

Achievement and Delight: When Mathematics and Literature Cross Paths

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Overview

“No mathematician can be a complete mathematician unless he (or she) is also something of a poet.” K. Weierstrass

*“The same people who cringe when words such as ‘imply’ and ‘infer’ are confused react without a trace of embarrassment to even the most egregious of numerical solecisms.”
John Allen Paulos*

Student rosters clearly indicate the discreet compartmentalization of subject areas. On paper, in standardized testing and in rooms, academic disciplines appear to operate in distinct universes. In fact and in life, overlapping and interweaving of math, science, social studies, and language arts are the more authentic reality. Certainly the pedagogical paths of inter- or multi-disciplinary planning and projects confirm this approach. In practice, however, teachers are more likely to focus on their individual passions and core curricula. Students lose out in this process.

This series of lessons will provide students in my majority-minority city career path high school a range of opportunities to combine their developing skills in language arts and mathematics in a way that is meant to foster current competency and a lifelong love of learning. Primarily intended for the 10th graders in my English 2 classes, a focus on blending math and ELA standards in the literature class will enhance their current achievement and their ability to excel in both standardized tests and challenging course work as high school upper classmen, and as college and technical school students after they graduate. A happy coincidence of the sophomore scheduled reading, “The Sword in the Stone”), the availability of Cindy Neuschwander’s beautifully illustrated *Sir Cumference and the Sword in the Cone* and geometry as the 10th grade math course provides a ready-made opportunity for interdisciplinary collaboration.

Seniors in regular English 4 classes and Advanced Placement English Literature and Composition may have their confidence in both literary analysis and computation bolstered as they confront and deal with cold-blooded statistics in Jonathan Swift's "A Modest Proposal," metric units and French currency in Albert Camus' *The Stranger*, and time payment calculations and batting averages in August Wilson's *Fences*. Their teacher will gain confidence as she works with them in the role of learning colleague.

Rationale

One news article alone can be used as proof of the interconnectedness of academic disciplines: "Inaugural Squeeze on the Mall" from the Philadelphia Inquirer, December 8, 2008: using math to estimate whether and how 4 million people can fit on the National Mall to hear a new President (social studies) deliver a speech (language arts) while their physical needs (biology) via Port-a-Potties and wool socks are met.

I recall a Temple University admissions official explaining that a student with verbal SAT scores higher than her/his math scores would be preferred over one with higher math than verbal. Reason: verbal facility could be utilized to unlock mathematical concepts, while the reverse did not hold true. (Apologies to my math colleagues.) Should this hold true, students at A. Philip Randolph hold the potential, as indicated by their fairly impressive writing and reading PSSA scores, to enhance trailing math scores?

A letter writer to *The New York Times* perfectly sums up the argument for a multi-faceted academic curriculum for all students, identifying the skills to be gained as including "thinking analogically... [knowing] his or her way around a metaphor... knowing a fact from a factoid, reasoning from data to underlying patterns and practical implications, all while feeding careful observation through the strainer of valid logic." (Jimenez) Even as my career path high school prepares carpenters, electricians, chefs, nurses and fire fighters, we need to provide thorough preparation in high level language and mathematical thinking that will prepare them to live fruitfully in our complex and of late economically hazardous times. Charles Seiter, in his *Everyday Math for Dummies*, offers a suddenly ironic-sounding assurance: Citing the scary deflationary economies of the far distant past, he promises that this sort of financial ruin we are "unlikely to see in a carefully managed modern consumer economy..." (27) It should be noted that both reading level and computational challenges in career tech texts often exceed those encountered in straight academic courses.

My own academic journey perfectly mirrors the struggle so many students have with mathematics. Year after year I sat attentively in math class, whether algebra or geometry, feeling fairly confident in my understanding as long as the teacher was there. At home, faced with the evening's assignments, the problems became impervious puzzles, offering no entry to their mysteries that I could discern. Although a college course in the Fundamentals of Mathematics focusing on permutations and the like provided me with a modicum of success, I proceeded on through life unashamedly uttering the oft-heard statement highlighted by John Allen Paulos in his introduction to *Innumeracy*: 'I always hated math.' (4) I even felt justified in attempting to pass the

aversion on to my children, although in typical younger generation form, they rebelled by the elder taking Advanced Placement Calculus and the younger working as a statistics analyst for the City of New York.

The road to increased literacy holds the key to increased numeracy, that is to say, as reading expert Kylene Beers has observed, student reading levels invariably ascend when students are reading material relating to their interests. Add in John Dewey's "Learn by Doing," and it stands to reason that if students actually create the mathematical constructs with which they have the most difficulty, their fluency in numeracy should improve as well.

As in all pedagogical endeavors, debate on which approaches to take are roiled in controversy. A professor at one university advocates focus on computational skills and barring the use of calculators. At another school across town, math majors are encouraged to read a wide range of literature, to view mass media productions relating to mathematics (not excluding cartoons and Abbot and Costello set pieces!) and to consider the significance of metaphor in numerical analysis. Another expert insists that every child should be provided with a calculator at the earliest possible moment. One scholar strongly recommends a strict adherence to the hierarchy of math courses: arithmetic, algebra, geometry, calculus. Another scoffs at such rigidity. A widely-implemented narrative-focused alternative to standard math courses, Interactive Mathematics Program (IMP) was hotly debated and sometimes panned by traditional teachers in Philadelphia not too long ago. Activists of integration between academics and technical classes in career education consistently recommend "real-world applications" to enhance understanding of mathematics while a recent research study indicates that such examples shoe-horned into the traditional instruction has not yielded higher test scores.

Fortunately, as a putative outsider, I needn't take sides. Yet my bias will always be in favor of verbalizing learning as a clear-cut positive. And I will stand further in favor of both writing and speaking to learn as I recall the American Association of University Women's finding that girls achieve better results in math through working in pairs or in small groups. Similar success through study groups has been documented for African American college students. Encouragement abounds, as many a high school teacher can acknowledge awe at student side conversations on sports where stats and strategies are tossed about with ease. A "simple" lesson on transference – syllogism of sports to fundamentals of factoring or "wordy" to "mathy" (Holt *Algebra 1*: Lesson Tutorial Videos CD, www.hrwtchsupport.com) may be all that is required.

Although students sometimes demonstrate conservatism in the face of intermingling subject areas that are clearly separate on their individual rosters, most notably in my English class when youngsters object to seeing historical dates written on the board in the midst of a poetry lesson (birth and death, time and place of poet's education, beginning and end of a contemporary war), a recent news story discussion proved their openness to crossovers. A dog named "Blue" played a significant in the plot development in the play *Fences*. Connecting to a *NY Times* article on pet accidents in the home was deemed acceptable by the students gathered in my early morning class. Introduction of the

statistics represented by columns sparked no protest as the students animatedly first predicted then analyzed the data comparing incidents caused by cats versus dogs, likelihood of injury by age of the injured human, and gender differences found significant in both type of pet and nature of accident. Neither math anxiety nor resentment at the subject blending surfaced that day. Admittedly this example is more anecdotal than statistical, yet it seems to offer hope for bringing the multiplicity of academic skills required for everyday living and learning to any high school classroom, regardless of designated subject matter.

Background (or Common Ground)

What do the languages of numbers and words have in common? Where do they diverge? What is required to bring them together for the benefit of the student? A brief consideration regarding the history of each, a bracing dip into popular texts from the two worlds, and a survey of modern day standards for instruction in each can provide clues.

Children learn both words and numbers from their earliest days of babyhood. ABC's and counting from 1 to 10 are universals and from the beginning, the elements of poetry inform both. This little piggy went to market; this little piggy stayed home; this little piggy had roast beef; this little piggy had none; this little piggy went "Whee!" "Whee!" "Whee!" all the way home. Rhyme, repetition, alliteration, imagery, personification: here is the groundwork for the youngster's first standardized test! Base 10 learning supports are perennially at hand – and foot. W.W. Sawyer defines mathematics as "...the classification and study of all possible patterns." (*Prelude*, 12) Here is a clear link to literature: the grammar of the language, repetition in poetry, genres, themes, motifs. Shakespeare's sonnets forever with 14 lines, word roots that delineate the same quantity in math (quadratic equation) and literature (quatrain). Narrative explains the solution to a word problem. The linkage seems obvious.

Even a cursory survey of math and literary texts and tasks reveals the basic and extended interplay of the two fields. Peter Bentley, in *The Book of Numbers*, waxes poetic: "Numbers flow past us like a blizzard, wherever we are on the planet. We drive in rivers of numbers." (8) No more succinct lesson on the difference between simile and metaphor can likely be found. Even more direct is his simple statement, "Numbers are words (and symbols) that we use to describe patterns." (13) And we might say that words are symbols that are used to express numbers! (13) Bentley's chapter on the concept of zero is entitled "Much Ado About Nothing," an obvious tribute to the Bard, not the Banker.

In parallel partnership, Marjorie Garber, cites chiasmus ('Shakespeare makes modern culture; modern culture makes Shakespeare'), the crossing of words or internal parallelism to a mathematical formula yielding a theme suitable for literary analysis: characters losing power gain "stature" (*King Lear*), while characters gaining power are diminished (*Macbeth*). An algebraic formula could easily express these tragic relationships. Garber also cites the Brian Rotman text, *Signifying Nothing: The Semiotics of Zero* in a thorough-going analysis of Shakespeare's literary use in *King Lear* of this

Arabic improvement on the Roman numeral system which yields heart-rending and mathematically expressible phraseology like “Nothing will come of nothing,” “Can you make no use of nothing?” and “I am better than thou art now; I am a fool, thou art nothing.” A sample graphic organizer for ‘Reading a Poem’ provided online by the Georgia Department of Education asks for evidence of patterns in rhyme, meter and sound; for number of lines; and for structure, including “least to greatest.”

A careful examination of Pennsylvania state standards and assessment anchors reveals numerous areas where goals are shared. English Language Arts asks that students “identify and/or apply meaning of multiple-meaning words used in text.” Arcs and angles in literature are distinct in meaning from the same words in mathematics. Students are required to “Make inferences and/or draw conclusions based on information from the text.” The same skill is used over and over in algebra, geometry and calculus. In Language Arts, by 11th grade, Pennsylvania expects that a student will be able to “Explain, interpret compare, describe, analyze, and/or evaluate the relationships (of characters, including subjects of biography) within fiction and literary nonfiction.” Biographies and autobiographies of mathematicians offer just such subject matter. When students are able to select from a range of biographical material, their comparisons can become classroom presentations and be linked to the concepts discovered and developed by these historical figures.

Coming from the math perspective, where young people are asked to “Determine the validity of an argument,” the ELA echoes with “Explain, interpret, describe and/or analyze the use of facts and opinions to make a point or construct an argument in nonfictional text.” Attention to the use of “graphing and other types of mathematical representations to communicate observations, predictions, concepts, procedures, generalizations, ideas and results” are useful in the English classroom where the documented struggle with informational text can be addressed with articles of interest from the daily newspaper and the web.

Objectives

My first objective is the same overarching goal I have had throughout my years as a teacher: to assist students to develop both skill in and love of an academic subject. The first, of course, is considerably more measurable; the second is rarely acknowledged or encouraged in state standards. To provide opportunities to improve in and to find joy in the academic subject where I am not certified might be a daunting challenge. Nevertheless, there are growing signs that the blending of inquiries, exercises, and endeavors which combine these two disciplines in contemporary pedagogy is widespread and increasing.

My own professional organization, the National Council of Teachers of English provides quite a large number of approaches advocating the joint presentation of these two languages. The National Science Foundation funded the development of an academic

approach with its Mathematics Across the Curriculum (MAC) project, with the goal of “creating curricula to enable their students to experience the quantitative and mathematical aspects of many disciplines.” (www.math.dartmouth.edu). Though not stated explicitly, it seems quite likely that even literature might be one of those disciplines.

Bringing mathematics into the English classroom can provide an increase in student comfort with both understanding mathematical concepts and expressing them through writing, as articulated by Deann Leoni in her introduction to “Algebra the Write Way:” writing might “reduce the anxiety about learning mathematics.” In the English course, readings and composition took “mathematics and quantitative reasoning” as the content and conversely, the assigned readings and writing could “support and reinforce the mathematical concepts.” As students work through their assignments, their ability to analyze problems and the requirement to reflect concretely through writing can provide a solid grounding for both assessment and future learning.

Two math concepts have proven problematic to students at A. Philip Randolph: graphing co-ordinates and utilization of formulae. By practicing both skills outside geometry and pre-calculus class, with an emphasis on developing their own examples from literary contexts, students can reinforce and strengthen their confidence in applications for other disciplines: the sciences and social studies; for advanced studies in college; and for real-world applications into their adult lives and careers.

Two facets of the English classroom may provide an additional boost to competence and confidence: the absence of calculators and the routine of essay writing. As a proctor for our annual Pennsylvania State System of Assessment, I have observed a common propensity among test-takers when they are working the math sections. Once the five calculator-forbidden problems are completed and sealed off, students begin entering numbers immediately upon or sometimes it seems even before reading the instructions for the math queries. This happens predictably, in spite of the clear reminder in the test instructions that none of the problems actually require the use of a calculator. As the Glatzers, authors of the AMSCO test prep book remind students: “If you try to use the calculator for every question, you will waste too much time.” In addition, where the workings of the problem are completed on the calculator, but are asked to be shown in writing in the answer booklet, students lose points. With the routine practice or writing out the steps in the thinking process for almost all English assignments, answering the open-ended math questions may come to be seen as routine as well.

Strategies

Through a series of activities that would include shining a spotlight on math in literature (poetry meter, geometry in descriptions of setting, Lewis Carroll logic problems); creating essays on algebra and pre-calculus; surveying, analyzing and writing informational texts (newspaper, magazine and website articles) covering areas of interest for high school scholars (entertainment and sports), students will grow more comfortable and competent in blending the two disciplines, with the possible added benefit of bolstering math scores.

Statistics on poverty and child malnutrition can be gained both from Jonathan Swift's satiric essay, "A Modest Proposal," but comparisons can be made with similar social challenges in modern-day Ireland: "Irish Beggars Told to Mind Manners." (See Mary Jordan in the *Washington Post*.) Seniors reading *The Stranger* can create metric conversion charts that will both dramatize the distance from the protagonist's home to his mother's nursing facility and the distance between prisoner and visitor in the jailhouse, as well as re-enforce the knowledge needed for students in auto technology. Measurement and construction of model settings: house, yard and neighborhood will create vivid images that inform the background for characters in *A Raisin in the Sun*, *Fences*, *Death of a Salesman* and *To Kill a Mockingbird*.

Student experts can be developed by offering young people the opportunity to present mini lessons to their classmates which blend career path projects in carpentry, as an example, with concept and measurement skills sharpened in geometry. W.W. Sawyer emphasizes that "Mathematical thinking is a tool. There is no point in acquiring it unless you mean to use it." (*Mathematician's Delight*, 7) Every student at A. Philip Randolph is substantially more knowledgeable in their shop area than almost any one of her or his academic teachers and most of their classmates studying other disciplines. Pennsylvania state test materials already provide discreet renderings of the math concept anchors present in the 11th grade math test. Practical and public application of these ideas will go far to put students at ease in the high stakes test atmosphere. By offering a variety of genres in literature (biography, mystery, poetry) where math concepts can be found and practiced, our school can enrich the life skills and leisure reading proclivities for students far into their future.

A culminating individual research project selected from a differentiated instructional choice board will provide an opportunity to gather information from sources already extant. John Allen Paulos' *Innumeracy* offers accessible narratives on topics like "Probability and Coincidence." Students can compare their own impressions of the relative likelihood of events happening (meeting someone with the same birthday) or power of relatedness (Zodiac signs predicting personality) with well-researched data. In *A Mathematician Reads the Newspaper*, Paulos provides guideposts for locating and analyzing data on wars, gambling and the prevalence of computers in diverse parts of the world. Individuals may consider selecting one of the 179 citations on the National Council of Teachers of English that appear when Googling "English and Math." *The New York Times* Learning Connection can provide individual students access to articles relating to their own interests or, as member of a cooperative learning group, they may select one aspect of the September 16, 2008 piece on "Gut Instinct's Surprising Role in Math" and investigate it from prediction through research to classroom presentation; and then establish a personal area of expertise to share with classmates.

By interviewing math teacher colleagues in my building, I have confirmed that graphing and making the transition from verbal to numerical expression are among the most troublesome areas for students. Competence and comprehension may be improved by approaching concepts through the language arts door. Given my own earlier struggles

with the concepts, I might prove to be a role model of sorts by my willingness to share in the challenge along with them. Notably, teachers at Philadelphia's School for the Future have already developed a 9th grade curriculum that seeks to elucidate math concepts through reading the novel *Kite Runner*.

Consistent reference to the School District of Philadelphia's *Strategies Guide – Resources for Effective Teaching* provides a framework for organizing lessons and projects. Citing research in education, the guide recommends commencing with clear high expectations. In this case, I will assure students that they have the capability to combine the disciplines of literature and mathematics to forge a pathway both to rigorous discussion and to higher education. Attention to culturally relevant instruction will play out in each portion of the presentation, both in selection or research subjects and in culling of current news stories featuring diversity (gender, ethnicity, religion, ability, sexual orientation, all protected and encouraged to be considered by Philadelphia School District Policy 102) among individuals and communities. Cultural relevancy also plays a part in the utilization of cooperative learning and calling forth and honoring the “fund of knowledge in families and the community.” (*Strategies Guide*, 1-5) Students respond well and gain more secure academic footing through “Instructional Conversations” that include “cognitively guided instruction” and “technology-enriched instruction.” The “Caring Relationships” and “Parent and Community Involvement” that round out results-rich teaching are essential to twin underpinnings of true learning: comfort and confidence. Essentials were stated another way by Radcliffe's president in 1996 at a Harvard freshman orientation: student success is based on three anchors: resilience, healthy resistance and competence.)

Lesson plans may follow the format from the School District of Philadelphia *Strategies Guide* in the framework of “Instructional Hierarchy.” Acquisition represents the beginning stage where knowledge is sketchy and skill hesitant. As the students work with the materials, whether numerical or literary, the work begins to flow with fluency. Once in command, students can extend their learning to other examples or fields through generalization. Finally, with the confidence established from the first three steps, students can be flexible in the application of their skill, utilizing it in dramatically different situations through adaptation.

The goal of differentiation will be met through the provision of alternative assessments – a variety of means for measuring understanding; graduated rubrics – moving from the simple to the complex; peer tutoring – coaching in co-operative learning groups; and independent study – the pursuit of individual interests in unique formats.

Activities

Lesson #1 Biographies and Math: Mathematicians as Human Beings, Crusaders, etc.
Time Requirement: Three class periods.

Materials needed: Journal books, chart paper and markers or smart board, book biographies (library-permitting) and/or web access.

By surveying a series of websites, online and printed newspaper and magazine articles and biography books, students will collect a varied list of mathematicians through the ages and around the world. A beginning list might include Euclid (geometry for the 10th graders), Venn (inventor of one of the most ubiquitous comparison charts in modern-day education), Newton (humanist and inventor), Benjamin Banneker (African freeman who challenged his society's strictures and severities), Charles Dodgson (the whimsical author of children's literature), Mary Wright and Robert Moses (civil rights activists and math advocates), and Charles Nalley (gay teacher in New York City).

1. Provide students with a book or web-based list of prominent mathematicians throughout history. Students working in pairs select a mathematician unique to them. One student will be the biographical presenter, the other the math specialty presenter.
2. Accessing print or web source (older students consult at least two sources), students take rough notes in journal books. Report preliminary findings to class. Record three clarifying questions at end of notes.
3. Partners assist one another in determining which information is best for display and how to phrase bullet points. Biographical and math contribution data are both included.
4. Conclusion of each presentation should address where the mathematician's contribution connects with issues covered in courses students have taken to date.

Lesson #2 Blending Student Interest with Informational Reading and Linear Equations.

Materials needed: collection of news articles combining student interest (see Student Resources) and multiple numerical permutations or web links to articles if classroom sets of computers are available. Journal books, chart paper and markers or smart board, access to Drexel University op on graphing via a chameleon pointing the way to where co-ordinates are placed.

Time Requirement: Five class periods, scheduled at beginning or end of curriculum unit.

As a means of meeting reading, writing, listening and speaking standards for comprehension of informational writing, students will select from a broad array of newspaper and magazine articles relating to their personal, recreational and career interests. Examples include the debate over which sport, basketball or baseball is the true national pastime, how effective varied sex education courses are, measuring success in the wars in Iraq and Afghanistan, and analyzing our economy's meltdown, foul shot stats over the last 50 years, the growth of Facebook on the internet, the future of the U.S. auto industry, and others.

1. Students select an article of greatest interest – individually, in pairs or in small groups.

2. Make a prediction on what the data will show. Record in journal. Shared read-outs.
3. Identify and record in journal books the data amenable to expression in a linear equation, e.g. number of people attending a particular professional sport co-ordinated with the different years when the numbers were gleaned.
4. Create and work out the equation, label the graph, record co-ordinates on large chart graph paper or on smart board. The computer app providing a chameleon moving across, up and down the grid can provide amusement and aid comprehension.
<https://mste.uiuc.edu/pavel/java/chameleon/basic/index.htm>
5. Make a direct teaching presentation to the class which delineates the importance of correct co-ordinate identification and placement and how to read and record the result in narrative form.
6. Extension: Students may move on to their own search for numeracy-rich news items as a one-time follow-up or on a continuing basis throughout the year.

Lesson #3 Research Intersections: Wandering Through Wikipedia

Time Requirement: Occasional as opening enticement or end of class stimulation.

Materials Needed: Journal books; chart paper; web access.

Given a starting point of choice from a variety of math concepts, students will create a path of inquiry as they identify in each article read the possible literary links to math and math links to literature. Each step in the journey will be recorded in a journal, including definition of term or explanation of link to math, and then on an organization chart to demonstrate the manner of linkage.

Sample Journey: Beginning: linear equation, extrapolation, uncertainty (philosophy, physics, psychology), gambling, sports betting, Pittsburgh Steelers, Pittsburgh PA, local dialect, New York Times, comics, literary technique, ticking clock, DEAD END!

Lesson # 4 Interdisciplinary Project (Academic and Career Path) at the Crossroads of Math and Literature ("The Walrus and the Carpenter"):

Materials needed: Copies of "The Walrus and the Carpenter"; textbooks for individual career path of each student, or one per shop-centered cooperative learning group.

"The Walrus and the carpenter were walking close at hand; they wept like anything to see such quantities of sand. If this could all be cleared away, they said, it would be grand. If seven maids with seven mops swept it for half a year, do you suppose, the walrus said, that they could get it clear? I doubt it said the carpenter and shed a bitter tear."

Lewis Carroll

Students would first write a formula to express the question. The size of the beach would be established along with the type and weight per unit of sand. Is there more than one way to complete this task? Create a graph where x is time and y is the number of workers.

Write a narrative explaining how the problem, if organized for solution, would involve mathematical calculations in the student's career path, e.g.

1. Carpentry (represented by the pessimist of the literary pair): designing and building living quarters for the workers in the seashore environment;
2. Health Related Technology: blood pressure measuring of the workers;
3. Culinary: menus for feeding the number of workers for the amount of time;
4. Electrical construction: design lighting for the living quarters and outdoor lights for possible night time sweeping work;
5. EMS: medical equipment needed for workers who pass out from exhaustion or sunstroke;
6. Automotive technology: recommendations for types of engines required in support vehicles (street sweepers, earth movers, humvees, jeeps)
7. Preventive and restorative body work for exteriors damaged by the salt air.

Culminating Activity: Display in main hallway of each career path's task and solution, including research report, narrative, and mathematical formulae with elucidation. Schedule a gallery walk for each advisory.

Lesson #5 Mathematics and Poetry

Materials required: current literary anthology; variety of poetry books from school and/or public library. Journal books, computer word processor; internet access; color printer.

Time Requirement:

1. From anthology, literary terms guidebook or web source, establish definitions for iambic pentameter (cousin to the geometric pentagon), monometer, dimeter, and tetrameter, trochaic, anapestic, dactylic, spondee. Record in journal and on classroom wall.
2. Begin by copying, then marking through mathematical diagram, one or more examples from print or web sources. Students will create their own numerically charted poems which in turn may be published for an end-of-year magazine.

3. Locate and record descriptions and examples for:
 - a. cinquain

(<http://teams.lacoe.edu/documentation/classrooms/amy/algebra/5-6/activities/poetry/cinquain.html>) and/or

Among the sources for the cinquains is:

http://www.flanaganhighschool.com/student_projects/Mogilka3/Cinquain%20Assignment.htm

- b. sonnets

<http://www.sonnets.org/>

3. haiku

<http://www.everypoet.com/haiku/default.htm>

<http://haikuprofessor.wordpress.com/category/math/>

(Surprise source: Richard Wright)

Begin by copying, then marking through mathematical diagram, one or more examples from print or web sources. Students will create their own numerically charted poems which in turn may be published for an end-of-year magazine.

4. Access definitions/explanations of Fibonacci numbers. Add individual examples that meet definition.

From Google Books, locate *It* by Scandinavian Inger Christensen. Select one poem as a model to follow. Describe the poem's comportment or divergence from the strict mathematical term. Write a poem imitative of the one selected, substituting appropriate words of the student's choice.

http://books.google.com/books?hl=en&id=jICuljIcQtcC&dq=Inger+Christensen,+it&printsec=frontcover&source=web&ots=l6fXEuXp4D&sig=trEBKqQhsUH4H0-aYUcKxicpfVw&sa=X&oi=book_result&resnum=3&ct=result#PPR9,M1

Accessed February 1, 2009

Lesson #6 Amplifying and Linking Math Elements in Literature

Materials Needed: Class sets of essay, play, or novel. Chart paper. Journal Books.

Time requirement: One class period in connection with study of the particular work.

Procedure: Gather mathematical references from text; design a task or create a formula that incorporates the numbers in the narrative; write a report on how the mathematics and/or sketching, marking and measuring tasks help convey the theme of or clarify the work of literature.

a. "A Modest Proposal," "Irish Beggars Told to Mind Manners." (See Mary Jordan in the *Washington Post*.) Swift: Estimated cost of feeding a child for one year: two shillings. Number of souls (people) in Ireland: one million and a half. Couples of child-bearing age: two hundred thousand. Number able to support their children: thirty thousand. There are one hundred seventy thousand potential parents. Miscarriages and deaths in early childhood: fifty thousand. Poor children remaining: one hundred twenty thousand. Compare contrast content and tone of the two sources: fiction and informational.

b. *The Stranger* provides opportunities for the creation of metric conversion charts that will both dramatize the distance from the protagonist's home to the town where his

mother's nursing facility is located (Google distance from Algiers to Marengo), the distance from the town bus stop to the nursing home, the distance the mother's gentleman friend lagged behind the funeral procession and the distance between prisoner and visitor in the jailhouse. (4, 16, 73)

Students can estimate living expenses by converting the 20 francs a day for food, 3000 francs for the room, 600 overall for food, incidentals accumulating to a total of 1,000 francs paid by the protagonist's neighbor for the upkeep of his live-in friend. (30)

Estimate the physiological effects of a liter of wine. (31)

c. Measurement and construction of model settings: house, yard and neighborhood in *A Raisin in the Sun*, *Fences*, *Death of a Salesman* or *To Kill a Mockingbird*.

In cooperative learning groups of five, assign tasks: 1., reader (aloud), 2. vocabulary elucidator, 3. sketch artist and 4. draftsman: measuring and marking dimensions to scale. 5. presenter. When drawings are complete, post on classroom wall and allow presenter to elucidate the created product.

d. Logic and memorization techniques from Lewis Carroll via his *Complete Works*. A plethora of additional charming challenges may be extracted from Robin Wilson's *Lewis Carroll in Numberland*.

(1) babies are illogical;

(2) Nobody is despised who can manage a crocodile;

(3) Illogical persons are despised.

Univ. "persons"; a=able to manage a crocodile; b=babies; c=despised; d=logical

Create formula, write conclusions and create further examples.

Lesson #7 Fun and Games

Materials needed: game books, newspaper puzzles, internet. Journal books to record both puzzle and triumph.

Time Requirement: One introductory period, then occasionally as time allows, particularly on Fridays, after examinations, or on days before holidays.

Students will study mathematics in word games (Scrabble) and words in math games (at the very least providing a narrative for the creation of a magic square tied to math and the means of creating a magic square relating to words), Sudoku, KenKen and Cryptograms.

Identify at least one student who is familiar with or willing to learn each game. That student will then train members of her/his cooperative learning group. Each group will take part of a period to solve a puzzle or play the game. Record in journals the steps followed and occurrences of success and/or frustration. Share with class. Rotate games so that each student gains experience in all the offerings.

<http://www.mste.uiuc.edu/pavel/java/chameleon/basic/index.htm>

<http://mathforum.org/alejandre/magic.square.html>

Parting note: NPR reporter and author David Ulsher, author of the new book, *From Square One: A Meditation -- With Digressions – on Crosswords*, noted in an interview broadcast on July 1, 2009, that this pastime has particular appeal for those with math or music inclinations and that, lacking a narrative, this popular kind of puzzle resembles, more closely than any other form a literature, a poem. Norman Mailer’s offering of a simile was that working crosswords was most like “combing his brain.”

#

Teacher Resources

Access to the Core Curriculum: Strategies Guide. School District of Philadelphia, 2006.

Appelbaum, Peter. Mathematics Education. Excerpt from *Critical Thinking and Learning:: An Encyclopedia for Parents and Teachers*, Joe Kincheloe and Danny Weil (eds.) Greenwood Press, 2004.

Starting with the observation that majoring in math does not ipso facto produce students adept in critical thinking applicable to myriad life and employment situations, Appelbaum advocates utilizing youngsters’ already-acquired thinking skills to learn the math operations that, coincidentally, match the skill needed for reading as well.

Ball, Deborah Loewenberg, Heather C. Hill, and Hyman Bass. “Knowing Mathematics for Teaching: Who Knows Mathematics Well Enough to Teach Third Grade, and How Can We Decide?” *American Educator*: Fall 2005, 13-19.

Bentley, Peter J. *The Book of Numbers: The Secret of Numbers and How They Changed the World*. Buffalo: Firefly, 2008.

Comprehensive, beautifully illustrated, and though published recently, still lacking (and upfront admittedly) in female mathematics figures. Helpful sections on biographies, and superstitions. Boxed interest items like Russell’s and Barber’s paradoxes

Carlan, Audrey. *Everyday Math for the Numerically Challenged*. Franklin Lakes NJ: Career Press, 1998.

More concerned with truly everyday than figurative, but useful as grounding in the basics: fractions, decimals, percents, ratios and proportions.

Dunham, William. *Journey through Genius: the Great Theorems of Mathematics*. New York: Wiley, 1990.

Dunham views biography, the close acquaintance with mathematicians as living, breathing, struggling human beings. As he chronicles the lives of these men beginning with Hippocrates and Euclid, he helps the general reader understand both the content and the import of their discoveries.

Long, Littleton, ed. *Writing Exercises from Exercise Exchange*. Urbana: NCTE, 1976. In a vocabulary-building exercise, Littleton embeds a math variations exercise meant to make the student with numeric talent feel affirmed.

Paulos, John Allen. *Innumeracy: Mathematical Illiteracy and Its Consequences*. New York: Hill and Wang, 1988.

Paulos looks at aspects of everyday life: ordering in restaurants, calculating baseball stats, and teachers fearing their students' brightness, as places and reasons for mathematics struggles. He provides practical advice on how to improve both education for the young and coping for those out in the world.

_____. *Beyond Numeracy: Ruminations of a Numbers Man*. New York: Knopf, 1991.

Written in Paulos' signature conversational style, the book contains numerous sections devoted to the intersection of numeracy and literacy: "Combinatorics, Graphs and Maps;" "Mathematical Folklore; Humor and Mathematics;" "Oulipo—Mathematics in Literature;" "Tautologies and Truth Tables;" "Variables and Pronouns."

Plesnarski, Cathleen. "Integrating Math into CTE." Presentation at the Governor's Institute for Improving Literacy in CTE Education. Allentown PA 2006, 2007.

In both of her conference Power points, Plesnarski helps career path teachers identify which math concepts are essential for effecting their curricula and by extension, helps academic teachers see where they can partner with their colleagues to clarify numbers problems for all students. PSSA anchors for the basis of the exercise.

_____. "Reading Math Word Problems." Ibid.

Sawyer, W.W. *Mathematician's Delight*. New York: Pelican, 1943

Sawyer proves to English teachers that mathematicians understand the value and beauty of literature. He addresses as well the need for teaching not for a dry test but for real-life situations which are destined to diverge from careful classroom exercises.

_____. *Prelude to Mathematics*. Middlesex: Penguin, 1957

Although hoary in time, Sawyer's humanistic approach to mathematics shines through, offering encouragement and solace: "Nearly every mathematical discovery depends upon

a fairly simple idea. Textbooks often conceal this fact.” He advocates for establishing student confidence and skill in facing “unforeseen situations.”

Seiter, Charles. *Everyday Math for Dummies*. Hoboken: Wiley, 2006

In accessible but respectful language that belies the title, Seiter provides both background and practical steps for coping with areas adults need help with (checkbooks, investments, gambling) but also presents clear reviews of high school math courses that current students might find helpful.

Wilson, Robin. *Lewis Carroll in Numberland: His Fantastical Mathematical Logical Life*. London: Norton, 2008.

Carroll is the quintessential purveyor of the world where numbers and words live in concert. This biography provides detailed accounts of Lewis’ imaginative thinking and many opportunities for participating in the puzzles and games the children’s writer developed throughout his life.

Student Resources

Adams, William, Peter Conn and Barry Slepian. *Afro-American Literature: Drama*. New York: Houghton Mifflin, 1970.

Three plays: *A Raisin in the Sun*, *A Land Beyond the River* and *Purlie Victorious*. Each includes a sketch of the scene design that can serve as a model for and a basis for adding and calculating dimensions algebraically and geometrically.

Angier, Natalie. “Gut Instinct’s Surprising Role in Math.” *The New York Times*: Sept 16, 2008, Science 16.

Angier shows that students can develop competence and confidence in approaching numeracy issues.

Blow, Charles M. “Love Shouldn’t Hurt.” *The New York Times*: Feb. 12, 2009, Op-ed.

_____. “Watch the Tone in Washington.” *The New York Times*: Feb 7, 2009, A ____

_____. “Pot, Meet Kettle.” *The New York Times*: June 6, 2009.

Here is a challenging question: can one quantify love? Tone? Supreme Court nominee bias? Blow suggests yes. Blow’s numerical renderings of current hot-button issues are a regular feature of the *Times* op-ed page. Additional columns may be found at <http://blow.blogs.nytimes.com/>

Campbell, Jason, Michael O’Hanlon, Jeremy Shapiro and Amy Unikewicz. “Op-Chart: The States of Iraq and Afghanistan.” *The New York Times*, Mar 20, 2009.

All three articles provide data that might engage students as they approach graphing exercises in English class.

Carroll, Lewis. "A Selection from symbolic Logic." *The Complete works of Lewis Carroll*. New York: The Modern Library, 1965.

Original presentations of the combined word and number play that Dodgson devoted himself to throughout his life. Of particular interest: logic problems steeped in whimsy.

Chang, Kenneth. "John R. Stallings Jr., 73, Obituary; Partly Solved Math Puzzle." *The New York Times*: Jan 19, 2009, A18.

An article for use with the study of mathematicians' biographies. They didn't all live 2000 years ago.

Curtis, Bryan. "The National Pastime(s)." *The New York Times*: 02/01/2009, 5.

Stats comparing baseball, football and basketball. Good source for classroom debate and graphing.

Dominus, Susan. "Most of the Seventh Grade Will Be at the Commitment Ceremony." *The New York Times*: Mar 23, 2009.

Another window into the humanity of mathematicians. In this case, students in New York are invited to their gay teacher's ceremony of union.

Eastway, Rob and Jeremy Wyndham. *Why Do Buses Come in Threes? The Hidden Mathematics of Everyday Life*. New York: Wiley, 1998.

Humorous and engaging, this text includes sections that could well spark student interest: "How many people watch Friends?" "How do you explain a coincidence?" "What's the best view of the Statue of Liberty?" "How do you keep a secret?"

Fox, Margalit. "Inger Christensen, 73, Scandinavian Poet, Obituary." *The New York Times*: Jan 12, 2009, B9.

The life story of a poet who based one of her major creations on a mathematical concept. Portions of her book "It" are available in Google books.

Gaffney, Matt. "I was Told There Would Be No Math." www.slate.com/toolbar.aspx?action=print&id=2211595. Accessed 2/21/2009.

Every English teacher's hope as they pile on the literature courses. Life makes no such promise and Gaffney encourages participation in the latest newspaper game, KenKen.

Gammage, Jeff. "Inaugural squeeze on the Mall? The biggest crowd ever could gather on Jan. 20." *Philadelphia Inquirer*, December 8, 2008, 1.

The event whose preparation and appreciation required knowledge in every academic discipline known to high schoolers.

Glatzer, David J. and Joyce Glatzer. *Preparing for the Pennsylvania PSSA Mathematics: Grade 11*. New York: AMSCO, 2005.

Although early for 10th graders and late for seniors, this test prep book provides all the basics in philosophy, formulae and practice that both sets of students can use, either in preparation or for review from number sense through calculus. Particularly valuable for students lacking confidence for ‘calculator-neutral’ questions: “By the time you have put all the data into the calculator, you could have solved the problem mentally.”

Graves, Sarah. *Unhinged: A Home Repair Is Homicide Mystery*. New York: Bantam, 2003.

The heroic life of a carpenter in a murder mystery from a series that celebrates the building trades.

Henry, Neil. “35 Who Made a Difference: Robert Moses.” *Smithsonian Magazine*, Nov. 1, 2005.

A civil rights activist who identifies mastery of algebra as of equivalent importance with the right to vote.

Juster, Norton. *The Phantom Toll Booth*. New York: Random House 1961. Although aimed at middle schoolers, 10th graders who have limited reading experience may enjoy the fantasy, word play, conflict between numbers and antipathy for learning presented in chapters designated Dictionopolis, The Dodecahedron Leads the Say, and This Way to Infinity.

Lewis, Michael. “Money(Basket)Ball!” *The New York Times Magazine*: 02/15/2009, 26ff.

A guaranteed topic of interest for high school students – or should I say topics.

Lohr, Steve. “All May Not Be Lost For the American Car.” *The New York Times*: 02/01/2009, 4.

Stats that students in auto technology will find of interest as they calculate the future of American cars and their attendant jobs.

Nocera, Joe. “Risk: What Led to the Financial Meltdown: Mathematical Models used to Evaluate Wall Street Trades? Or Bankers Who Misread Or Ignored Them?” *The New York Times Magazine*: Jan 4, 2009, 26-33, 46, 50-51.

Not math, but its usages and abuses, lead to our current debacle. Here students can get a grip on a situation that has eluded the comprehension of their elders.

Paulos, John Allen. “How to Measure a Cheshire Grin? (Book Review: *Lewis Carroll in Numberland*). *The New York Times Book Review*: 02/01/2009.

Paulos writes with keen appreciation for all of Lewis Carroll’s (and Charles Dodgson’s) gifts, providing enticing tidbits from the just-published mathematical biography.

_____. *A Mathematician Reads the Newspaper*. New York: Basic Books, 1995.

Amusing yet serious examples of how the popular press misleads sometimes deliberately, and sometimes unintentionally. He provides accessible and brief anecdotes for the

classroom (politics, entertainment, sports, health and other fields) that dramatize the ways numbers and their applications can lead us astray. Here is clear encouragement for teachers to utilize newspapers on a regular basis and possibly prevent their disappearance.

Porter, Eduardo. "Ponzi Schemes: The Haul Gets Bigger, but the Fraud Never Changes." *The New York Times*: Dec 27, 2008, A24.
Understanding and warning about this recurring blight.

Sherwood, Ben. "The Wrong (and Right) Lessons of the Continental Plane Crash." http://www.huffingtonpost.com/ben-sherwood/three-real-lessons-of-the-b_166891.html?vi...
Look here for reasons to tremble every time one enters an automobile.

Sullivan/Anderson, Amy. "How to End The War Over Sex Ed." *Time*: 03/30/2009, 40-43
Statistics used to measure how to discuss and provide effective life lessons for the young.

Thurman, Judith. "Spreading the Word: The new Scrabble mania." *The New Yorker*: Jan 19, 2009, 26-31.
Stats and history about a word board game. Never boring.

Wright, Richard. *Haiku: This Other World*. New York: Anchor, 1998.
Here are many delightful models of a poetry form defined by numbers of syllables that lead to the expression of one theme.

"A Modern History of Blacks in Mathematics."
www.math.buffalo.edu/mad/madhists.html.
Role models for students in any high school.

Appendix A English Language Arts Standards/Anchors

ASSESSMENT ANCHORS

R11.A.1 Understand fiction appropriate to grade level.

ELIGIBLE CONTENT

<p>R11.A.1.1 Identify and apply the meaning of vocabulary.</p>	<p>R11.A.1.1.1 Identify and/or apply meaning of multiple-meaning words used in text.</p> <p>R11.A.1.1.2 Identify and/or apply a synonym or antonym of a word used in text.</p>
<p>R11.A.1.2 Identify and apply word recognition skills.</p>	<p>R11.A.1.2.1 Identify how the meaning of a word is changed when an affix is added; identify the meaning of a word from the text with an affix.</p> <p>R11.A.1.2.2 Define and/or apply how the meaning of words or phrases changes when using</p>

context clues given in explanatory sentences.

R11.A.1.3 Make inferences, draw conclusions, and make generalizations based on text.

R11.A.1.3.1 Make inferences and/or draw conclusions based on information from text.

R11.A.1.3.2 Cite evidence from text to support generalizations.

R11.A.1.4 Identify and explain main ideas and relevant details.

R11.A.1.4.1 Identify and/or explains stated or implied main ideas and relevant supporting details from text.

Note: Items may target specific paragraphs.

****1.1.11.G** Demonstrate after reading understanding and interpretation of both fiction and nonfiction text, including public documents.

****1.2.11.A** Read and understand essential content of informational texts and documents in all academic areas.

****1.3.11.F** Read and respond to fiction and nonfiction including poetry and drama.

1.1.11.E Establish a reading vocabulary by identifying and correctly using new words acquired through the study of their relationships to other words.

****1.1.11.F** Understand the meaning of and apply key vocabulary across the various subject areas.

R11.A.1.6 Identify, describe, and analyze genre of text.

R11.A.1.6.1 Identify and/or analyze the author's intended purpose of text.

R11.A.1.6.2 Explain, describe, and/or analyze examples of text that support the author's intended purpose.

R11.A.2 Understand nonfiction appropriate to grade level.

R11.A.2.1 Identify and apply the meaning of vocabulary in nonfiction.	R11.A.2.1.1 Identify and/or apply meaning of multiple-meaning words used in text. R11.A.2.1.2 Identify and/or apply meaning of content-specific words used in text.
R11.A.2.3 Make inferences, draw conclusions, and make generalizations based on text.	R11.A.2.3.1 Make inferences and/or draw conclusions based on information from text. R11.A.2.3.2 Cite evidence from text to support generalizations.
R11.A.2.5 Summarize a nonfictional text as a whole.	R11.A.2.5.1 Summarize the major points, processes, and/or events of a nonfictional text as a whole.
R11.A.2.6 Identify, describe, and analyze genre of text.	R11.A.2.6.1 Identify and/or describe the author's intended purpose of text. R11.A.2.6.2 Explain, describe, and/or analyze examples of text that support the author's intended purpose.

R11.B.1.1 Interpret, compare, describe, analyze, and evaluate components of fiction and literary nonfiction.

R11.B.1.1.1 Explain, interpret, compare, describe, analyze, and/or evaluate the relationships within fiction and literary nonfiction.

Character (may also be called narrator, speaker, subject of a biography):

Explain, interpret, compare, describe, analyze, and/or evaluate character actions, motives, dialogue, emotions/feelings, traits, and relationships among characters within fictional or literary nonfictional text.

Explain, interpret, compare, describe, analyze, and/or evaluate the relationship between characters and other components of text.

Setting:

Explain, interpret, compare, describe, analyze, and/or evaluate the setting of fiction or literary nonfiction.

Explain, interpret, compare, describe, analyze, and/or evaluate the relationship between setting and other components of the text.

Plot (May also be called action):

Theme:

Explain, interpret, compare, describe, analyze, and/or evaluate the theme of fiction or literary nonfiction.

Explain, interpret, compare, describe, analyze, and/or evaluate the relationship between the theme and other components of the text.

Tone, Style, Mood:

Explain, interpret, compare, describe, analyze, and/or evaluate the tone, style, and/or mood of fiction or literary nonfiction.

Explain, interpret, compare, describe, analyze, and/or evaluate the relationship between the tone, style, and/or mood and other components of the text.

Symbolism:

Explain, interpret, compare, describe, analyze, and/or evaluate the use of symbolism in fiction or literary nonfiction.

Explain, interpret, compare, describe, analyze, and/or evaluate the relationship between symbolism and other components of the text.

R11.B.1.2 Make connections between texts.

R11.B.1.2.1 Explain, interpret, compare, describe, analyze, and/or evaluate connections between texts.

R11.B.2 Understand literary devices in fictional and nonfictional text.

R11.B.2.1 Identify, interpret, describe, and analyze figurative language and literary structures in fiction and nonfiction.

R11.B.2.1.1 Identify, explain, interpret, describe, and/or analyze examples of personification, simile, metaphor, hyperbole, satire, imagery, foreshadowing, flashbacks and irony in text.

R11.B.2.1.2 Identify, explain, interpret, describe, and/or analyze the author's purpose for and effectiveness at using figurative language in text.

R11.B.2.2 Identify, interpret, describe, and analyze the point of view of the narrator in fictional and nonfictional text.

R11.B.2.2.1 Identify, explain, interpret, describe, and/or analyze the point of view of the narrator as first person or third person point of view.

R11.B.2.2.2 Explain, interpret, describe, and/or analyze the effectiveness of the point of view used by the author.

R11.B.3 Understand concepts and organization of nonfictional text.

ELIGIBLE CONTENT

R11.B.3.1 Interpret, describe, and analyze the characteristics and uses of facts and opinions in nonfictional text.

R11.B.3.1.1 Explain, interpret, describe, and/or analyze the use of facts and opinions to make a point or construct an argument in nonfictional text.

<p>R11.B.3.2 Distinguish between essential and nonessential information within or between texts.</p>	<p>R11.B.3.2.1 Identify, explain, and/or interpret <u>bias and propaganda techniques in nonfictional text</u>.</p> <p>R11.B.3.2.2 Explain, describe, and/or analyze the effectiveness of bias and propaganda techniques in nonfictional text.</p>
<p>R11.B.3.3 Identify, compare, explain, interpret, describe, and analyze how text organization clarifies meaning of nonfictional text.</p>	<p>R11.B.3.3.1 Explain, interpret, and/or analyze the effect of <u>text organization</u>, including the use of headers.</p> <p>R11.B.3.3.2 Explain, interpret, and/or analyze the <u>author's purpose for decisions about text organization and content</u>.</p> <p>R11.B.3.3.3 Explain, interpret, and/or analyze graphics and charts, and/or make connections between text and the content of graphics and charts.</p> <p>R11.B.3.3.4 Identify, explain, compare, interpret, describe, and/or analyze the <u>sequence of steps in a list of directions</u>.</p>

Appendix B Mathematics Standards

2.1. Numbers, Number Systems and Number Relationships

- A. Use operations (e.g., opposite, reciprocal, absolute value, raising to a power, finding roots, finding logarithms).

2.2. Computation and Estimation

- 3. Develop and use computation concepts, operations and procedures with real numbers in problem-solving situations.
- 4. Use estimation to solve problems for which an exact answer is not needed.
- 5. Construct and apply mathematical models, including lines and curves of best fit, to estimate values of related quantities.
- 6. Describe and explain the amount of error that may exist in a computation using estimates.
- 7. Recognize that the degree of precision needed in calculating a number depends on how the results will be used and the instruments used to generate the measure.
- 8. Demonstrate skills for using computer spreadsheets and scientific and graphing calculators.

2.3. Measurement and Estimation

- A. Select and use appropriate units and tools to measure to the degree of accuracy required in particular measurement situations.
- B. Measure and compare angles in degrees and radians.
- C. Demonstrate the ability to produce measures with specified levels of precision.

2.4. Mathematical Reasoning and Connections

- A. Use direct proofs, indirect proofs or proof by contradiction to validate conjectures.
- B. Construct valid arguments from stated facts.
- C. Determine the validity of an argument.
- D. Use truth tables to reveal the logic of mathematical statements.

E. Demonstrate mathematical solutions to problems (e.g., in the physical sciences).

2.5. Mathematical Problem Solving and Communication

- A. Select and use appropriate mathematical concepts and techniques from different areas of mathematics and apply them to solving non-routine and multi-step problems.
- B. Use symbols, mathematical terminology, standard notation, mathematical rules, graphing and other types of mathematical representations to communicate observations, predictions, concepts, procedures, generalizations, ideas and results.
- C. Present mathematical procedures and results clearly, systematically, succinctly and correctly.
- D. Conclude a solution process with a summary of results and evaluate the degree to which the results obtained represent an acceptable response to the initial problem and why the reasoning is valid.

2.6. Statistics and Data Analysis

- A. Design and conduct an experiment using random sampling. Describe the data as an example of a distribution using statistical measures of center and spread. Organize and represent the results with graphs. (Use standard deviation, variance and t-tests.)
- B. Use appropriate technology to organize and analyze data taken from the local community.
- C. Determine the regression equation of best fit (e.g., linear, quadratic, exponential).
- D. Make predictions using interpolation, extrapolation, regression and estimation using technology to verify them.
- E. Determine the validity of the sampling method described in a given study.
- F. Determine the degree of dependence of two quantities specified by a two-way table.
- G. Describe questions of experimental design, control groups, treatment groups, cluster sampling and reliability.
- H. Use sampling techniques to draw inferences about large populations.
- I. Describe the normal curve and use its properties to answer questions about sets of data that are assumed to be normally distributed.

2.7. Probability and Predictions

- A. Compare odds and probability.
- B. Apply probability and statistics to perform an experiment involving a sample and generalize its results to the entire population.
- C. Draw and justify a conclusion regarding the validity of a probability or statistical argument.
- D. Use experimental and theoretical probability distributions to make judgments about the likelihood of various outcomes in uncertain situations.
- E. Solve problems involving

independent simple and compound events.

