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Mathematics Education and Multiple Intelligences

By

Bethany Brownlee

An Honors Thesis submitted to the
Department of Mathematics, Engineering, and Computer Science
in partial fulfillment of the requirements
for graduation with honors.

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Abstract

This thesis explores the utilization of Multiple Intelligences in the mathematics classroom. There are eight distinct multiple intelligences found in students. Each intelligence is unique and every student has a blend of the eight intelligences. The thesis discusses different methods and modes for integrating multiple intelligences into the classroom, and more specifically the mathematics classroom. The major contribution of the thesis is 22 original multiple intelligence activities for the mathematics classroom.

Chapter 1 - Introduction

Every student in a mathematics class has a signature method of learning and many times mathematics education does not reflect the diversity in learning among students. The theory of Multiple Intelligences developed by Howard Gardner is an adept model for mathematics education. Utilizing the different intelligences in the classroom, and more specifically in the mathematics classroom, can be a challenge for any teacher; however implementing the different intelligences in the classroom can lead to deeper learning and also enhance the experience of every student.

Multiple Intelligences is a theory that was formulized by Howard Gardner in 1983. His book, *Frames of Mind,* challenges the way that educators view the learning styles of students. Gardner identifies seven different intelligences in the book, and since 1983 he has added an eighth intelligence. Before examining each individual intelligence, it is essential to understand what an intelligence contains. Gardner defines an intelligence as "a biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture." [3, pg. 33-34] Gardner emphasizes the fact that every person is born with the potential for all intelligences. The potential can then be "realized to a greater or lesser extent as a consequence of the experiential, cultural, and motivational factors that affect each person." [3, pg. 82]

Basically, every person has their own unique mix of intelligences. While one person has cultivated strengths in one intelligence, someone else has strengths in another. Our various strengths and weaknesses are similar to a learning fingerprint. Each person has a mix of intelligences that is uniquely his or hers. While some students may share

similarities, every student is different. With this basic understanding of what multiple intelligences are, we can now look at each type of intelligence.

Chapter 2 - Descriptions of Each Intelligence:

Gardner identifies eight distinct intelligences. Each intelligence is a unique blend of characteristics. It is crucial that teachers recognize individual differences and strengths when it comes to multiple intelligences. For that reason, it is important to understand the makeup of each intelligence.

Section 1 - Logical-Mathematical

Logical-Mathematical intelligence is the intelligence of mathematics. This intelligence is most closely related to the study of mathematics. Mathematics is often a subject that is abstract enough to be understood solely by mathematicians. Gardner notes that "while the products fashioned by individuals gifted in language and music are readily available to a wide public, the situation with mathematics is at the opposite extreme. Except for a few initiates, most of us can only admire from afar the ideas and works of mathematicians." [2, pg. 136] It is understandable then why many students struggle with mathematics. It is a hard subject to grasp, especially if the logic-mathematical is not one's predominate intelligence. The logical-mathematical intelligence "underlies the deductive methods of science and law. Its way of working is not just through symbols and syllogisms, however, but is often initially non-verbal – a *sense* of how causes are related though a series of steps." [8, pg. 3] Logical-mathematical intelligence is more than mechanics; it involves intuition. Students that excel in logical-mathematical intelligence often are "fascinated with patterns in numbers or with science and will pursue ideas far beyond their apparent utility." [8, pg. 3] Students high in this intelligence are able to internalize the intricacies of logic and mathematical reasoning. Gardner writes that "the

most central and least replaceable feature of the mathematician's gift is the ability to handle skillfully long chains of reasoning." [2, pg 139]

Section 2 - Linguistic

Linguistic intelligence is all about words. Gardner writes that the core of linguistic intelligence is a varying degree of sensitivity. Sensitivity to the meaning of words, sensitivity to the order of words, sensitivity to the sounds, rhythms, inflections, and meters of words, and sensitivity to the different functions of language all exemplify this intelligence. [2, pg. 77] Each person has a varying degree of those sensitivities. A person that is extremely skilled in all would be an exceptional poet. Gardner isolates four aspects of linguistic intelligence. The first is rhetoric of language, or the ability to persuade others through language. The second is the mnemonic aspect with the ability to remember information. Third is the role of language in explanations, the aspect a teacher uses the most often. The final and fourth aspect is using language to talk about language, much as this paragraph has been doing. [2, pg. 78] This intelligence is "the strength of many people who are comfortable in the universe of words, reading, and writing ... A linguistically strong child with average math skills may do fairly well on an IQ test." [8, pg. 4] Students with linguistic skills are able to function exceptionally well in an education system that deals with words. These students are adept in the realm of language.

Section 3 - Musical Intelligence

The height of musical intelligence is exemplified in a young Mozart, writing complex symphonies in his childhood. Musical intelligence is the earliest intelligence to emerge. [2, pg. 99] The main components of musical intelligence center around "pitch (or

melody) and rhythm: sounds emitted at certain auditory frequencies and grouped according to a prescribed system… Next in importance to pitch and rhythm is timbre – the characteristic qualities of a tone." [2, pg. 104-105] Obviously, these first three components of musical intelligence are auditory. There is at "least one central aspect of music – rhythmic organization – [that] can exist apart from any auditory realization." [2, pg. 105] Musical intelligence is more than just an auditory experience, although it is mainly an auditory experience.

In addition, just listening to music can increase overall learning. In fact, music can increase learning "preceding study, accompanying work, or by actually being the subject of study, like fractional notes and rhythmic patterns." [8, pg. 18] Music intelligence incorporates understanding the complexity of various aspects of music and can also be triggered by merely listening to music.

