric column 2) and developing (rubric columns 3 and 4).

The enthusiasm, ambition and thoughtfulness could be perceived when looking at these projects, as well as the time that went into each one. It was enjoyable just going through each one. Students used their hands and art supplies, worked together on them with friends from class, and reported having learned more about the content through art. Projects were displayed on the walls of the college campus for faculty, staff, and students to enjoy (Figure 14), simultaneously with those from other math courses I was teaching.

Figure 14: Projects displayed on campus.

Rhodes's 4P's Model [1] was an excellent fit as the theoretical framework for this undertaking. Each student (person) had to come up with ideas with their partners. Meanwhile, they had to think and collaborate about the steps involved and what materials to use (process). The environment in which the thinking and creating took place was mostly outside of class in their homes or in the STEM Center (press), and the final products were those described.

As for limitations, it seemed that even though the rubric was easy to follow, not all students used it advantageously and did not maximize the number of possible points. This could be due to a lack of motivation, either internal or external. Some students may not have read the rubric. Perhaps some students felt the projects constituted busy work, or their busy schedules between work and extracurricular activities could have restricted time to devote to the endeavor. Not many college students have a lot of down time or blocks of free time, so I naturally took this into account since it was a pilot endeavor.

Statistics is typically a daunting course for undergraduates. Many students have been away from math for several years and are apprehensive about such a course. Interestingly, most students reported appreciating the projects as authentic assessments to demonstrate their knowledge in more personally creative ways. They also liked the projects as a way to improve their overall course grades. Although art supplies were readily available free of charge from the STEM Center, some students did not visit the STEM Center. This could be because they did not know that the STEM Center was available, or perhaps they did not have the time to go there. Other students may just not like doing art and they may not see it as useful or important as other college-level work. Perhaps some students do not feel artistic and think that they are not good at drawing, coloring, and painting. It may be the case, too, that making connections between probability and statistics with art is more challenging than it seems, and requires thinking outside of some students' normal comfort zone.

Creativity and originality emerged in several different forms, with some being as basic as just using a pencil to draw squares with letters for the crossword puzzles, while others involved typed words that were manually cut and glued onto the poster board. The word walls also varied in the level of creativity with some just involving hand written words without definitions while others had used post-it notes for the words with the definitions underneath them.

The graffiti math art projects were all quite creative and interesting, with actual cards and dice being attached.

Common themes that were revealed included students' enjoyment working with their hands and with a partner. Some students indicated having learned about statistics more naturally without pressure of remembering formulas and figuring out difficult word problems. Many liked talking face-to-face with one another instead of texting in cyberspace. They reported having enjoyed being able to break the endless cycle of going online to access the textbook and complete homework assignments. Some missed the old days of just sitting down with friends and doing something enjoyable with their hands. The therapeutic benefits of using artist tools and stretching their imaginations were remarkable. Students reported reduced math anxiety and feeling more connected to the class and the course. Evidence of success included overall acceptable grades using the rubrics, favorable post-project collaborative discussion, and positive overall end-of-course comments.

The more students understand a topic, the more creative they can be with incorporating their knowledge. The evidence of student work shows that some projects integrated more content and creativity than others. As Csikszentmihalyi [13] emphasizes, creativity is not merely a cognitive process. Rather, it is a product of the interaction of the person and the social and cultural contexts. A systems approach to creativity suggests that creativity does not exist in a vacuum, but is rather an interaction of the individual and the environment. It is clear that this study resonates with componential theory (cf. [8]). Domain or content knowledge is necessary to expand cognition into new unexplored directions. Intrinsic motivation is also an underlying component, as some students take pride and spend time on the projects for the satisfaction of doing well whereas others do not put the time in and submit what appears minimal effort and creativity. Zhou and Shalley [14] maintain that the interaction between the person and situation should be used to guide future studies of creativity. It seems clear how the social aspects of working together to exchange ideas were welcomed by the students and lead to favorable outcomes in the form of creative poster projects.

7. Summary/Conclusion

Fostering creativity and originality in statistics and any other math course appears to be an asset to teaching and learning. Students can access their hidden creative skill sets and express their originality by assimilating content knowledge and expressing it through various projects. Students thrive on the social interaction. Working together helps reduce stress. The mere enjoyment of using art supplies with their hands can be therapeutic for students.

Similar math literacy and artistic poster projects could serve as authentic assessments in any instructor's course requirements. Knowledge can be expressed in ways other than through high-stakes testing. Thinking, flexibility, and adaptability should be encouraged as these skill sets can ultimately be utilized in just about all fields of employment. Students can show what they know and enjoy telling their story in the process and will ultimately retain this knowledge because it was created, processed, and produced by them. When a task is meaningful and has personal importance, it tends to be remembered longer than some multiple-choice question on a written test.

By participating in activities that aim to foster creativity and original ideas in the mathematics classroom, students not only have to think logically but also can think creatively. They can acquire social skills in the process by collaborating with their peers, and can acquire even new skill sets when experimenting with different artistic tools and describing their work in writing. Making the connection between the art work and their written descriptions encourages creative processes and products, which have become replaced in public schools with high-stakes testing. It is important to let students show what they know by expressing their ideas in interesting ways outside of the box, rather than just by finding solutions to equations. Artistic artifacts such as these could be part of a K-12 portfolio for students with special needs, in a regular education environment, as well as in the undergraduate college classroom where learning to adapt to diversity will prepare students for the real world.

Final projects, or products, of these kinds of activities can later be used to supplement college transcripts, as they provide evidence of artistic ability. In this way, they can be included in a career portfolio to use on job interviews in the areas of teaching, business, sales, marketing, or engineering. Attaining good grades in college is a common goal for many students, but creativity is not always expected or encouraged in the college curriculum.

Creating unique, original artistic projects as evidence of being able to apply knowledge prepares students to become problem-solvers and attain leadership roles in their careers.

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A. Sample Student Work

Here are three more student projects for the reader to peruse, included here with permission of the students.¹

The first is a graffiti art poster:

¹This applies more generally to all student work included in this paper.

Here is a crossword puzzle:

And finally, here is a word wall: