Poetry in a Math Classroom

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Introduction

Poetry in a math classroom? It turns out that there are lots of connections between poetry and mathematics. Poems can be about anything, including mathematics. Poems can be structured using mathematics. Some forms of poetry, such as sonnets, villanelles, and rhymed quatrains, contain symmetry in their rhyming patterns or repeating lines.[1] A "concrete" poem forms the shape of its subject in the way it is printed on a page.[2] In an essay, Jonathan Holden wrote, "Passages of algebra, indented and breaking free from prose text, visually resemble passages of poetry."[3] Scott Buchanan stated, "Both [poetry and mathematics] employ sets of symbols and systems of notation,"[4] and also, "Mathematical formulae and poetic insights are believed to contain hidden meanings,"[5] that ultimately lead to explanations of things in the universe.

From my research and readings, the recurring theme that will be the foundation of this curriculum unit is that both poetry and mathematics require precise vocabulary to help the reader visualize the ideas. According to Sarah Holbrook, some of the things math and poetry have in common are attempts to find patterns and define the unknown, breaking things into parts, using symbols, and making comparisons.[6] In this unit, students will use poems to help them gain a deeper understanding of concepts and make connections. Students will write poems to define vocabulary terms for algebra and geometry. They will write poems to reinforce mathematical content such as equations of horizontal and vertical lines and linear regression, and their poems will be used for review or as a form of assessment.

Rationale

I teach at one of the five high schools in the Red Clay Consolidated School District in Delaware. It is a comprehensive high school with an emphasis on both academics and career preparation; there are 10 career and technical pathways offered at the school. There are approximately 825 students in 9^{th} – 12^{th} grade. In 2017-2018, the student population was 31.3% African-American, 36.2% Hispanic/Latino, 30.1% White, and the remaining 2.4% was American Indian, Asian or multi-racial. Nearly half of the students were categorized as low income, 12.7% as English Language Learners, and 26.7% as Special Education students. Last school year was my first year at this school, and I found that many of my students lack confidence and perseverance. One of my goals for this unit is to reach and encourage my students to engage with the mathematics using different and novel (to me) strategies.

In her book, *Practical Poetry: A Nonstandard Approach to Meeting Content-Area Standards*, Sara Holbrook names eight ways in which "poetry can be a practical route to learning."[7] While I agree with all of them, the first three provide the strongest justification for the activities outlined in this curriculum unit. First, "Writing poetry jogs the memory." Students must have a deep understanding of a mathematical concept in order to condense it into the structure of a poem. They may need to review all they know about the concept before writing a poem. Second, "Writing poetry demands keen observation." Writing a poem requires more than repeating the steps in a procedure to solve a problem or answer a question. Every poem is unique and requires students to observe and internalize the ideas to be used in the poem. Third, "Writing poetry requires precise language." It can enhance students' vocabulary as they search for the right word(s) to fit into a poem. They may need to find synonyms that will fit a rhyme, or alternate words with a given number of syllables to fit the form. The act of writing a poem, therefore, becomes another problem-solving activity for students.

I have been teaching all levels of high school mathematics for the past 25 years. I also taught Chemistry and Physics during my tenure and I have always tried to make the subjects relative to my students. As a math and science person, I readily admit that I have never been a fan of poetry, mostly because I didn't understand a lot of it. I chose to participate in this seminar to put myself in the same position as many of my students – they don't like math because they don't understand it. I hope I will get some buy-in from my students as they realize that I was able to learn about poetry and even write some poems of my own. I am writing this unit for my 9^{th} and 10^{th} grade Algebra 1 and Geometry students, but the activities could be adapted for other math topics at all grade levels.

Content Objectives

I signed up for this seminar without even knowing the meaning of its title: The Fantastic Ekphrastic Scholastic! Fortunately, our seminar leader, David Teague, spent time helping us define both Poetry and Ekphrasis. Our group definition of Poetry is "an art form consisting of figurative language and intentional structure provided by lines." We discussed the meaning of ekphrasis over several seminars. During our first seminar David told us ekphrasis is generally a poem about art in another genre. Further discussions included looking to see what's in artwork and use that to develop a character, mood or theme. We agreed that art takes place within the five senses, which would include music, dance, photography, culinary dishes in addition to drawings, paintings, sculptures, etc. Our group definition of Ekphrasis became "poetry about any art form created to evoke a sensory response."

We were fortunate enough to experience Ekphrasis first-hand during one of our seminar meetings. Teaching Artist Nanci Hersh led us through several activities in which

we wrote poems based on our reactions and feelings about pieces of art. We learned some strategies that teachers of any grade level or subject can easily adapt for their own classrooms. In our first activity we studied a piece of art, individually, for five minutes. We then paired up and one partner described his/her piece of art to the other who wrote down the description. After switching roles, each partner wrote a poem using the description they recorded, without seeing the artwork. It was interesting to hear the different forms of poetry written by the Fellows. A key idea that came from our discussion was that choosing a genre of poem with a set number of lines, syllables, or rhyme, etc. made it easier to write in a short period of time. We generally agreed that guiding students to a specific genre would create an entry level for all students to write poetry. In another activity, each Fellow wrote a single word or brief phrase as a reaction to or description of each of five pieces of art. We put the words on sticky notes near each piece. Each Fellow was assigned one of the pieces of art and used the word bank generated by the group to write a poem. As a group, we concluded that having a word bank generated by multiple people made it easier to write a poem. Having words and phrases from different perspectives broadened our view of the piece of art and gave everyone a starting point for writing a poem. I plan to use Nanci's model of generating a word bank from multiple perspectives in this curriculum unit's activities.

I continue to find connections between mathematics and poetry. According to Sara Holbrook, math and poetry both attempt to find patterns, look at things as a whole and then break them into parts, use symbols to represent the unknown, and make comparisons.[8] David Teague sent me a link to an article at talkingwriting.com titled "Why Poets Sometimes Think in Numbers." In addition to convincing me to sign up for this seminar, that site lists Starting Points for Math Poetry. That led me to a blog by JoAnne Growney called "Intersections-Poetry with Mathematics." Several other searches for math and poetry connections led back to Growney's blog. Another resource that surfaced multiple times is the *Journal of Humanistic Mathematics*. I also learned about an annual international conference put on by The Bridges Organization. The conference focuses on connections between mathematics, arts, music, architecture, education and culture.[9] Sarah Glaz, a math professor at University of Connecticut, has coordinated Poetry events at the conference, and has written papers and books about their connections.

Initially I thought this curriculum unit would be based on the mechanical structure of poems since I am using it in my math classes. However, based on my research and my experiences in this seminar, it will go beyond that. I will act on Sarah Glaz's opinion, "Poetry projects are used in the mathematics classroom for their power to engage attention and enhance memory. Careful project construction often results in additional pedagogical benefits, such as better integration of material and easier transition to its applications."[10]

One way to bring poetry into the math classroom is simply to read poems about math people. More than once, I have heard students ask, "Who ever thought of this?" Learning some history about the people and the context of mathematical disciplines can make it more relevant for them. Refer to the Teacher Resources for a link to and article written by JoAnne Growney that has some history, along with excerpts from poems about math people. Another way to bring in poetry is to read or listen to poems about math. Students with an understanding of the math concept(s) can appreciate the humor and/or cleverness of the poem. One example can be found in Harry Baker's Ted Talk video in which he recited his award-winning poem about the love life of the prime number 59. Another example from "Math in Seventeen Syllables: A Folder of Mathematical Haiku," written by Christina Carroll about the concept of Infinity is

> There's not enough room
> in seventeen syllables
> to contain infin— [11]

Finally, since math has its own vocabulary with its own precise definitions, and poets use "precise descriptions of images,"[12] it makes sense to use poetry in the math classroom to help students learn and retain math terminology.

Poetry Basics

I found a quote that resonated with me: "To write so clearly that they might bring "all things as near the mathematical plainness" as possible - that was the goal of scientists, according to Bishop Thomas Sprat, who lived in the seventeenth century." Plain and concise writing is my kind of writing. That is one reason I never liked poetry when I was a student. The quote continued with "Although it may have troubled Bishop Sprat, the tendency of a word to have multiplicity of meaning rather than mathematical plainness opens broad avenues to poetry."[13] Throughout this seminar, I have learned to appreciate a poet's choice of words and poem structure as a means of presenting his/her message or point of view. I still can't say I understand most poems when I read them, but I do appreciate them more than I used to, and I learned a lot by listening to my colleagues discuss them.

Our seminar leader, David Teague, had us consider what a poem *does*, as opposed to what it *means*. We discussed three genres of poems: lyric, narrative, and dramatic. Lyric poems are generally short and capture an emotion. Originally they were sung to music of a lyre, often written in first person expressing thoughts and feelings of the speaker.[14] Narrative poems tell a story. Ballads are an example of a narrative poem. They have short stanzas that relate a series of events.[15] The structure of a ballad and the ebb and flow of its rhyme allows them to be retold orally. Finally, dramatic poems are written as a speech, or monologue. The speaker is a character that presents his/her point of view to another imaginary character, often the audience.

Beyond genre, the mechanics of a poem can affect what it *does* to the reader. Prosody is the study of that mechanical structure. It analyzes and measures rhyme and sounds in a poem. Prosody is the analytical means this math and science teacher needed in order to become more comfortable with poetry. Jonathan Holden stated, "Poetry is roughly equivalent to what formal proof is in mathematics."[16] He went on to explain that by analyzing a poem's meter, as in measuring the number of syllables per line, "conspicuously dividing language into units…focuses unaccustomed attention on each unit."[17] We read Sylvia Plath's poem "Metaphors" in seminar. The poem about pregnancy has nine lines and nine syllables per line where the meter is certainly intended to lead the reader to the poem's meaning. Square Poems are its own category of poems. The stanzas are symmetric; either the number of words per line is equal to the number of lines, or the number of syllables per line is the same as the number of lines. For example, JoAnne Growney wrote the following 5 x 5 square poem that she posted next to a photo of colorful high-heeled shoes (ekphrasis going on!).

All over the world
fashionable shoes –
trendy, hazardous,
uncomfortable –
keep women in place.[18]

Prosody has its own set of symbols (just as math does). The symbol for an unaccented syllable is ∪, and the symbol for an accented syllable is /. When accented and unaccented syllables are grouped together and repeated in a line of poetry, the unit that is repeated is called a *foot*. I had heard of iambic pentameter before this seminar, but didn't know what it was. I can tell you now that an **iamb** is a *foot* that contains one unaccented followed by one accented syllable (∪ /). Iambic pentameter means that the foot is repeated five times per line. Overall, it describes the rhythm of the poem.

The term *meter* refers to the rhythmic pattern of stresses in lines of poetry.[19] It can refer to a fixed number of syllables (syllabic meter), a fixed number of stressed syllables (accentual meter), or a fixed number of both syllables and stresses (accentual-syllabic meter)[20] in a line of poetry. In addition to the iamb, there are several other so-called "Major Feet." The **trochee** foot is the opposite of the iamb with one stressed syllable followed by an unstressed one (/ ∪). The **pyrrhus** foot contains two unstressed syllables (∪∪) and can be combined with a **spondee** (/ /) to form an **ionic** foot (∪ ∪ / /). The **dactyl** foot contains one stressed syllable followed by two unstressed syllables (/ ∪ ∪). The **amphibrach** (∪ / ∪) , **anapest** (∪ ∪ /), **bacchic** (∪ / /), **antibacchic** (/ / ∪), and **cretic** (/ ∪ /) feet also contain a combination of 3 syllables with stressed syllables in different orders.[21]

Stanzas can be built with patterns of feet per line, a set number of lines, rhymed or unrhymed. My reference book by Miller Williams entitled *Patterns of Poetry: An Encyclopedia of Forms*" has a chapter devoted to "Fully Defined Traditional Stanza Patterns." Stanzas that have only two lines are called couplets. Stanzas with three lines are triplets, and stanzas with four lines are quatrains. Stanzas having five and six lines are called cinquains and sestets, respectively. There are longer ones, as well. For my math classroom, however, I will stick to shorter stanzas and poems unless students want to write longer ones.

There are many named couplets with varying numbers of stresses and rhymes. For example, the **short couplet** has two rhymed lines and either iambic or trochaic tetrameter (four feet per line). A **split couplet** also has two rhymed lines but the number of stresses per line changes from five in the first line to only two in the second line.[22] Iambic pentameter is an example of a heroic couplet. **Heroic couplets** are two rhymed lines with five stresses per line.[23]

Longer stanzas vary the rhyming patterns. The prosodic notation for nonrhyming lines of poetry is *x*. Rhyming lines are denoted with lowercase letters. Lines that rhyme use the same letter; a different letter represents a different rhyme.[24] Sometimes alternate lines rhyme with the lines between also rhyming, as in "*abab*," or without the lines between rhyming, as in "*xaxa*." There is also an envelope rhyme in which the "outside" lines rhyme, as in "*abba*."

My reference book has another chapter that defines "Traditional Poems of Set Length." These poems have the most structure and are the forms that I will most likely ask my students to write. The shortest poem is the Haiku. Haiku is a three-line, unrhymed syllabic poem; its first line contains five syllables, its second line contains seven syllables and its third line contains five syllables.[25] In seminar, we learned that Haiku poems are typically lyrical and, since they originated in Japan, often overlay two images or senses connected to nature. There is a variation on Haiku called a Haiku Sonnet. Four individual Haiku poems become stanzas with a couplet stanza at the end to tie them together.

A less common set length poetry form is a Clerihew poem. It has two rhymed couplets, but each line can be any length and meter. Another four-line poem is a Rubaiyat. It usually has five stresses per line, uses iambic feet, and lines #1, 2, and 4 rhyme (*aaxa*).

We looked at some examples of Tanka poems in our seminar. Tankas are made up of five lines with five, seven, five, seven and seven syllables in each respective line. The Tanka form also originated in Asia. Generally, the first three lines make a statement and the last two comment on it.[26] A limerick is another five-line poem. Lines #1, 2, and 5 are anapestic trimeters that rhyme with each other. Lines #3 and 4 are anapestic dimeters that also rhyme with each other. Using prosodic symbols, the form of a limerick is

Line #1:	∪ ∪ / ∪ ∪ / ∪ ∪ /	Rhyme: *a*
Line #2:	∪ ∪ / ∪ ∪ / ∪ ∪ /	*a*
Line #3:	∪ ∪ / ∪ ∪ /	*b*
Line #4:	∪ ∪ / ∪ ∪ /	*b*
Line #5:	∪ ∪ / ∪ ∪ / ∪ ∪ /	*a*

Some longer poems contain a set number of lines and each line is the same length, although the length can be any fixed number of stresses. Some poems have refrains that are repeated in specific positions; some poems have lines repeated in specific positions. For example, a **roundel** poem is eleven lines in three stanzas. The stanzas contain four, three, and four lines, respectively, and the lines can be any, but equal, length. In addition, the first line is repeated as the fourth and eleventh line of the poem.[27] Sonnets are 14-line poems with variable rhyme schemes. There are different types of sonnets with stanzas broken in different ways (8 lines followed by 6 lines, or three 4-line stanzas followed by a couplet). One of the most complex, highly structured, poems is the sestina. A **sestina** has 39 lines of any, but equal, length. It is written with six stanzas of six lines plus a three-line (triplet) concluding stanza called the terminal envoy. Additionally, the same six words end the lines of each of the sestet stanzas, and must be in a specific (rotating) order in each of those stanzas. Finally, the terminal envoy must contain all six words with three of them at the end of lines and the other three buried within the lines.[28] Some students may be attracted to these structured forms. To quote my seminar leader, David Teague, "a formal proof has a similar structure and feel to logic-driven forms like the sonnet" or sestina.

We discussed some other forms of poetry in our seminar that I think will be useful for my math classroom (and for other subjects, too, of course). One of them is the **acrostic** poem that is read down the page. It takes a word(s) and uses each letter in the word as the first letter of a line in the poem.[29] Each line of the poem is a self-contained statement that creates an image. The lines may have a rhyming pattern and/or meter, but it is not necessary. A very clever poet could even write a **double acrostic**, in which the last letters in the lines spell another (related) word or phrase.

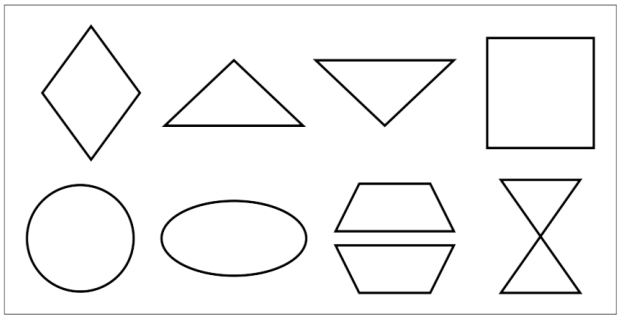

Figure 1

Concrete poems, sometimes called visual poems, are another form that teachers may find applicable in different subject areas and grade levels. These poems are written in a way that the line lengths and the position of the lines on the page create an image related to the message of the poem. Some common shapes used in concrete poetry are shown in Figure 1. A true mathematical example of a concrete poem about the Pythagorean Theorem is shown in Figure 2. The poem, "Right Triangle" by Li C. Tien was published in *The Mathematical Intelligencer* journal in April 2009.

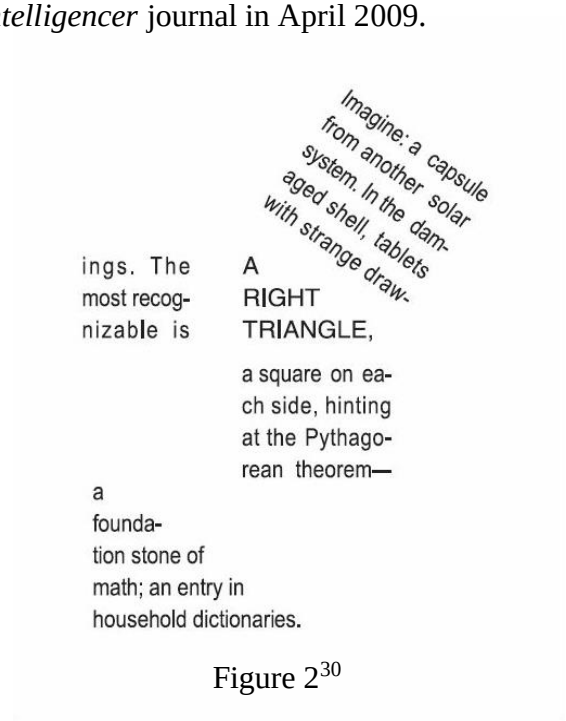

Figure 2[30]

Finally, all well-defined poems can have variations, sometimes giving them different names, and sometimes just at the poet's discretion. Then there are free verse poems that don't necessarily follow any strict patterns. Prosody is just an objective way to study poems – something I can relate to.

Mathematical Art

There are many forms of art that relate directly to mathematics. Leonardo da Vinci made use of the golden ratio, a ratio that is considered to be aesthetically pleasing. Symmetry in Moorish, Islamic or Turkish tiles and carpets, perspective drawings, colorful computer-generated fractals, origami, and Fibonacci spirals in nature are just a sampling of artwork that can be used in the classroom for various purposes. The following artists are ones whose artwork I found online easily and will likely use in my classroom.

Piet Mondrian

Piet Mondrian is a Dutch artist that initially created many paintings using only horizontal and vertical black lines on a white canvas. He added color by filling in some of the rectangles formed by the intersections of some of the lines. Later, when he lived in New York, he painted *Broadway Boogie Woogie* with yellow gridlines and red and blue squares at their intersections. According to a gallery label at MoMA (Museum of Modern Art) in New York City, these colorful pathways suggest "the city's grid, the movement of traffic, and blinking electric lights, as well as the rhythms of jazz."

M. C. Escher

M. C. Escher is another Dutch artist that is well known for his intricate illustrations that, in his words, apply "three main principles of regular plane filling."[31] The plane filling that Escher refers to is also known as tiling, and refers to the use tessellations to cover a plane. The main principles Escher uses are translations, rotations and glide reflections. These are common topics taught in Geometry courses.

Anatolii Fomenko

Anatolii Fomenko is a Soviet and Russian mathematician and artist. Some of his art was featured in the book *Mathematical Impressions,* published by the American Mathematical Society.[32] His work was described on brainpickings.org website as "part Escher, part German Expressionism, part something else entirely." Several of his images that I have seen include dice, which can be connected to Statistics. Other images use circles and lines, which can connect to Geometry.

Teaching Strategies

Google Apps

All students in the Red Clay Consolidated School District are issued Chromebook computers and use them daily in all of their classes. They have extensive experience using Google apps such as Google Docs, Sheets, and Slides. In this unit, students will work collaboratively with other students on shared documents.

Schoology

The Delaware Department of Education has adopted (purchased) a learning management system called Schoology. Teachers and students can access it from any computer, tablet or Smartphone; there is a downloadable app, also. My students use Schoology in multiple ways in different classes. All of them are familiar with how to login, access files, submit assignments, send messages to teachers, and write discussion posts. I upload class notes from my SMART Board files daily. Teachers also have the ability to assign Google Drive assignments in Schoology. When students open the assignment, they get a working copy

without changing the original. Additionally, their work is automatically saved to my Google Drive in a Schoology Assignment folder, and automatically separated by class. In this way, I can provide sample poems and instructions for students via Schoology. Another useful tool in Schoology is the Discussion. I can "assign" a class discussion in which students can post their poems and have others provide feedback, questions and comments. I also have the option to require students to make their own discussion post before they can see posts from others.

Classroom Activities

Activity #1 - 100% Me

This activity is written for the first week of school. It is a chance to inform students that poetry will be used throughout the course and also as a way to get to know students. This activity is adapted from Sara Holbrook's book *Practical Poetry*.[33] It took about 30-45 minutes for most students to complete, and I used it for all of my (9th and 10th) grade classes.

Objectives

1) Poetry expresses ideas or feelings in a concise form, just as mathematical formulas and properties consolidate patterns into statements. Poetry will be used as a creative form of learning and as an alternate assessment.
2) The 100% Me poem will help the teacher learn about students - their interests, backgrounds, and what's important to them.

Instructions

First, I projected my personal 100% Me poem as an example. I began by pointing out key features of my poem such as physical characteristics (short, grey hair, expressive eyes, silly), my roles (teacher, wife and mother, DTI Fellow), and my favorite activities (kickboxing, travelling, eating chocolate). Then I explained how the percentages are relative to each other. For example, teaching and family are large percentages because they take up a large part of my time and they are important to me, whereas my hair color and eating chocolate are smaller percentage because they are less important and less time-consuming. The relative sizes of the percentages must make sense. For example, the percentage representing my grey hair should be less than the percentage representing my height because it is a smaller part of my entire body.

I recommend giving students five to ten minutes to write a list of their own characteristics and interests. Have them share with their partner or group to give them a chance to gather ideas to add to their own lists. Next, students should select a minimum of six items from their list to include in their poem. I chose six as the minimum so they would be forced to do a little math - not 20% each of five items, or 25% each of four items, etc. Since 100/6 results in a decimal quotient, even the laziest students (that want to use the minimum lines and split them evenly) are forced to decide where and how they want to round numbers to get exactly 100%. Some of my students did ask if it had to add up to 100%, which prompted a brief discussion about what it would mean if it didn't add up to 100%.

I had students add a lead-in phrase or line, and a concluding line, and then recopy their poems onto a clean sheet of paper. They mounted their poems onto a bright-colored piece of paper and added some illustrations. In hindsight, I would have students write their names on the back of the paper. I posted all of the poems around the classroom; parents were interested to read them when they came for Parent Open House, especially trying to find what their own child(ren) wrote.

A follow-up activity, especially for high school freshman, could be to have students share their poems with 1-3 people they do not know as a way to introduce themselves. Another follow-up could be to have students try to identify their classmates by their poems. This could be done in the first week, or several weeks later, after students have learned more about each other.

Activity #2 - Vocabulary

This activity can be used throughout the course. It can be a summarizing activity, a review activity, or a form of assessment.

Objective

Students will reinforce mathematical vocabulary by choosing words to fit into a specific poetry form.

Instructions

Select a poetry form for the activity. Some suggestions, for the first time the activity is used, are *concrete* poems (poems written in a shape that corresponds to the vocabulary term), *acrostic* poems (each line of the poem begins with a letter in the vocabulary term), *Haiku* (three lines containing 5, 7, and 5 syllables, respectively), or *tanka* (5 lines containing 5, 7, 5, 7, and 5 syllables, respectively). Provide students with examples of the poetry form, either an original poem, or ones from the internet. (By the way, I found my students didn't truly understand how to count syllables until I demonstrated it for them.)

Provide students with a list of vocabulary terms. Give students 5-10 minutes to make a list of words or phrases associated with the vocabulary term(s). This can be done individually, or as a class. Using the model Nanci Hersh used during our seminar (refer to Content section above), post the vocabulary terms around the room. Depending on the number of terms, the class can be split up and assigned only a few terms, or all of the terms. Have students write words or phrases on sticky-notes for their assigned term(s). These words or phrases should help define the term or describe what it looks like. This list will act as an entry point for writing the poem.

If there are only a few terms, students, working individually or in pairs, could be required to write a poem for each. If there is a longer list of terms, students can be assigned just one and then all of the poems can be compiled into a single document accessible by all (such as a Google Doc). Another possibility is to combine student-written Haiku poems into a Haiku Sonnet, in which each stanza is an independent Haiku. Students can provide logic for determining the order of the stanzas in the sonnet. Additionally, students can critique (or make suggestions to) each other's poems, or ask questions about them via online Discussion Board posts.

Ideally, vocabulary poems should include illustrations and be enlarged and displayed in the classroom to reinforce the vocabulary throughout the unit, or throughout the entire course. The teacher may need to suggest revisions for poems that are incorrect mathematically, or not descriptive enough to help students understand the term's meaning.

Activity #3 - Prosody and Regression Equations

This activity introduces the term *prosody* to students. For this activity, students can count the number of stresses in a line of poetry, or the total number of syllables in a line. This specific activity is written for Algebra 1 students studying linear functions.

Objective

Students use poetry as a source of data for evaluating patterns, determining lines of best fit and interpreting correlation coefficients.

Instructions

Select a poem or poems, or have students search for poems online. Refer to Teacher Resources for some suggestions. As a first try, I used Walt Whitman's *Song of Myself*, and I provided students with a link to the full poem. The poem has a total of 52 verses ranging from 6 lines to over 100 lines. Using Stanza 1, I demonstrated how to create a data table using the line number as the independent variable, *x*, and the number of syllables as the dependent variable, *y*.

Students then enter the data table into either a graphing calculator or an online graphing program; I used free software, Desmos.com. Next, create a scatterplot of syllables (*y*) versus line number (*x*); Desmos creates the plot as the data is entered. Ask students to describe any patterns they see in the data - increasing, decreasing, constant, random. Use technology to do a linear regression and generate a correlation coefficient.

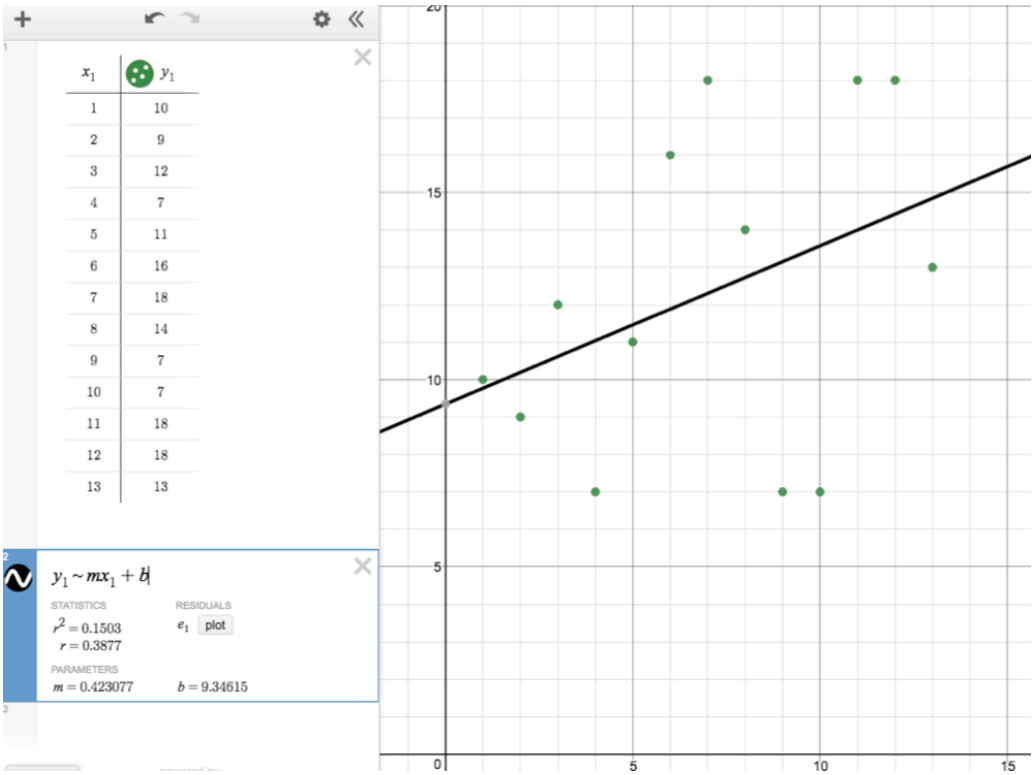

Figure 3

Figure 3 shows the Desmos graph of Syllables vs Line Number for Stanza 1 in Walt Whitman's *Song of Myself*. Students can see the broad scatter of the points around the Regression Line, and begin to associate that scatter with a weak correlation coefficient of $r = 0.3877$.

After modeling the process, students repeat the process on a different stanza of the poem (if using *Song of Myself*). They can take a screenshot showing their scatterplot, Regression equation, and correlation coefficient and enter it into a shared document. By reviewing the graphs for all of the different stanzas, students can determine whether there is a pattern from stanza to stanza. Encourage students to make suggestions for other ways to compare the data.

As an alternative to using a single poem with multiple stanzas, students can compare the prosody of different poets (i.e. Yeats, Frost, Shakespeare, Byron, Longfellow), or of different poetry forms (e.g. Sonnet, Rondel, Rondeau, Ballade, Villanelle, Terzanelle, Sestina).

Activity #4 - Graphing Piet Mondrian's Art

For some reason that I do not understand, students do not recognize equations of horizontal or vertical lines. This project required students to use Desmos online graphing software to recreate one of Piet Mondrian's geometric paintings, and write a poem to describe the steps.

Objective

Students write multiple equations for horizontal and vertical lines to recreate a geometric image to help them internalize the form of those equations.

Instructions

Introduce the Dutch artist Piet Mondrian and images of some of his most famous paintings. I copied images (or portions of them) from the internet and placed them in a folder with a link for my students to use. I also created a Google Assignment with instructions for students to upload one of the Mondrian images into Desmos and how to move the image so that its lower left corner was at the origin. The instructions also explained how to set endpoints for lines. For example, to draw a vertical line at 4 from 0 to 8 on the y-axis, the instruction in Desmos is $x = 4\{0 \leq y \leq 8\}$. Likewise, a horizontal line at 7 between 2 and 6 on the x-axis would be $y = 7\{2 \leq x \leq 6\}$. Students can immediately see if the line is in the proper place, and make corrections if it is not. They can move the image aside to make sure they have written equations for all of the lines in the image.

Once the equations of all lines are complete, students write instructions for recreating Mondrian's artwork in the form of a poem. The teacher can suggest a specific poetry form, or allow students to choose. The poems may have a rhyming pattern, or a set number of stresses or syllables. (My students chose a fixed number of syllables per line; only one used rhyme.) The instructions within the poem should include where there are blocks of color. More creative students may want to include feelings or reasons for the placement of colors. Tell students that the goal of the poem/set of instructions is for another student to be able to recreate the image they describe.

Ideas for Additional Activities

Tessellations

In a Geometry unit on Transformations, students can write an ekphrastic poem to describe the transformations in one of Escher's prints. Wallpaper is another source of geometric transformations for ekphrastic poetry.

Proofs

Instead of writing formal two-column (Geometry) proofs, some students may prefer to write a proof as a poem. As an example, when proving two triangles are congruent, perhaps students can create a concrete poem with the reasoning in the shape of a triangle.

Teacher Resources

Bibliography

The Bridges Organization. http://bridgesmathart.org/

This is the home page for The Bridges Organization that oversees an annual international conference focusing on connections between math and art forms. Each conference includes poetry readings, art exhibitions, papers, etc.

Brown, Kurt. *The Measured Word: On Poetry and Science*. Athens: University of Georgia Press, 2001.

This book is a compilation of articles by different authors. Several of the chapters made interesting connections between poetry and mathematics.

Buchanan, Scott. *Poetry and Mathematics*. New York: J. Day Company, 1929.

Buchanan's book provides a historical perspective of mathematics, but is not particularly relevant to current math instruction.

Growney, JoAnne. *Intersections—Poetry with Mathematics* (blog). https://poetrywithmathematics.blogspot.com

JoAnne Growney's blog has an enormous collection of math poems. There are links to even more resources connecting math and poetry. The website can be awkward at times, but offers so much, it's worth exploring.

Growney, JoAnne "Mathematics and Poetry," *Math Horizons* 26, no. 1 (September 2018): 34. https://doi.org/10.1080/10724117.2018.1468141.

This article written by JoAnne Growney contains poems about math people. It provides some background about connections between math and poetry and a little history as well.

Holbrook, Sara. *Practical Poetry: A Nonstandard Approach to Meeting Content-Area Standards*. Portsmouth, NH: Heinemann, 2005.

Holbrook's book has a wealth of ideas for integrating poetry into any content area. I found this book extremely useful to validate the use of poetry in math classrooms. The book has examples and instructions for easily adaptable poetry-writing lessons.

Kennedy, X. J., Gioia, Dana. *Backpack Literature: An Introduction to Fiction, Poetry, Drama, and Writing.* Boston: Pearson, 2016.

This book is part resource book, part anthology of poems, and part instruction manual. Chapter 16 provided background information about prosody.

"Math in Seventeen Syllables: A Folder of Mathematical Haiku," *Journal of Humanistic Mathematics* 8, no. 1 (January 2018): 441-472, https://doi.org/10.5642/jhummath.201801.22.

This journal article is just what it says it is: a folder of haiku poems written by many different authors about mathematical content.

Pulsipher, Yasmin. "Ecphrastic poetry & the development of professional literacy in Computing," https://slideplayer.com/slide/4134046/, accessed December 11, 2018.

This website has a slide show with some examples of ekphrastic poetry

Williams, Miller. *Patterns of Poetry: An Encyclopedia of Forms.* Baton Rouge: Louisiana State University Press, 1986.

This encyclopedia was my reference guide that explained the characteristics of different forms of poetry. It was also a great reference for prosody.

Appendix 1: Common Core State Standards

This curriculum unit primarily addresses CCSS Mathematical Practice Standards that apply to all Mathematical Content Domains.

CCSS.MATH.PRACTICE.MP2 – Reason abstractly and quantitatively.
Students need to decontextualize situations in order to write a poem about a mathematical concept, such as vocabulary terms. Incorporating quantitative ideas into the poem helps reinforce the content.

CCSS.MATH.PRACTICE.MP7 – Look for and make use of structure.
Students are using structure when they find words to fit a specific poetry form. Seeing structure in a mathematical concept can be the basis for a poem.

CCSS.MATH.PRACTICE.MP8 – Look for and express regularity in repeated reasoning. The description of this standard states, "As they work to solve a problem, mathematically proficient students maintain oversight of the process, while attending to the details." This process is very similar to writing a poem, paying attention to the prosody and form.

Activity #3 addresses Statistics & Probability content standards on interpreting data, making a scatterplot and fitting data using linear regression.

CCSS.MATH.CONTENT.HSS.ID.B.6 - Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.
CCSS.MATH.CONTENT.HSS.ID.B.6.A - Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models.
CCSS.MATH.CONTENT.HSS.ID.B.6.B - Informally assess the fit of a function by plotting and analyzing residuals.
CCSS.MATH.CONTENT.HSS.ID.B.6.C - Fit a linear function for a scatter plot that suggests a linear association.

Students apply high school function content standards as they graph horizontal and vertical lines in Activity #4.

CCSS.MATH.CONTENT.HSF.IF.C.7 - Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

CCSS.MATH.CONTENT.HSF.IF.C.8 - Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function.

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[1] Kurt Brown, *The Measured Word* (Athens: University of Georgia Press, 2001), 156.
[2] Miller Williams, *Patterns of Poetry* (Baton Rouge: Louisiana State University Press, 1986), 143.
[3] Brown, *The Measured Word*, 90.
[4] Scott Buchanan, *Poetry and Mathematics* (New York: J. Day Company, 1929), 19.
[5] Buchanan, *Poetry and Mathematics*, 73.
[6] Sara Holbrook, *Practical Poetry* (Portsmouth, NH: Heinemann, 2005), 58.
[7] Holbrook, *Practical Poetry*, 4.
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[9] http://bridgesmathart.org/
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[14] Kennedy and Gioia, *Backpack Literature*, 367.
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[16] Kennedy and Gioia, *The Measured Word*, 101.
[17] Kennedy and Gioia, *The Measured Word*, 102.
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[26] Williams, *Patterns of Poetry*, 71.
[27] Williams, *Patterns of Poetry*, 75.
[28] Williams, *Patterns of Poetry*, 93-94.

[29] Williams, *Patterns of Poetry,* 139-140.
[30] Growney, *Intersections* (blog). October 27, 2018, "Right Triangle" by Li C. Tien, https://poetrywithmathematics.blogspot.com/2011/06/right-triangle.html.
[31] M. C. Escher, *Escher on Escher: Exploring the Infinite*. (New York: Abrams, 1989), 26.
[32] Growney, *Intersections* (blog). October 28, 2018, https://poetrywithmathematics.blogspot.com/2018/06/visual-poetical-mathematical-impressions.html#more.
[33] Holbrook, *Practical Poetry,* 76-9.