Section 4 - Spatial Intelligence

Spatial Intelligence is directly correlated to the visual realm. Spatial intelligence is neatly described by Gardner in saying that, "central to spatial intelligence are the capacities to perceive the visual world accurately, to perform transformations and modifications upon one's initial perceptions, and to be able to re-create aspects of one's visual experience, even in the absence of relevant physical stimuli." [2, pg. 173] Spatial intelligence involves students visualizing pictures in their minds. People that excel in the spatial realm are adept at converting problems from the linguistic form into a spatial idea. In the classroom, students that are high in spatial intelligence learn well from visual aides, such as diagrams, flow charts and manipulatives. Spatial intelligence is

exceedingly important since "about 40% of children are visual learners, thus elevating the spatial intelligence to a prime position in communicating and understanding." [8, pg. 15]

Section 5 - Bodily - Kinesthetic Intelligence

Bodily – Kinesthetic Intelligence is exactly what the name implies: it is the intelligence that uses body movement. The people with a high level of bodily intelligence are "individuals – like dancers and swimmers – who develop keen mastery over the motions of their bodies, as well as those individuals – like artisans, ballplayers, and instrumentalists – who are able to manipulate objects with finesse." [2, pg. 207] Those with a highly developed sense of bodily intelligence can then have both mastery of their entire body, and also mastery over the objects used by the body. This is evident in the pianist's rapid finger movements and the gymnast's body manipulations in floor routine. Bodily-kinesthetic intelligence is "used by many to gain insight, solve problems, and process information in other areas. For instance, a violinist uses it to control the bow even though melodic decisions are made by his or her musical intelligence." [8, pg. 3] Students that excel in bodily-kinesthetic intelligence are often the restless students, who cannot seem to sit still while in class. In fact, "many students who get in trouble in the school setting are kinesthetic. They need movement, action, and physical content. When most teachers don't provide it, they create it by falling off chairs [and] horesplaying with classmates." [8, pg. 20] This intelligence can be tapped into by teaching activities that involve body movement, as well as touching and manipulating objects. They will learn by "being 'walked though' math procedures, having a 'hands-on experience,' getting a 'gut feeling,' and 'going through the motions'." [8, pg. 3] Often learning the material

through these bodily ideas can lead to deeper understanding in one of the other intelligences.

Section 6 - Interpersonal Intelligence

The first of the two people intelligences, interpersonal intelligence is the capacity to interact well with other people. The core capacity of interpersonal intelligence is "the ability to notice and make distinctions with other individuals and, in particular, among their moods, temperaments, motivations and intentions." [2, pg. 239] The people that are adept in interpersonal intelligence are very skilled at reading other people and perceiving their needs and moods. Every single person has interpersonal intelligence. Most of our lives are "filled with interpersonal relationships; some of us are more agile at problem solving in this area than others." [8, pg. 3] People highly skilled in interpersonal intelligence are often found in political or religious arenas. In the classroom, these students thrive on group projects. They excel in cooperative learning. They may "demonstrate leadership, and be continually drawn into social situations. They may acquire friends easily and even obligingly alter their personae with each." [8, pg. 4] Interpersonal intelligence often can be easy to spot in students, and it can help foster learning within an entire group.

Section 7 - Intrapersonal Intelligence

In contrast to interpersonal intelligence, intrapersonal intelligence looks inward, at oneself. The core capacity of intrapersonal intelligence is "access to one's own feeling life – one's range of affects or emotions: the capacity instantly to effect discriminations among these feelings and, eventually, to label them, to enmesh them in symbolic code, to draw upon them as a means of understanding and guiding one's behavior." [2, pg. 239] A

common word applied to those strong in this intelligence is introspective. These students may seem thoughtful and sensitive. [8, pg. 4] While the students may be strong in internalizing answers about themselves, they may not have the linguistic or interpersonal skills to effectively communicate. [8, pg. 4] This intelligence is strongly shown in philosophers that wonder about their meaning in life, or religious theologians.

Section 8 - Naturalist Intelligence

When Howard Gardner first published *Frames of Mind* in 1983, he only delineated seven distinct intelligences. Since then, Gardner has added an eighth intelligence, the naturalist intelligence. Gardner affirms the validity of this eighth intelligence by saying in a later book, "the naturalist intelligence proves as firmly entrenched as the other intelligences." [3, pg. 49] Thus, the naturalist intelligence is as important as the seven previous intelligences and deserves as much attention. The naturalist intelligence is demonstrated in "expertise in the recognition of the numerous species – the flora and fauna – of his or her environment… The naturalist is a biologist who recognizes and categorizes specimens in terms of accepted formal taxonomies… The word naturalist is readily applied to those with extensive knowledge of the living world." [3, pg. 48] Naturalist intelligence then is the ability to understand the world around oneself. More in depth, it "has to do with observing, understanding and organizing patterns in the natural environment." [8, pg. 5] Even beyond the natural world, this intelligence is also used to recognize patterns in all aspects of life. To students gifted in the naturalist intelligence, learning in a natural setting can often increase learning in any subject.

Chapter 3 - Multiple Intelligences in the Classroom

Section 1 – Diversity of Intelligences in Students

Even beyond delineating the philosophy of multiple intelligences, Gardner talks of how the current school systems may not adequately teach to all intelligences. In fact, "linguistic and logical-mathematical are the ones that have been typically valued in school." [3, pg. 41] IQ tests are based on a verbal and mathematics section, which clearly tap into the linguistic and logical fields of intelligence. Many standardized tests given to students test verbal skills and mathematical skills. These are the basic intelligences that school systems have been built upon. It is important to recognize that linguistic and mathematical are not the only intelligences present in the minds of students. Students possess at least six other intelligences in varying degrees, and for many, linguistic and mathematical are not the strong intelligence. Educators need to be aware that not every student has strength in logical-mathematical and linguistic intelligence. Every single subject can be learned utilizing the eight distinct intelligences. Every person has stronger intelligences and weaker intelligences. A major premise to using the multiple intelligence theory in the classroom is that "a teacher should more often attempt to tap processes that are strong and natural in the learner than consistently demand production from a weaker intelligence mode." [8, pg. 5] Students will learn topics easier and with better understanding if they learn the topic through their predominate intelligence. Armstrong sums this idea as a series of four points.

1. Each persona possess all [eight] intelligences.
2. Most people can develop each intelligence to an adequate level of competency.

