The Role of the Golden Ratio in Greek History

Christian E. Kissinger

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In Cooperation With and Celebration Of

The Nashville Parthenon
Foreward

When I entered high school as a freshman, I already knew that I wanted to do a Senior Project. Therefore, I looked to my main interest, which is history. Due to the fact that the Greeks are my favorite historical culture, looking to the Nashville Parthenon for a project seemed a perfect fit. However, I was not certain of a focus for the project. Initially, my suggestion to the Parthenon was a study of music and acoustics. The Parthenon staff was very receptive to this idea and invited me to a lecture and provided initial reading materials. As I began to search deeper into this topic, the Golden Ratio kept appearing. I began to follow that path and found the implications of this ratio quite fascinating. The number appears to be connected to and studied by everyone from artists, to philosophers, mathematicians, scientists and astronomers. In addition, the ratio is quite connected to the Greek culture and the Parthenon. However, there was one problem. The problem was that Golden Ratio is a ratio, and that meant the project’s focus would be math.

So, why did I pursue this in the end? I must admit that at first I did not truly understand the ratio. I also found that its connections were so intertwined in so many different areas of life that I felt I was in a maze not knowing which path to take. Yet, there were some strong forces that pushed me ahead and became the focal points of not only finishing this project, but really trying to make it something of significance. Those reasons were:

- A challenge within myself to take on a math project and successfully fulfill it;
- The desire to provide a project that might reach students in some impactful manner. Possibly there would be something in this project that would allow them to see math in a different way or another way to understand math rather than just formulas on a board;
I have always believed that there must be a way to explain math to make it more relevant and interesting. Now is my chance to see if I can prove that to be the case.

In the end, I have decided to tie in another nonprofit to this project, VSA Tennessee. I have worked with this organization since I was seven years old, and therefore have been exposed to the positive impact the organization makes in the lives of children with disabilities through the arts. Since I am using the arts to explain the Golden Ratio’s role in Greek history, I believed that this organization could provide some valuable input. At the back of this curriculum guide, you will find some lesson plans used with students with disabilities. The final performance for this project will feature the art of some of these young people as they demonstrate the Golden Ratio.
Special Thanks

There are several notes of thanks that I wish to express to those who provided guidance and support to make this project happen.

First and foremost, a huge thank you goes to DeeGee Lester and the Nashville Parthenon for allowing me to do this project with them. In addition to agreeing to let me focus on the Parthenon, Ms. Lester provided me with resources, direction and the use of the facilities for the final presentation.

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Chapter 1: What is the Golden Ratio?

The Golden Ratio is an irrational number that is approximately equal to 1.618 and is represented by the Greek symbol known as “phi”. Sometimes the Golden Ratio is called by other names such as the Golden Proportion, Divine Proportion, Divine Section, Golden Number or Golden Mean. When the ratio is used in cubic geometry, it is called the Golden Section. The Golden Rectangle refers to a rectangle with a short to long side ratio of 1: 1.618. An interesting aspect of the Golden Rectangle is that if you cut out a square starting from one of the short sides of the Golden Rectangle you will have another Golden Rectangle. (Craft 2). When an isosceles triangle has the ratio of the leg $a$ to base $b$ in the Golden Ratio, it is called a Golden Triangle. Finally, there is the Golden Spiral which grows logarithmically. It is important to know that the geometrical shapes of the rectangle, triangle and spiral get their “golden” name when they have properties that connect them back to the Golden Ratio.

The Golden Ratio is known as an irrational number because 1.618 is a convenient approximation, but digits in the Golden Ratio just keep on going and never end ….. 1.6180398874989484820... (etc.).

The idea behind the Golden Ratio is that if you divide a number into two parts so that:

- The longer part divided by the smaller part
- Is also equal to
- The whole length divided by the longer part

Then you will have the Golden Ratio

![Image from http://www.mathsisfun.com/numbers/golden-ratio.html](http://www.mathsisfun.com/numbers/golden-ratio.html)
To calculate the ratio:

1) Given two numbers $A$ and $B$ where $A$ is larger than $B$ divide the smaller number by the larger number.

2) Add 1.

3) Continue this process until the number gets close to the Golden Ratio.

The knowledge of the Golden Ratio is ancient. Many believe that the Egyptians were well aware of this ratio and used it in building the pyramids and that they later taught this information to the Greeks. Yet, others believe that the ratio was used, but not truly understood in these early times. The ratio is very connected to the Greeks as it was named after the sculptor of Athena and much of the decorations on the Parthenon, Phidias, which is why it is represented by the Greek symbol phi.

Legend says the Golden Ratio was discovered by Pythagoras, and that it was through him that the true knowledge of this ratio began to be understood. The Golden Ratio Used By Greeks states that the Greek Philosopher Pythagoras discovered the concept of harmony while listening to the different sounds given off when the blacksmiths’ hammers hit their anvils. After further studies using stringed instruments and observing nature, he came to the conclusion that the ratio of small integers is what defined beauty. “Astonished by this discovery and awed by it, the Pythagoreans endeavored to keep this a secret; declaring that anybody that broached the secret would get the death penalty. With this discovery, the Pythagoreans saw the essence of the cosmos as numbers and numbers took on special meaning and significance. The symbol of the Pythagorean brotherhood was the pentagram, in itself embodying several Golden Means.” (Parveen 1). Euclid, a Greek mathematician who is known as the “Father of Geometry”, was the
first person to write a definition of the Golden Ratio: “A straight line is said to have been cut in extreme and mean ratio when, as the whole line is to the greater segment, so is the greater to the less.” (Dimare 2)

A concept that is tied to the Golden Ratio is the Fibonacci Sequence which is named after a man named Leonardo Fibonacci. This sequence begins with the numbers 1 and 1. In order to get the next number, a person must add the previous two numbers in the sequence. For example: 

\[ 1 + 1 = 2, \quad 1 + 2 = 3, \quad 2 + 3 = 5, \quad 3 + 5 = 8, \quad 5 + 8 = 13, \quad 8 + 13 = 21. \]

Therefore, the actual numbers in the sequence are: 1, 1, 2, 3, 5, 8, 13, 21, 34, 55 ….. Where the Golden Ratio ties in to this sequence is through the ratio between the numbers. This can be seen in the following:

\[
\begin{align*}
2/1 &= 2.0 \\
3/2 &= 1.5 \\
5/3 &= 1.67 \\
8/5 &= 1.6 \\
13/8 &= 1.625 \\
21/13 &= 1.615 \\
34/21 &= 1.619 \\
55/34 &= 1.618 \\
89/55 &= 1.618 \\
\end{align*}
\]

As stated by Mr. Narain on The Golden Ratio Page, as the numbers in the sequence get larger, the ratio will eventually become the same number, which is the Golden Ratio. “One more interesting thing about Phi is that it is reciprocal. If you take the ratio of any number in the Fibonacci sequence to the next number, the ratio will approach the approximation of 0.618. This is the reciprocal of Phi: \(1/1.618=0.618.\)” (Narain 2) There is not another known number to have this property outside the Fibonacci Sequence.
To some, The Golden Ratio is considered sacred due to its relationship to nature, music, beauty, poetry, art and even the construction of the universe and the human body. However, others have stated that the relationships associated with the Golden Ratio are coincidence and exaggerations. Regardless if it is sacred or just an amazing coincidence of mathematics, the Greeks revered this ratio and used it in cubic architecture to represent kingship, philosophy and wisdom. Therefore, a good starting point in understanding this ratio is the Parthenon.

The Parthenon was created for the Greek goddess Athena. Athena is credited with having taught Prometheus architecture and mathematics as well as bringing the domestic crafts to humankind. Athena is also connected with the invention of the flute, the trumpet and being a teacher of music. Interestingly, the mathematical concept of the Golden Ratio is found throughout the arts in architecture, visual arts, music, and poetry. Also, probably one of the best architectural examples of this ratio is the Parthenon.

Since the attributes of Athena clearly showcase the Golden Ratio, and the Parthenon that was built to honor her stands as quite possibly the greatest structure to bring the ratio to life, it seems only fitting to categorize the ratio into four of those attributes. In each of the attributes an example of a specific instance in which we find the ratio will be provided, as well hands-on activities and real-life diagrams and examples to help every individual to understand and take away from it what they may. The four categories will be as follows: Architecture, Art, Music and Poetry.

*Fun Facts: It is estimated that it cost 1000 Talents or around 6 million drachmae to build the Parthenon.
Chapter 2: The Golden Ratio and Architecture

The Golden Ratio can be found in ancient and modern architecture. An interesting study could be made just in comparing the many structures that use this ratio. Yet, this guide is focused on the ratio’s connection specifically to the Greeks. Phidias, the sculptor for the decorations of the Parthenon and the Athena sculpture which the Parthenon housed and the man whom the ratio is named after, was a master Greek sculptor and was known to use this ratio in many of his works. He created a huge bronze statue of Athena that could be seen by sailors returning to the city at the port of Piraeus. The actual architects of the Parthenon were Iktinos (Ictinus) and Kallikrates (or Callicrates). Whether by planning or coincidence, the Golden Ratio was used extensively throughout the construction of the Parthenon.

Between 447-438 B.C, the Parthenon was constructed on a Golden Rectangular plot of land that of course fits the dimensions of the Golden Ratio, and was carved out of Pentelic marble. It took approximately 10 years to construct the building. In comparison, Nashville's Parthenon was created from brick, stone, structural reinforced concrete, and cast concrete aggregate. The Nashville Parthenon was originally built in 1897, but it was renovated and reopened in 1931. It also took approximately 10 years to build. According to the Nashville Parthenon website, “one of the subtleties employed by the Greeks in building the Parthenon is that no two major lines are exactly parallel nor exactly equal in length.” The original Parthenon was 30.88m wide, 13.72 meters high, 69.5 m long. It was a relatively small temple compared to structures such as the Zeus Temple with its measurements of 110m long and 55m wide.
The Parthenon is surrounded by columns. This is fitting since columns have a spiral shape and spirals help describe the Golden Mean logarithmic spiral. There are various ways to count the columns. In some materials provided by the Nashville Parthenon, there are 17 columns on each side and 6 columns in the front without counting the corner columns twice. Using this method, the Golden Mean can be determined by the ratio between 17 and 6. In addition, Athena had a special number and it was 6. Therefore, it would make sense that there would be 6 columns as the entrance and exit of her temple. However, Christopher Witcombe, a Professor of Art History at Sweet Briar College, counts the number of columns in the front as 8 and 16 on the side (not counting the corner columns twice). This is also significant because the number 8 represents infinity. The interesting point of this method is that 8 x 2 (the number of columns in the front and back) equals 16 (the number on each side) and if the Golden Ratio method of adding 1 is used, then the total is 17. If the Parthenon is viewed from the side, it does have 17 columns. He states that this is said to be geometrically proportional. Therefore, both methods provide both significance to the Greek culture and connections to the Golden Ratio. It is interesting to note that other Doric temples used 6 and 13 pillars for width and length respectively. Therefore, the Parthenon did stray from this custom. The columns are 1.9 m in diameter and 10.4m high.

**Activities:**

In order to understand the connection of the Golden Ratio to the Parthenon, consider the following dimensions associated with the Parthenon and see if the calculations will come close to the Golden Ratio. These dimensions are based on the dimensions at the Nashville Parthenon, which is a replica of the Parthenon in Greece.
1) The size of the columns is approximately 34 feet high and 6 feet in diameter.

2) The great bronze doors are 24 feet high and 7 feet wide.

3) In the interior, the building is divided in two sections. One section is the naos (temple), which is 98 feet long and 43 feet high.

4) In addition, the naos (temple) is 98 feet long and 63 feet wide.

5) The second room was where priests left gifts to Athena and it is called the Treasury. This room is 63 feet long wide and 44 feet long.

Look at the floor plan for the original Parthenon and make a list of all of the Golden Rectangles.

This image was found at: http://perseus.holycross.edu/Courses/Greek_History/JPEGView.Docs/Archive/Parthenon/GIFs/08.Frieze.schematic.GIF
How many Golden Rectangle overlays can be found in the diagram below of the Parthenon?

This image was found at: http://www.missioncollege.org/depts/math/keller/golden.htm

*Fun Fact: The statue of Athena in the original Parthenon was made of elephant ivory and gold.
Chapter 3: The Golden Ratio and Music

Music was a very important part of the life of the Greeks. It played an especially strong role in their festivals. Considering that Athena was the goddess thought to have introduced some of the musical instruments to humans, it was only fitting that music would be a large part of any festival dedicated in her honor. According to Roger Dunkle in *Athenian Daily Life*, “The Parthenon is decorated with a Frieze that runs around the exterior walls of the building. The frieze was carved in situ and can be dated back to 442 BC-438 BC. The Frieze depicts an interpretation of the procession from the Dipylon Gate in the Kerameikos to the Acropolis. The procession occurred every year and was meant to honor the goddess Athena.” In this Frieze (which is a horizontal band around the top of the exterior of the building), is the likeness of musicians and they are depicted due to their importance in this celebration. Dunkle goes on to state that “The Panathenaea (‘all-Athenian festival’) was Athens' most important festival and one of the grandest in the entire Greek world. Except for slaves, all inhabitants of the city and suburbs could take part in the festival. Even metics (resident aliens) and freed slaves could participate (up to a certain point).” One of the important aspects of this festival was the musical and rhapsodic contests that resulted in prizes of crowns and cash. Therefore, it can be seen that music was very important to the Greeks in general and to the Parthenon in specific.

The next point to make is the connection of music to the Golden Ratio. Calvin Bower explains this connection best in *Greek Music and the Greek Gods* by saying, “Although many names of musicians are recorded in ancient sources, none played a more important role in the development of Greek musical thought than the mathematician and philosopher PYTHAGORAS
OF SAMOS (6th-5th century BC). According to legend, Pythagoras, by divine guidance, discovered the mathematical rationale of musical consonance from the weights of blacksmiths’ hammers. He is thus given credit for discovering that the interval of an octave is rooted in the ratio 2:1, that of the fifth in 3:2, that of the fourth in 4:3, and that of the whole tone in 9:8. Followers of Pythagoras applied these ratios to lengths of a string on an instrument called a canon, or monochord, and thereby were able to determine mathematically the intonation of an entire musical system. The Pythagoreans saw these ratios as governing forces in the cosmos as well as in sounds, and Plato's Timaeus describes the soul of the world as structured according to these same musical ratios. For the Pythagoreans, as well as for Plato, music consequently became a branch of mathematics as well as an art; this tradition of musical thought flourished throughout antiquity in such theorists as Nicomachus of Gerasa (2nd cent. AD) and PTOLEMY (2nd cent. AD) and was transmitted into the Middle Ages by BOETHIUS (6th cent. AD).

The mathematics and intonation of the Pythagorean tradition consequently became a crucial influence in the development of music in medieval Europe.” What Bower describes is a connection between the Golden Ratio and the element of intervals in music. However, the Golden Ratio is also connected to music in the areas of acoustics, beat and composition. Acoustics is sound that is produced due to mathematical dimensions of the height, width and length of a location. Also, the material of the surfaces in the space will affect the sound.

According to Alan Lofft in Room Acoustics: The Forgotten Component, he states that creating a room based on Golden Ratio dimensions will minimize room peaks and nodes and create the best acoustical sound. Other acoustics’ experts also note that “Not only does the design of architectural spaces based on 'Φ' give them visual beauty and harmony but, in addition,
such spaces are well known for their superior acoustics. There is indeed theoretical and experimental justification in this.” (Phi Acoustics 1). Due to the fact that the Greeks were very interested in public presentations of drama and music, acoustics were important to them and they demonstrated a mastery of acoustics at many locations. Due to the fact that the Parthenon is built using the dimensions of the Golden Ratio, it is understandable that the acoustics would be quite good in this building.

When Pythagoras was listening to the hammers, he not only noticed the intervals in the sound or the pitches, but he also noted the interval of time between each sound. These time intervals in a song create the beat or the rhythmic quality. These intervals can also be measured in length of time and the time ratios can be compared to the Golden Ratio. It is said that the closer a musical piece’s beat is to the Golden Ratio the more appealing its rhythm will be to the human ear.

Finally, the Golden Ratio has also been associated with the composition of some musical pieces. It has been argued that classical composers such as Mozart, Beethoven, Bartok, Debussy and Satie used the ratio to compose some of their pieces. Edmund Harris from the University of Arkansas’ mathematics department says that “James Tenney reconceived his piece "For Ann (Rising)", which consists of up to twelve computer-generated tones that glissando upwards (see Shepard tone), as having each tone start so each is the golden ratio (in between an equal tempered minor and major sixth) below the previous tone, so that the combination tones produced by all consecutive tones are a lower or higher pitch already, or soon to be, produced. In Bartok's Music for Strings, Percussion, and Celesta, the xylophone progression at the beginning
of the 3rd movement occurs at the intervals 1:2:3:5:8:5:3:2:1. French composer Erik Satie used the golden ratio in several of his pieces, including “Sonneries de la Rose Croix.” The golden ratio is also apparent in the organization of the sections in the music of Debussy's Image, "Reflections in Water", in which the sequence of keys is marked out by the intervals 34, 21, 13, and 8 (a descending Fibonacci sequence), and the main climax sits at the φ position. Because there are few records left of ancient Greek music, it is impossible to say if the Golden Ratio was used in the beat or composition of pieces. However, it can be said that it did play a part in the acoustics and understanding of pitch. It is also obvious that music was an important part of celebrations that were connected to the Parthenon.

Activities:
Consider the following in regards to the connection between the Fibonacci sequence and music:

How many piano keys are in an octave? [13: 8 white and 5 black]
What is a scale and how many notes are in it? [8]
How many white keys are in an octave? [8]
How many black keys are in an octave? [5]
Black keys are split into groups of? [ 2 and 3]
How many tones are in a pentatonic scale? [5]
How many notes are in a chromatic scale? [13 – all the notes of an octave]

Create a Greek Canon (The Greek canon, “κανόν”, means rule, principle and also mode. It comes in various shapes and ranges and is typically a small portable instrument. )

Items needed: an empty shoe box, empty toilet paper roll, 7 rubber bands, 12 brass fasteners and scissors.
Directions: 1) Cut a hole slightly off-center on the top of a shoe box. 2) Push 12 brass fasteners into the shoe box, evenly space six on one end and six on the other end. 3) Cut six rubber bands in half so they become six long rubber band strings. For each rubber band string, tie one end to a brass fastener and then stretch it across the hole, tying the other end to the opposite brass. 4) Cut open an empty toilet paper roll, and slip it underneath one side of the strings, lifting them up slightly.

Examine a piece of sheet music for one of the classical compositions mentioned above by considering the following:

Count the total number of measures in a piece

Count the number of beats per measure

Consider the pattern of notes and their ratios to each other

Create a piece of music

Use the Fibonacci sequence by selecting to use a repeat pattern of beats in a repeat number of measures using the numbers of 3, 5, 8 or 13.

Create a pattern of notes going up (such as 3) and then notes going down (such as 5) in a repeating fashion.

Create a pattern of notes per measure such as 3 notes in the first measure, 5 in the second and 8 in the third. Then repeat the pattern.

*Fun Fact: Through the years, the original Parthenon served as a church, a mosque, and was used as a munitions depot.
Chapter 4: The Golden Ratio and Poetry

Of all of the art forms, poetry has the strongest connection to the ancient Greeks. Poetry was used in music, education, as a craft to praise governmental leaders, and in philosophy. The words were sung usually to a musical instrument. Men called rhapsodes made a living by reciting poetry. In fact, it is impossible to truly study Greek history without being exposed to Homer and his poetry of the Iliad and the Odyssey. The goddess Athena is a main character in both poems, which connects back to the Parthenon.

Homer was also known for his Homeric Hymns, which were poems set to music. In N.S. Gill’s, *Hymns To Athena*, there is a Homeric Hymn that fits the Fibonacci Sequence by having 5 lines. “Of Pallas Athene, guardian of the city, I begin to sing. Dread is she. With Ares she loves deeds of war, the sack of cities and the shouting and the battle. It is she who saves the people as they go out to war and come back. Hail, goddess, and give us good fortune with happiness!”

The Roman poet, Publius Vergilius Maro, known as Virgil (70-19 BC), is famous for a poem called Aeneid. This poem copies the style of Homer and incorporates some of the content of the Iliad and the Odyssey. In Prof George Eckel Duckworth's book *Structural patterns and proportions in Virgil's Aeneid: A study in mathematical composition*, Duckworth argues that Virgil consciously used Fibonacci numbers to structure his poetry and so did other Roman poets of the time.
Activity:

Write a poem using the Fibonacci sequence:

- Use the Fibonacci sequence to determine how many words will be in each line. For instance, the first line will have one word, the second line will have one word, the third line will have two words. An example

I
am
writing a
poem using the
Fibonacci sequence as a template.

- Or use the same method as above, but use syllables instead of words.

- Fun Fact: Lord Elgin, an Englishman, claimed he received permission from the local Turkish authorities to remove whatever he wanted from the ruins of the Parthenon. But based on surviving documents, he apparently interpreted even that "permission" quite liberally. The Greek government has been demanding the return of the Parthenon Marbles and an entire vacant floor awaits them at the New Acropolis Museum. At present, they are displayed at the British Museum in London, England. (Taken directly from http://gogreece.about.com/od/athenssightseeing1/a/parthenonathens.htm)
Chapter 5: The Golden Ratio and Art

In the second half of the 5th century B.C., Greece was entering the Golden age. At the same time, geometry was entering into its own classic period. By combining geometry into the creation of art, this time period saw the creation of what are know as some of the most beautiful art and architecture in Greece’s history. Phidians, and several of their architects of the time, believed that mathematical proportions and geometric harmony are what created beauty. In Why the Golden Ratio Pleases the Eye, Adrian Bejan, professor of mechanical engineering at Duke University, states “the human eye is capable of interpreting an image featuring the golden ratio faster than any other. Whether intentional or not, the ratio represents the best proportions to transfer to the brain.” Even after the Athenian democracy collapsed, the Greek philosopher Plato continued these beliefs through the earliest institution of higher learning, which was called The Academy. Above the gate of the academy was the inscription: LET NONE IGNORANT OF GEOMETRY ENTER HERE. (Jovanovic 2)
The ratio can be found in the artistic decoration on the Parthenon in the Frieze (band of sculpture) that runs about the columns.
In some Greek sculptures, the navel (belly button) represents the mean of the golden ratio. The navel is positioned such that the ratio of the short half to the long half is equal to the ratio of the whole to the long half. An example of this is seen in the sculpture of Apollo of the "Belvedere".

\[
\frac{B}{A} = \frac{A+B}{B}
\]

\[
11.15:6.92 = 18:7 = 1.61...
\]

http://goldenratio.wikidot.com/greek-and-roman-art
It is said that a number of Renaissance artists also used the golden ratio when creating their art. The Golden Ratio can be found in Da Vinci’s “The Annunciation,” “Madonna with Child and Saints”, “The Mona Lisa” and “St. Jerome.” Leonardo Da Vinci was especially known for using the ratio in his work. Due to the fact that there were so many examples of the Golden Ratio in his work “The Last Supper”, an example of this work has been provided.

However, the focus in this guide is on the Golden Ratio’s connection to the Greeks, which takes us back to Athena. The statue below demonstrates the use of the ratio. Even when viewed from the side, the human head illustrates the Golden Ratio. In the Statues of Athena, the first Golden Ratio is the length from the front of the head to the ear opening compared with the length from the forehead to the chin. The second one appears in the ratio of the length from the nostril to the earlobe compared with the length from the nostril to the chin.

Image found at: [http://library.thinkquest.org/trio/TTQ05063/phihistory.htm](http://library.thinkquest.org/trio/TTQ05063/phihistory.htm)

*Fun Fact:* It is estimated that Nashville’s 42’ tall Athena would require a woman’s shoe size of
Activity

It is said that the closer the dimensions of the face fit to the Golden Ratio, the more beautiful the person will be perceived to be by others. Find some close up photos of famous people and determine their facial ratios. You may even want to take close up photos of yourself and your friends to determine your own ratio. Remember that 1.62 is considered golden when it comes to beauty.

\[
\begin{align*}
\text{a} &= \text{Top-of-head (1) to chin (2)} = \underline{\quad} \text{cm} \\
\text{b} &= \text{Top-of-head (1) to pupil (3)} = \underline{\quad} \text{cm} \\
\text{c} &= \text{Pupil (3) to tip of nose (4)} = \underline{\quad} \text{cm} \\
\text{d} &= \text{Pupil (3) to lip (5)} = \underline{\quad} \text{cm} \\
\text{e} &= \text{Width of nose (6 to 7)} = \underline{\quad} \text{cm} \\
\text{f} &= \text{Outside distance between eyes (8 to 9)} = \underline{\quad} \text{cm} \\
\text{g} &= \text{Width of head (10 to 11)} = \underline{\quad} \text{cm} \\
\text{h} &= \text{Hairline (12) to pupil (3)} = \underline{\quad} \text{cm} \\
\text{i} &= \text{Nosetip (4) to chin (2)} = \underline{\quad} \text{cm} \\
\text{j} &= \text{Lips (5) to chin (2)} = \underline{\quad} \text{cm} \\
\text{k} &= \text{Length of lips (13 to 14)} = \underline{\quad} \text{cm} \\
\text{l} &= \text{Nosetip (4) to lips (5)} = \underline{\quad} \text{cm}
\end{align*}
\]
Now, find the ratios.

a/g = ____ cm

b/d = ____ cm

i/j = ____ cm

i/c = ____ cm

e/l = ____ cm

f/h = ____ cm

k/e = ____ cm

Activity

When the 2 front teeth form a rectangle with a Golden Ratio measurement (height to width of the center 2 teeth of 1.62) it is perceived as a perfect smile. Another ratio used is from the width of the first tooth to the second tooth and a third using the width of the smile to the third tooth from the center. (Goodstein 2). Take some photos of smiles and figure the ratios.

Image found at http://facethis.blogspot.com/2012/01/perfect-face-golden-ratio-beauty.html
Chapter 1 Quiz

1. The Golden Ratio is what type of number?
   A) Rational C) Fraction
   B) Irrational D) Integer

2. The Golden Ratio is represented by which Greek symbol?
   A) Phi            C) Beta
   B) Delta          D) Alpha

3. The Golden Ratio rounds off to what number?
   A) 3.14           C) 1.618
   B) 2.68           D) 3.75

4. Which name is used for the Golden Ratio?
   A) Golden Proportion C) Divine Proportion
   B) Golden Mean      D) All of the above

5. The Golden Ratio was named after whom?
   A) Phidias           C) Athena
   B) Odysseus         D) Pythagoras
6) The answer to number 5 was the architect of what famous ancient Greek structure?
A) Paestum  C) Parthenon
B) Poseidon’s Temple  D) Erechtheum

7) Which Greek Philosopher is credited with discovering the Golden Ratio?
A) Socrates  C) Plato
B) Pythagoras  D) Aristotle

8) Which mathematical sequence is tied to the Golden Ratio?
A) The Sigma Notation  C) The Infinite Series
B) Proof by Induction  D) Fibonacci Sequence

9) The Parthenon was created for which Greek goddess?
A) Hera  C) Athena
B) Artemis  D) Demeter

10) Which other early civilization is credited with using the Golden Ratio for architecture and possibly teaching it to the Greeks?
A) Romans  C) Persians
B) Egyptians  D) Chinese
Chapter 2 Quiz

1. The interior of the Parthenon is divided in two sections which are called the _______ and the _______.

2. No two major lines in the Parthenon are exactly parallel.  T       F

3. From what materials was the original Parthenon constructed?
   A) Granite   C) Concrete
   B) Pentelic Marble   D) Limestone

4. The Great Doors of the Nashville Parthenon are made of what material?
   A) Bronze   C) Titanium
   C) Brass   D) Gold

5. Approximately how many years did it take to build each Parthenon?
   A) 5       C) 12
   B) 8       D) 10

6. What was the name of the room in which the priests left gifts for Athena?
   A) Temple   C) Treasury
   B) Labyrinth   D) Peristyle
7. What is another name for the *naos*?
   A) Temple      B) Acropolis
   B) Treasury    D) Amphitheater

8. The Nashville Parthenon was renovated and reopened in what year?
   A) 1897        B) 1950
   C) 1931        D) 1929

9. The Parthenon has how many total columns?
   A) 46          B) 52
   C) 50          D) 48

10. The statue of Athena in the original Parthenon was made of gold and _____________
Chapter 3 Quiz

1. Which composer was not mentioned as using the Golden Ratio in one of his pieces?
   A) Bach  C) Beethoven
   B) Bartok  D) Mozart

2. The Panathenaea was Athens most important festival?  T  F

3. What does Panathenaea mean?
   A) all-Greek festival  C) all-Athenian festival
   B) All-People’s festival  D) All Pelopoanesian festival

4. Pythagoras discovered the Golden Ratio through musical consonance from the weights of hammers used by blacksmiths?  T  F

5. An octave is rooted in the ratio 3:1?  T  F

6. What Greek philosopher described the soul of the world as structured according to musical ratios?
   A) Socrates  C) Aristotle
   B) Pythagoras  D) Plato

7. Music was considered a branch of math and art to the Greeks?  T  F
8. Acoustics are produced due to mathematical dimensions of the length, width and height of the location? T F

9. The closer a music piece’s beat is to the Golden Ratio the less appealing its rhythm will be to the human ear? T F

10. What is a Greek canon?
   A) Song                C) Math ratio
   B) Musical instrument D) Weapon
Chapter 4 Quiz

1. Homer wrote the __________ and the ____________

2. Besides poetry, what else was Homer known for writing?
   A) Novels        C) Short Stories
   B) Hymns        D) Poetry

3. Who was Virgil?
   A) A Greek Philosopher        C) A Roman Poet
   B) A Greek Poet                D) A Roman mathematician

4. Athena is not mentioned in Homer’s poetry, but only in his other writings? T   F

5. Virgil’s full name was Publico Veno Magilus?   T    F

6. The Aeneid was written before the Iliad.   T    F

7. Who wrote the Aeneid?

8. Write a poem with 5 lines using the Fibonacci Sequence.

9. What were the names of men who were paid to perform poetry?
Chapter 5 Quiz

1. In the second half of what century BC did the Greeks enter their Golden Age?
   A) 2nd  C) 4th
   B) 3rd  D) 5th

2. What made the art of this time so beautiful?

3. Plato taught at the Academy.
   T  F

4. Above the entrance to the Academy was written what?

5. The navel of a sculpture is the what?
   A) Bellybutton  C) Eye
   B) Nose  D) Armpit

6. The navel of a sculpture represents the golden ratio.
   T  F

7. What famous Renaissance artist also used the golden ratio in his art?
   A) Monet  C) Picaso
   B) Da Vinci  D) Michaelangelo

8. The Athena statue in Nashville would require a women’s size ____ shoe.
9. The human eye can interpret an image featuring the golden ratio faster than other images.
   T   F

10. Phideans did not believe mathematical proportions and geometric harmony created beauty.
    T   F
Quiz Key

Chapter 1 Quiz Answers
1) B
2) A
3) C
4) D
5) A
6) C
7) B
8) D
9) C
10) B

Chapter 2 Quiz Answers
1) Temple, Treasury
2) T
3) B
4) A
5) D
6) Treasury
7) A
8) C
9) A
10) elephant ivory

Chapter 3 Quiz Answers
1) A
2) T
3) C
4) T
5) F
6) D
7) T
8) T
9) F
10) B
Chapter 4 Quiz Answers
1) Iliad and Odyssey
2) B
3) C
4) F
5) F
6) F
7) Virgil
8) (Answers will vary)
9) rhapsodes

Chapter 5 Quiz Answers
1) D
2) Combining geometry into the creation of the art
3) T
4) LET NONE IGNORANT OF GEOMETRY ENTER HERE
5) A
6) T
7) B
8) 177
9) T
10) F
Glossary