2.8. Algebra and Functions

3. Analyze a given set of data for the existence of a pattern and represent the pattern algebraically and graphically.
4. Give examples of patterns that occur in data from other disciplines.
5. Use patterns, sequences and series to solve routine and non-routine problems.
6. Formulate expressions, equations, inequalities, systems of equations, systems of inequalities and matrices to model routine and non-routine problem situations.
7. Use equations to represent curves (e.g., lines, circles, ellipses, parabolas, hyperbolas).
8. Identify whether systems of equations and inequalities are consistent or inconsistent.
9. Analyze and explain systems of equations, systems of inequalities and matrices.
10. Select and use an appropriate strategy to solve systems of equations and inequalities using graphing calculators, symbol manipulators, spreadsheets and other software.
11. Use matrices to organize and manipulate data, including matrix addition, subtraction, multiplication and scalar multiplication.
12. Demonstrate the connection between algebraic equations and inequalities and the geometry of relations in the coordinate plane.
13. Select, justify and apply an appropriate technique to graph a linear function in two variables, including slope-intercept, x- and y-intercepts, graphing by transformations and the use of a graphing calculator.
14. Write the equation of a line when given the graph of the line, two points on the line, or the slope of the line and a point on the line.
15. Given a set of data points, write an equation for a line of best fit.
16. Solve linear, quadratic and exponential equations both symbolically and graphically.
17. Determine the domain and range of a relation, given a graph or set of ordered pairs.
18. Analyze a relation to determine whether a direct or inverse variation exists and represent it algebraically and graphically.
19. Represent functional relationships in tables, charts and graphs.
20. Create and interpret functional models.
21. Analyze properties and relationships of functions (e.g., linear, polynomial, rational, trigonometric, exponential, logarithmic).
22. Analyze and categorize functions by their characteristics.

2.9. Geometry

- A. Construct geometric figures using dynamic geometry tools (e.g., Geometer's Sketchpad, Cabri Geometre).
- B. Prove that two triangles or two polygons are congruent or similar using algebraic, coordinate and deductive proofs.
- C. Identify and prove the properties of quadrilaterals involving opposite sides and angles, consecutive sides and angles and diagonals using deductive proofs.
- D. Identify corresponding parts in congruent triangles to solve problems.

- E. Solve problems involving inscribed and circumscribed polygons.
- F. Use the properties of angles, arcs, chords, tangents and secants to solve problems involving circles.
- G. Solve problems using analytic geometry.
- H. Construct a geometric figure and its image using various transformations.
- I. Model situations geometrically to formulate and solve problems.
- J. Analyze figures in terms of the kinds of symmetries they have.

2.10. Trigonometry

- A. Use graphing calculators to display periodic and circular functions; describe properties of the graphs.
- B. Identify, create and solve practical problems involving right triangles using the trigonometric functions and the Pythagorean Theorem.

Appendix C

. Mathematics Assessment Anchor Glossary Grade 11

The definitions for this glossary were taken from one or more of the following sources: Webster's Dictionary, various mathematics dictionaries, the PA Mathematics Standards glossary and various textbook glossaries.

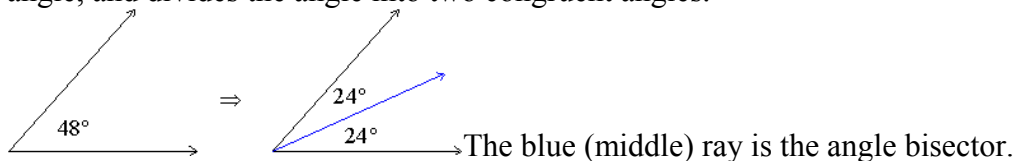
Absolute value: A number's distance from zero on a number line. The absolute value of $+2$ is equal to the absolute value of -2 .

Altitude (of a triangle): A segment drawn from a vertex of a triangle and perpendicular to the opposite side or to the line containing the opposite side.



Analytic geometry: A branch of geometry in which points are represented with respect to a coordinate system, and in which the approach to geometric problems is primarily algebraic.

Angle bisector: A ray in the interior of an angle, whose endpoint is the vertex of that angle, and divides the angle into two congruent angles.



Arc: A continuous part of a circle between two points on the circle.

Binomial: A polynomial with two terms (e.g., $7a + 4b$).

Central angle:

- Of a circle: An angle whose vertex is the center and whose sides are the radii of the circle.
- Of a regular polygon: An angle whose vertex is the center and whose sides intersect the regular polygon at adjacent vertices.

Circumscribed polygon: A polygon that surrounds a circle with each of its sides tangent to the circle.

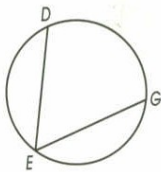


Dependent events: Two events in which the outcome of one event affects the outcome of the other event.

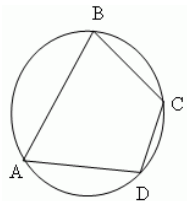
Direct proportion: Two quantities that always have a constant ratio. A direct variation is described by an equation of the form $y = kx$, where k is a constant not equal to zero.

Exponential function: An exponential function is a function that can be described by an equation of the form $y = a^x$, where $a > 0$ and a does not equal 1.

Inscribed angle: An angle whose vertex is on the circle and whose sides are chords of the circle.



Inscribed polygon: A polygon surrounded by a circle, where each of its vertices fall on the circle.



Interquartile range: The difference between the first and third quartile.

Inverse proportion: Two quantities that are inversely related. An inverse variation is described by an equation of the form $xy = k$ or $y = k/x$, where k is a constant not equal to zero.

Irrational number: Numbers that cannot be written as a ratio of two integers. It is a non-repeating, non-terminating decimal.

Line of best fit (regression line): A line drawn on a scatter plot to best estimate the relationship between two sets of data.

Median (of a triangle): A line segment that connects a vertex of a triangle to the midpoint of the side opposite that vertex.

Midpoint: The point on a line segment that is halfway between the endpoints of that segment.

Monomial: A monomial is a number, a variable, or a product of a number and one or more variables (e.g., $7ab$).

Odds: The odds of an event occurring is the ratio of the number of ways the event can occur (successes) to the number of ways the event cannot occur (failures).

Outlier: A value that is much greater or much less than the rest of the data is an outlier. More specifically, it is an element of a set of data that is 1.5 interquartile ranges greater than the upper quartile or less than the lower quartile.

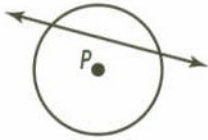
Polynomial: An algebraic expression that contains one or more monomials.

Quadratic function: Equations which are expressed in the form $y = ax^2 + bx + c$, where a is not equal to zero.

Rational number: A number that can be expressed as a ratio of two integers. A rational number can be expressed in the form a/b , where a and b are integers and b is not equal to zero.

Real number: The combined set of rational and irrational numbers.

Secant (of a circle): A line that intersects a circle in exactly two points.

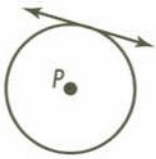


Semicircle: An arc of a circle whose endpoints are the endpoints of a diameter.

Slope: The ratio of the change in the vertical distance to the change in the horizontal distance of two points on a line. Slope measures the steepness of a line from left to right.

$$\text{Slope} = \frac{\text{change in } y}{\text{change in } x}, \text{ or } \frac{\text{rise}}{\text{run}}$$

Tangent (of a circle): A line that touches a circle in exactly one point.



Trinomial: A polynomial with three terms (e.g., $7a + 4b + 9c$).