3. Intelligences usually work together in complex ways.

4. There are many ways to be intelligent within each category. [1, pg. 11-12]

Keeping these four main points in mind, it is vital to now look at how teachers can implement multiple intelligences that best suit the individual student in a classroom full of diverse learners.

There is not one single way to teach using multiple intelligences. The multiple intelligence theory is a premise about how the mind works. Gardner is clear on this subject, saying, "MI theory is in no way an educational prescription. There is always a gulf between scientific claims about how the mind works and how the mind works and actual classroom practices. Educators are in the best position to determine whether and to what extent MI theory should guide their practices." [3, pg. 89] The author of the theory of multiple intelligences makes the claim himself that there is no one way to teach using multiple intelligences. Before looking at how one might teach using the theory, we will look at how not to teach using multiple intelligences. Gardner provides a list of implementations that should be avoided:

1. Attempting to teach all concepts of subjects using all of the intelligences. To be sure, most topics can be approached in varied ways, but applying a scattershot approach to each topic is a waste of effort and time.
2. Believing that going through certain motions activates or exercise specific intelligences… random muscular movements have nothing to do with cultivation of the mind, or even the body.
3. Using intelligences primarily as mnemonic devices.
4. Conflating intelligences with other desired outcomes.

5. Labeling people in terms of "their" intelligence… When these labels become shorthand references for educators, they carry considerable risk. [3, pg. 89-91]

Educators need to be aware of these pitfalls in teaching using multiple intelligences. These pitfalls are not effective ways to utilize such a powerful theory and may hinder student growth rather than help. It is important to remember that all students are different. Since all students are different, "education works most effectively if these differences are taken into account rather than denied or ignored." [3, pg. 91] The first and perhaps most crucial step is to know the students' differences.

Section 2 - Learning about the Minds of Students:

The first necessary requirement for teaching using multiple intelligences is to know the mind of every student. This "crucial ingredient is a commitment to knowing the minds – the persons – of individual students. This means learning about each student's background, strengths, interests, preferences, anxieties, experiences, and goals, not to stereotype or preordain but rather to ensure that the educational decisions are made on the basis of an up-to-date profile of the student." [3, pg. 151] There are many ways to learn about the mind of each and every student. Teachers should keep a file or portfolio on the intelligence makeup of every student. The first step in determining a student's intelligences is to reflect on the student's progress in school. Find out where the student excels, and where the student struggles. Once the teacher has reflected on their own thoughts for the student, the teacher should then question other teachers and the parents. The teacher should then question the student about his or her learning styles and intelligence makeup. The students know themselves the best. At this point, the teacher

should have the student fill out a multiple intelligence inventory. There are many sources for these tests, in books and online. Two sources for multiple intelligences inventories can be found as references 6 and 7 at the end of the thesis. These two web pages ask the student to answer questions that describe them. At the end of the test, the student is given a graph of their multiple intelligence makeup. Have the student print the graphs and put the graphs in each student's file. At the end of these activities, the teacher should have a good understanding of each student's dominant and weak intelligences. These intelligences can then be utilized into a multiple intelligence classroom.

Section 3 - Methods for Establishing Multiple Intelligences in the Classroom:

Before effectively using multiple intelligences in the classroom, it is important to use some steps for establishing an environment in the classroom around multiple intelligences. Gardner gives a list of some practices that are useful for the teacher to do before implementing multiple intelligences in the classroom:

1. Learn more about the MI theory and practices.
2. Form study groups.
3. Visit institutions that are implementing MI ideas.
4. Attend conferences that feature MI ideas.
5. Join a network of schools.
6. Plan and launch activities, practices, or programs that grow out of immersion in the world of MI theory and approaches. [3, pg. 145-146]

These six steps to creating a classroom environment for utilizing multiple intelligences involve two main ideas – learning all one can about the theory, and having a system of collaboration. To be able to effectively teach using the MI theory, an educator must be

fluent in the theory itself, and understand its implications and limitations. Secondly, an educator must have a support system, where he or she can talk about the successes and failures in the classroom. The support system should also give the educator new ideas to try and encourage the MI classroom. Before implementing multiple intelligences in the classroom, a teacher should adhere to the six guidelines above.

Section 4 - Methods of Using Multiple Intelligences in the Classroom:

Once the educator has thoughtfully considered all the implications of using multiple intelligences and is ready to implement it into the classroom, there are many methods for the implementation. Each of the eight intelligences can be expressed in the classroom using different activities and teaching methods. A brief idea of how this can be done is shown in Table 1 below:

Table 1: Summary of the "Seven Ways of Teaching" [1, pg. 52]

Intelligence	Teaching Activities (examples)	Teaching Materials (examples)	Instructional Strategies
Linguistic	lectures, discussions, word games, storytelling, choral reading, journal writing, etc.	books, tape recorders, typewriters, stamp sets, books on tape, etc.	read about it, write about it, talk about it, listen to it
Logical-Mathematical	brain teasers, problem solving, science experiments, mental calculations, number games, critical thinking, etc.	calculators, math manipulatives, science equipment, math games, etc.	quantify it, think critically about it, conceptualize it
Spatial	visual presentations, art activities, imagination games, mind-mapping, metaphor, visualization, etc.	graphs, maps, videos, LEGO sets, art materials, optical illusions, cameras, picture library, etc.	see it, draw it, visualize it, color it, mind-map it
Bodily-Kinesthetic	hands-on learning, drama, dance, sports that teach, tactile activities, relaxation exercise, etc.	building tools, clay, sports equipment, manipulatives, tactile learning resources, etc.	build it, act it out, touch it, get a "gut feeling" of it, dance it
Musical	rapping, songs that teach	tape recorder, tape collection, musical instruments, etc.	sing it, rap it, listen to it
Interpersonal	cooperative learning, peer tutoring, community involvement, social gatherings, simulations, etc.	board games, party supplies, props for role plays, etc.	teach it, collaborate on it, interact with respect to it
Intrapersonal	individualized instruction, independent study, options in course of study, self-esteem building, etc.	self-checking materials, journals, materials for projects, etc.	connect it to your personal life, make choices with regard to it

The chart gives an idea for how to implement multiple intelligences in the classroom. The first column has seven intelligences listed. The source of this table did not recognize the eighth intelligence, but it could easily be added to the end of the list. The next column gives examples of teaching methods for each intelligence. These examples are general ideas for how a subject can be taught using a specific intelligence. For example, if in a

literature class the teacher was trying to use a spatial intelligence, they may use mind-mapping for the plot in a novel. The third column is examples of teaching materials. This is a short list of materials an educator can use to help key into a specific intelligence. The last column gives specific verbs for the teacher to use for a subject that will tie the subject into different intelligences. If a teacher wants to use a specific intelligence for a concept in school, the teacher can look for a verb that matches with the intelligence and use that verb in relation to the concept. This table is only a short list of the different methods used to incorporate multiple intelligences in the classroom; many other examples can be easily thought of by the educator. Further on in this paper, multiple activities related to mathematics will be presented and discussed.

Section 5 - Mixing in Multiple Intelligences:

At this point, many educators may be daunted by the task of creating a multiple intelligence classroom. The task may seem arduous and time consuming. While most educators will agree that the idea of personalizing education to every individual student is an estimable goal, the actual method of individualization seems to be too much. Instead of diving into the idea of a multiple intelligence classroom, it may be better to start with spicing up the everyday uniform curriculum. Teachers may "enhance the flavor of your usual daily math instruction, (or any other subject for that matter) with Multiple Intelligences seasoning and you'll notice your students beginning to perk up. That in turn will energize you, your class preparation, and your teaching day. You'll get used to that extra spicy edge." [8, pg. 11]. Start slowly by working one different intelligence into a lesson plan. Look to see what the predominate intelligences are in the class and use those

intelligences in a lesson. Teachers should start slowly, and pick up momentum as they become comfortable with seasoning lessons with different intelligences.

Many multiple intelligence handbooks do not even use all of the eight intelligences. Jeff Zwiers in *Developing Academic Thinking Skills* uses the model of GruViMoMaMu. This stands for group work, visuals, movements, manipulatives, and music. This acronym encourages teachers to use interpersonal, spatial, bodily/kinesthetic, and musical intelligences. [9, pg. vi] The book uses this rationalization for using only four of eight intelligences, "I chose these four because of their prevalence and effectiveness in the research on high-quality teaching practices. I also chose them because I have seen activities based on these four intelligences work wonders for engaging students and for teaching academic language, thinking, and content in many secondary classrooms. [9, pg. vi] The key point to remember when adding multiple intelligences to the classroom is to start small. Start small, and when the teacher is comfortable with seasoning with multiple intelligences, then the teacher should simply add more.

Chapter 4 - Teaching Mathematics using Multiple Intelligences

Section 1 - Seven Ways of Teaching Mathematics:

The subject of mathematics falls neatly into the intelligence titled "logical/mathematical." However, it is important to remember when teaching mathematics that not every student excels in the mathematical intelligence. It is therefore important to teach students mathematics using different intelligences. This is not to say that there are certain subjects or content that should not be taught because it is not the predominate intelligence of students. Gardner neatly says "All young people should study the history of their country, the principles of algebra and geometry, and basic laws that govern living and nonliving objects. A commitment to some common knowledge does not mean that everyone must study these things in the same way and be assessed in the same way." [3, pg. 152] Instead, each concept in mathematics should be presented to best capitalize on students' predominate intelligences. An example of how this can be done is found in Table 2 on the next page. [4, pg. 59] This table shows different ways of teaching mathematics using seven different intelligences. Each section has five specific activities that can help a mathematics educator brainstorm methods of teaching concepts without relying heavily on the mathematical intelligence. This chart does not show the naturalist intelligence.

Table 2: Seven Ways of Teaching Mathematics

Verbal / Linguistic	Logical / Mathematical	Visual / Spatial	Bodily / Kinesthetic	Musical / Rhythmic	Interpersonal	Intrapersonal
Write a series of story problems for others to solve	Find unknown quantities / entities in a problem	Do a survey of students' likes / dislikes, then graph the results	Use different parts of the body to measure things	Learn mathematical operations through songs and jingles	Solve complex story problems in a group	Track thinking patterns for different math problems
Explain how to work a problem to others while they follow	Teach how to use a calculator for problem solving	Estimate measurement by sight and by touch	Add and subtract members to and from a group to learn about fractions	Learn addition and subtraction through drum beats	Do a statistical research project and calculate percentages	Bridge math concepts beyond school (what? so what? now what?)
Make up puns using math vocabulary or terms	Create number sequences and have a partner find the pattern	Add, subtract, multiply, and divide using various manipulatives	Design something that requires applying math concepts	Play the "Rhythm Game" to learn times tables	"Each one teach one" new math processes / operations	Use guided imagery to see complex story problems
Solve problems with a partner -- one solves and one explains process	Mind-map proofs for geometry theorems	Imagine using a math process successfully, then really do it	Create and act out a play in which the characters are geometric shapes	Break a set of tones into various groups to learn division tables	Describe *everything* you do to solve a problem with a partner	Evaluate your strengths / weaknesses in understanding math
Create poems telling when to use different math operations	Design classification charts for math formulas and operations	Learn metric measurement through visual equivalents	Make up a play-ground game that uses math concepts operations	Make up sounds for different math operations and processes	Have teams construct and solve problems linking many math operations	Watch mood changes as you do math problems -- note causes

Section 2 - The NCTM Standards:

Principles and Standards for School Mathematics, written by the National Council of the Teachers of Mathematics (NCTM), lays out several areas of mathematics to serve as guidelines for curriculum. The *Standards* "supplies guidance and vision while leaving specific curriculum decisions to the local level." [5, pg. 6] The different standards have cohesion across all grade levels and can be applied to all mathematical curricula. For this reason, the activities in the next section are divided into different sections from the NCTM Standards. The areas being used are: number and operations, algebra, geometry, measurement, data analysis and probability, proof and reasoning, and problem solving. In the next chapter we will discuss multiple intelligence activities we have created for each of the standards listed above.

Chapter 5 – Original Activities for a Multiple Intelligence Mathematics Classroom

Using the NCTM standards, we have compiled 22 activities for a high school level mathematics class. These activities use different intelligences for teaching different topics under the NCTM standards.

Section 1: Number & Operations

Activity 1.1

Activity Name: Introduction to Vectors

Intelligences used: Spatial, Logical-Mathematical

Objective: Students will be able to compute vector sums given two or more vectors in the plane.

Procedure:

Students will be supplied a sheet of graph paper and a number of vectors of varying lengths. The students will draw an origin and x- and y-axis. Using the paper vectors, the students will place the vectors on the graph paper and then calculate the vector sum of the two original vectors. (Bodily-Kinesthetic extension: Working in groups of three, two students can make vectors with their bodies on the floor and a third can measure the resulting vector sum.)

Activity 1.2

Activity Name: Number Classes Skit

Intelligences used: Interpersonal, Bodily, Linguistic

Objective: Students will be able to explain the difference between different classes of numbers (such as real, complex, rational, irrational, integer, etc.).

Procedure:

Students will be divided into groups of four or five. The group must write a skit about the differences in the number classes. Each person must be a different kind of number (real, integer, complex, etc.). At the end of the skit, the rest of the class should be able to tell the differences in each of the classes of numbers.

Activity 1.3

Activity Name: Estimating Branches

Intelligences used: Intrapersonal, Spatial, Naturalistic, Linguistic

Objective: Students will develop a method for approximating items with patterns.

Procedure:

Without counting the exact number, students must develop a method for approximating the number of branches on a tree. The students need to draw a picture showing the method for approximating. Along with the picture, students need to write a paragraph justifying how they accomplished the goal and stating the final answer.

Section 2: Algebra

Activity 2.1

Activity Name: Algebra and Life

Intelligences used: Intrapersonal, Linguistic

Objective: Students will write a paper defining the use of Algebra in everyday life, citing several examples.

Procedure:

Students will be assigned a paper that will answer the question, "How do I use algebra in everyday life? How can Algebra help me with everyday tasks?" The students will be required to cite at least four specific examples.

Activity 2.2

Activity Name: Quadratic Formula Rap

Intelligences used: Musical, Interpersonal

Objective: Students will be able to recite the quadratic formula.

Procedure:

In a group, the students will work on memorizing the quadratic formula. Their assignment will be to come up with a rap song where the words are the quadratic formula. The students will then present the rap to the class.

Activity 2.3

Activity Name: Graph Identification

Intelligences used: Spatial, Interpersonal, Logical/Mathematical

Objective: Students will be able to identify the correct function given a graph of a function.

Procedure:

Students will form groups of two or three. Each group will be given two worksheets. One worksheet has ten different graphs on it. These graphs can be of any form, such as linear, quadratic, or trigonometric. The graphs will not be labeled with their function, but may have coordinates labeled. The second worksheet will have fifteen different functions on it. The students must correctly match each graph with its function. A worksheet for this activity can be found in Appendix 1 at the end of the thesis.

Section 3: Geometry

Activity 3.1

Activity Name: Circles and Pi

Intelligences used: Interpersonal, Naturalistic, Bodily/Kinesthetic, Linguistic, Spatial

Objective: Students will derive the idea of pi based on measurements of diameter and circumference of circles.

Procedure:

Students will form groups of two or three. The groups will be assigned to measure ten different circles found outside. This can be tree trunks or branches, sign poles, railings, or any other circular object. On each circle, the students must measure the circumference and diameter in centimeters. Make sure the students know to measure the diameter at the largest area of the circle. Once the measurements are complete, the students must make a table with three columns. The first column will list the diameter and the second will list the circumference. In the third column, the student must divide the circumference by the diameter. Each group must then write a paragraph describing the significance of the resulting number. (The result should be approximately pi.)

Activity 3.2

Activity Name: Parallelogram Area

Intelligences used: Interpersonal, Logical/Mathematical, Spatial

Objective: Students will derive the formula for the area of a parallelogram.

Procedure:

Students will be divided into groups of three or four. Each group will receive a large cut-out parallelogram. The students must find the area of the parallelogram, without

looking it up. The students will need to break the parallelogram into smaller pieces, such as triangles and rectangles, to find the area. Once the groups have determined the correct area, they will derive the formula for the area of a parallelogram. For homework, each student will be given a cut-out isosceles trapezoid and asked to repeat the same exercise.

Activity 3.3

Activity Name: Geometry and Life

Intelligences used: Intrapersonal, Linguistic

Objective: Students will write a paper describing the use of geometry in everyday life, citing several examples.

Procedure:

Students will be assigned a paper that will answer the question, "How do I interact with geometry in everyday life?" Students will be required to cite at least five examples.

Section 4: Measurement

Activity 4.1

Activity Name: Which is more expensive?

Intelligences used: Intrapersonal, Logical/Mathematical, Spatial

Objective: Students will be able to compare values of different items using different currencies and different units of measure.

Procedure:

Students will be given ten different problems of the following form:

Gas in Helena costs $2.20/gallon. Gas in Germany costs €6.70/Liter. Which gas is cheaper?

In each problem, the students will need to convert two different measurements. In this problem, the students must convert US Dollars and Euros, and also liters and gallons. The students will complete all ten problems, and will also make a poster. The poster will illustrate the results of two different problems and also the thinking steps that each student used to arrive at the answer.

Activity 4.2

Activity Name: Radians and Degrees

Intelligences used: Interpersonal, Bodily/Kinesthetic, Linguistic

Objective: Students will be able to describe the differences between radians and degrees in measurements.

Procedure:

In groups of two, students will develop a list that compares and contrasts radians and degrees in measurement. Students will write up their results in a skit to present to the class. The students will also turn in their script, which should summarize the differences and similarities.

Activity 4.3

Activity Name: Understanding Graphs

Intelligences used: Spatial, Linguistic

Objective: Students will describe the differences in various types of graphs.

Procedure:

Students will write about five different types of graphs: bar, line, pie, scatter, and box and whisker graphs. Students will write a paper illustrating how each graph is used, and citing situations where the graph may be needed.

Section 5: Data Analysis & Probability

Activity 5.1

Activity Name: Box and Whisker Name Length

Intelligences used: Interpersonal, Spatial, Linguistic, Logical/Mathematical

Objective: Students will create a box and whisker plot given a set of data.

Procedure:

On the board, the class will make a table listing the total number of letters in each student's name. Then, the students will form groups of four and develop a box and whisker plot for the data on the board. The students will draw the graph on a large poster board. Once the poster is complete, each student will turn in a short write-up on where their individual number is and how it correlates to the plot.

Activity 5.2

Activity Name: Genetics Statistics

Intelligences used: Interpersonal, Logical/Mathematical, Naturalistic

Objective: Students will be able to compose ratios and probability statistics based on genetics.

Procedure:

Introduce Punnett Squares to the class. Use different genetic attributes found in nature to cross. Pea plants are a good example to use for this. Have the students cross different attributes and write the probability distribution for each cross. Once the students understand the basic principle, have the students form groups and find the probability distribution on a worksheet. For the last problem, have the students complete a single cross with two different attributes for a larger distribution.

Activity 5.3

Activity Name: Song Length Statistics

Intelligences used: Musical, Linguistic, Logical/Mathematical

Objective: Students will analyze a statistical problem based on music and write a report with their findings.

Procedure:

Students will be assigned the following problem:

"Do a statistical analysis on the length of songs. Pick a genre of music and find the twenty most popular songs in the genre for ten different periods. Analyze the data to determine whether there is a statistical correlation between the length of a song and its popularity."

Students will solve the problem and write a report on their findings. This includes their results and also a justification of their statistical methods.

Activity 5.4

Activity Name: Dice Probability

Intelligences used: Interpersonal, Logical/Mathematical, Spatial, Bodily/Kinesthetic

Objective: Students will derive probability distributions for dice rolls and then will test their results.

Procedure:

Students will form groups of two or three. The students will then write out the probability distribution for the sum of two regular six-sided dice. They will then do the same for the sum of two four-sided dice, and two eight-sided dice. Once each group has

completed their probability distributions, the group will test their distribution for six-sided dice with 12, 36, and 72 rolls.

Section 6: Problem Solving

Activity 6.1

Activity Name: Problem Solving Techniques

Intelligences used: Intrapersonal, Interpersonal, Spatial, Musical, Linguistic

Objective: Students will illustrate different problem solving techniques

Procedure:

In pairs, students will complete a project that shows the different problem solving techniques. Students will either make a poster that illustrates different problem techniques, or will compose a rap song describing different techniques. Each pair will demonstrate their project to the class. In addition, each student must turn in a paper describing their favorite problem solving technique and explaining why it works well for them individually.

Activity 6.2

Activity Name: Rectangles on a Checkerboard (Adapted from NCTM [5, pg. 335])

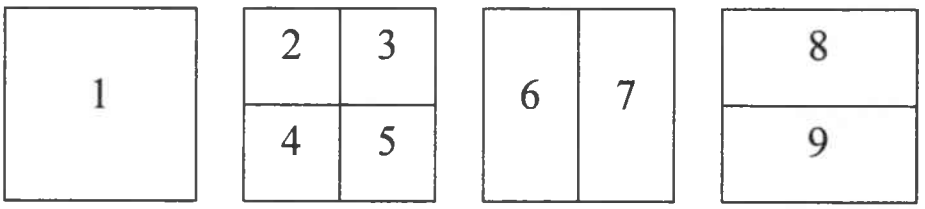
Intelligences used: Linguistic, Logical/Mathematical, Spatial, Intrapersonal

Objective: Students will solve story problems using various problem solving techniques.

Procedure:

Students will solve the following problem and write a report describing which problem solving strategy they used:

How many rectangles are there on an 8x8 checkerboard? For example, on a 2x2, there are 9.



Activity 6.3

Activity Name: Story Problem Composition

Intelligences used: Interpersonal, Linguistic, Logical/Mathematical

Objective: Students will write and solve story problems based on the subject matter.

Procedure:

For any given subject matter or unit, students will be required to write story problem based on the content. The student will write and solve their own story problem. The teacher will compile the problems, and assign the students to complete 75% of their peers' problems.

Section 7: Reasoning & Proof

Activity 7.1

Activity Name: Great Proof Investigation

Intelligences used: Linguistic, Spatial, Logical/Mathematical

Objective: Students will analyze a historical proof.

Procedure:

Students will be required to investigate a historical proof in mathematics. Students will be required to learn the proof, write a paper about the proof, and present the proof to the class with a visual aid.

Activity 7.2

Activity Name: Match-up Proof

Intelligences used: Interpersonal, Logical/Mathematical

Objective: Students will classify the steps and reasons of a proof in the correct order.

Procedure:

In groups of three or four, students will work to piece a proof into its proper order. The students will receive a worksheet that has a given statement and a to-prove statement. The steps of the proof will also be on the paper, but in a mixed up order. The groups must put the proof back in the proper order. A worksheet for this activity can be found in Appendix 2 at the end of the thesis.

Variation: Students will work in pairs. One student in the pair has a worksheet with different steps of a proof on it. The other partner will have a worksheet that has the justification for each of the steps. The group must correctly match the steps with the justifications.

Activity 7.3

Activity Name: Music is Mathematics Proof

Intelligences used: Intrapersonal, Musical, Linguistic

Objective: Students will use mathematical reasoning to prove a statement.

Procedure:

Students will be assigned a paper that requires them to link mathematics and music. Students will answer the question, "Use mathematical reasoning to prove that mathematics is related to music. Cite at least four different examples. Also, choose a piece of music that shows mathematics in music."

Chapter 7 - Conclusion

Mathematics is a subject that many students find difficult. A major reason why students struggle with mathematics is that the material is not always being taught with the individual in mind. The major contributions of this thesis address this problem using the model of Gardner's theory of Multiple Intelligences. Each intelligence has been described in detail. The thesis also develops a system for integrating multiple intelligences into the classroom, and more specifically, the mathematics classroom. The major contribution is a compilation of mathematics activities that will use multiple intelligences to enhance a normal standard. Using the NCTM Standards as a frame, each activity will foster learning with numerous multiple intelligences. There are many ways for an educator to use multiple intelligences in the mathematics classroom, and activities are easy to find and devise. Using the eight different intelligences and methods of implementation outlined in this thesis, teachers can easily help develop better learning and thinking skills in their students.

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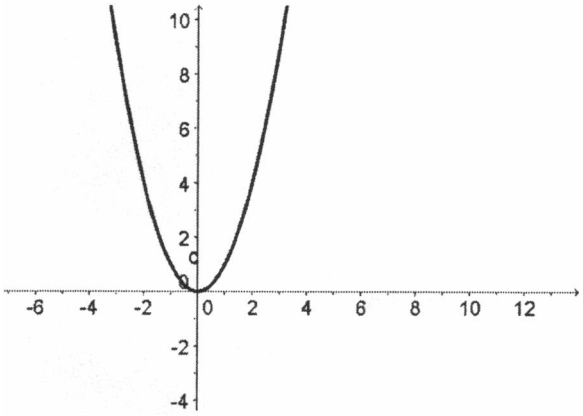
Appendix 1

Matching Graphs
Graph Page

Directions:
This worksheet has the graphs of 10 different functions. Match each graph with the correct function. The functions that can be used are on the Equation page.

1.



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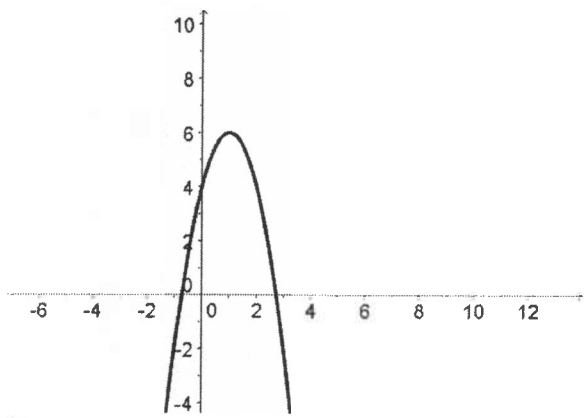

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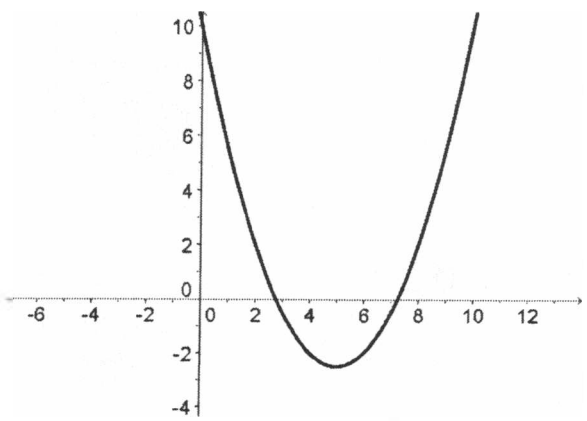

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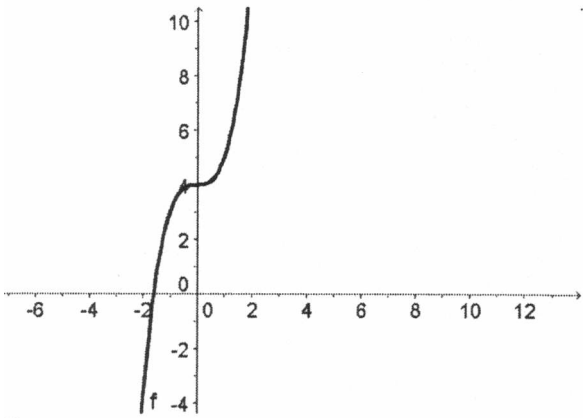

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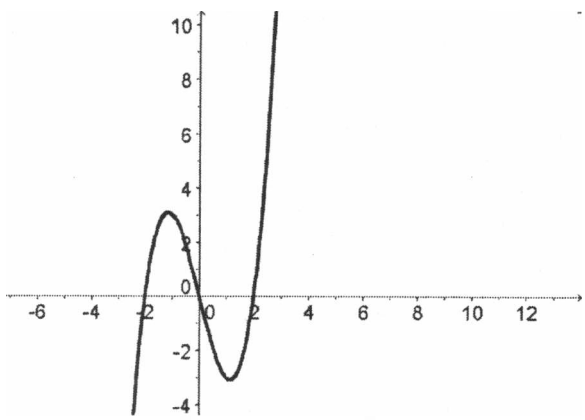

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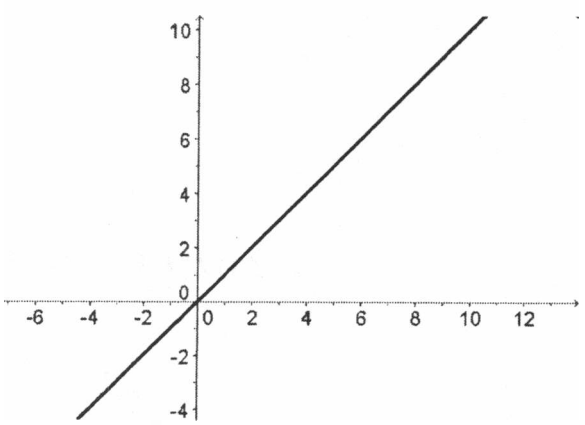

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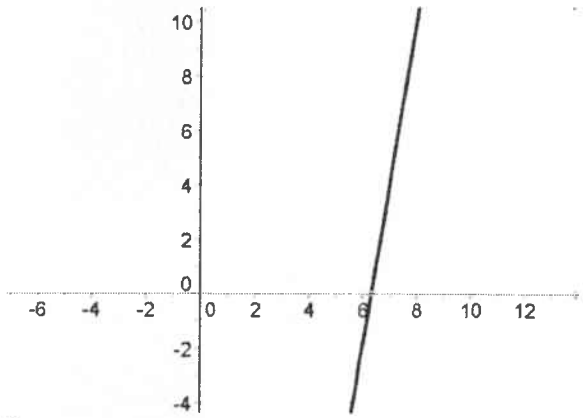
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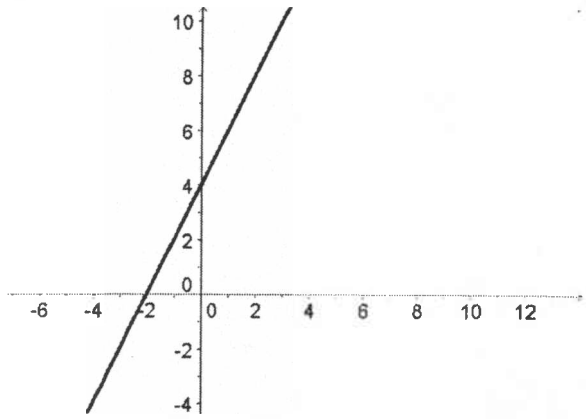
-6 -4 -2 0 2 4 6 8 10 12

10.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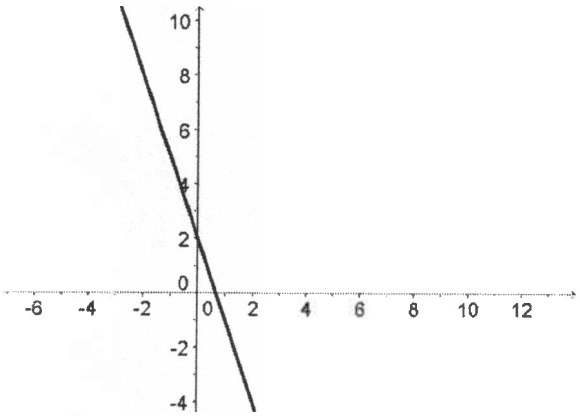
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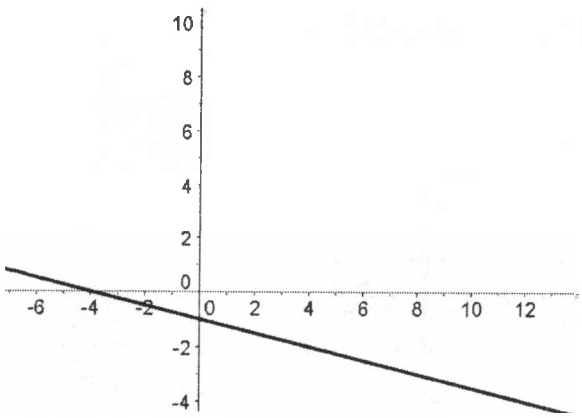
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-6 -4 -2 0 2 4 6 8 10 12

Matching Graphs
Equation Page

Directions:
Listed below are fifteen different functions. Match ten of the functions to the correct graph on the graph page.

A. $y = x$

B. $y = x^2$

C. $y = x^3$

D. $y = x^3 + 4x^2 + 2x + 4$

E. $y = -3x + 2$

F. $y = 6$

G. $y = \frac{1}{2}x^2 - 5x + 10$

H. $y = x^3 + 4$

I. $y = 2x + 4$

J. $y = -x^2 - 2x + 3$

K. $y = x^3 - 4x$

L. $y = 6x - 38$

M. $y = -x^2 - 2x + 3$

N. $y = -2x^2 + 4x + 4$

O. $y = -\frac{1}{4}x - 1$

Appendix 2

Match-Up Proofs:

Written below are seven different completed algebra proofs. These proofs should be printed and then cut out. Students must match up the statements with the correct reasons for each proof. This can be done individually, in groups, or with partners.

Statements	Reasons
$5x + 5 = 15 - 3x$	Given
$2x + 5 = 15$	Addition Property of Equality
$2x = 10$	Subtraction Property of Equality
$x = 5$	Division Property of Equality

Statements	Reasons
$2(x - 3) = 5x + 3$	Given
$2x - 6 = 5x + 3$	Distributive Property
$2x = 5x + 9$	Addition Property of Equality
$-3x = 9$	Subtraction Property of Equality
$x = -3$	Division Property of Equality

Statements	Reasons
$x^2 - 6x = 40$	Given
$x^2 - 6x - 40 = 0$	Subtraction Property of Equality
$(x + 4)(x - 10) = 0$	Distributive Property of Equality
Either $(x + 4) = 0$, or $(x - 10) = 0$	Multiplication Property of Equality
$x = 10$	Addition Property of Equality
$x = -4$	Subtraction Property of Equality

Statements	Reasons
$5(-x + 2) + 6 = 3x + 8$	Given
$-5x + 16 = 3x + 8$	Distributive Property
$16 = 8x + 8$	Addition Property of Equality
$8 = 8x$	Subtraction Property of Equality
$x = 1$	Division Property of Equality

Statements	Reasons
$x^2 + 5x = 24$	Given
$x^2 + 5x - 24 = 0$	Subtraction Property of Equality
$(x + 8)(x - 3) = 0$	Distributive Property of Equality
Either $(x + 8) = 0$, or $(x - 3) = 0$	Multiplication Property of Equality
$x = 3$	Addition Property of Equality
$x = -8$	Subtraction Property of Equality

Statements	Reasons
$x + 3 = 9$	Given
$x = 6$	Subtraction Property of Equality
$2y - 3x = 28$	Given
$2y - 3(6) = 28$	Substitution Property
$2y = 10$	Addition Property of Equality
$y = 5$	Division Property of Equality

Statements	Reasons
$\frac{1}{2}x + 5 = 7$	Given
$\frac{1}{2}x = 2$	Subtraction Property of Equality
$x = 4$	Multiplication Property of Equality
$y^2 + x^2 = 25$	Given
$y^2 + (4)^2 = 25$	Substitution
$y^2 = 9$	Subtraction Property of Equality
$y = 3$	Definition of Square Root