**Acoustics:** The sound quality of a space for performing music

**Acropolis:** A fortified part of an ancient Greek city, typically built on a hill

**Aeneid:** A poem written by the Roman poet Virgil which includes content from the Iliad and the Odyssey.

**Athena:** Greek goddess of wisdom, architecture, math, and the arts. The Parthenon was built in her honor

**Canon:** An ancient Greek instrument

**Divine Proportion:** Another name for the Golden Ratio

**Euclid:** A Greek mathematician known as the father of geometry

**Fibonacci Sequence:** A series of numbers tied to the Golden Ratio through the ratio between the numbers in the series

**Frieze:** A sculptured or ornamented band in a building

**Golden Mean:** Another name for the Golden Ratio

**Golden Proportion:** Another name for the Golden Ratio

**Golden Ratio:** An irrational number that is approximately equal to 1.618 and is represented by the Greek symbol phi

**Golden Rectangle:** A rectangle whose side lengths are in the Golden Ratio

**Golden Section:** Another name for the Golden Ratio

**Golden Spiral:** A logarithmic spiral whose growth factor is phi

**Golden Triangle:** An isosceles triangle such that the ratio of the hypotenuse to the base is equal to the Golden Ratio

**Homer:** A Greek poet most well known for the *Iliad* and the *Odyssey*

**Hypotenuse:** The side of a right triangle opposite of the right angle
**Iktinos (Ictinus):** One of the architects of the Parthenon

**Iliad:** A famous Greek poem written by Homer

**Irrational Number:** A number where the digits go on indefinitely

**Isosceles Triangle:** A triangle having two equal sides

**Kallikrates (or Callicrates):** An architect of the Parthenon

**Kerameikos:** An area of Athens located to the northwest of the Acropolis

**Leonardo Fibonacci:** Creator of the Fibonacci Sequence

**Metics:** A resident alien who did not have rights of a citizen

**Monochord:** Ancient musical and scientific instrument

**Naos:** The inner part of a Greek temple

**Odyssey:** A famous Greek poem written by Homer

**Panathenaea:** Ancient Greek religious festival to Athena

**Phi:** The twenty-first letter of the classical and modern Greek alphabet

**Phidias:** Classical Greek sculptor, painter and architect. Sculptor of Athena and the Parthenon

**Plato:** Classical Greek philosopher

**Prometheus:** A Titan and cultural hero in Greek mythology

**Publius Vergilius Maro:** Otherwise known as Virgil. A famous Roman poet that wrote *Aeneid*

**Pythagoras:** Ancient Greek philosopher and mathematician

**Pythagorean Brotherhood:** Colleagues, disciples and successors of Pythagoras

**Rhapsodes:** A man who made a living reciting poetry

**Virgil:** A famous Roman poet that wrote *Aeneid*
Bibliography


Weston, Pam. "Golden Ratio." E-mail interview. 7 July 2012.


Supplemental

VSA Tennessee (www.vsatn.org) worked with this project by focusing some of their teaching artist residencies on the Golden Ratio. VSA Tennessee offers several school residencies and after school workshops for children with disabilities across the state of Tennessee. These residencies and workshops utilize the arts to help teach a concept or skill.

The following pages were developed by the teaching artists during their residencies. Each artist completed a general overview of his/her project, offered a student story to demonstrate the skills and lessons learned, and provided a timeline for the residency.

Participating residencies included:

1) Teaching artist Bailey Earith working in east Tennessee at Maryville High School with students with learning disabilities by utilizing the visual arts through funding provided by the Tennessee Department of Education, Division of Special Education.

2) Teaching artist Debra Tayloe working in west Tennessee at Medina Elementary with students with a variety of disabilities by utilizing the visual arts through funding provided by the Tennessee Department of Education, Division of Special Education.

3) Teaching artist Pam Weston working in east Tennessee in an after school program at the Marcella Center with children with Down syndrome by utilizing the visual arts through funding provided by the Autism Society of East Tennessee, the East Tennessee Foundation through the George G Conner Jr fund, Mark Antonini and Mark Holcolmb.
4) Teaching artist Bob Stagner working in middle Tennessee at Hillsboro High School with students who are blind and at Overton High School with students with varied disabilities by utilizing music through funding provided by the Tennessee Department of Education, Division of Special Education.

5) Teaching artist Danielle Clement working with the VSA Movement Connection Dance program at the Dayani Center on Vanderbilt University’s campus with young people with Down syndrome by utilizing dance through funding provided by the Down Syndrome Association of Middle Tennessee.

6) Teaching artist Deanne Collins created lesson plans focused on creative writing and poetry.
Golden Ratio Residency

Teaching Artist: Bailey Earith
Art Form: Visual: Fiber Art: Sculpture: Doll making  
Grade or age level: High school
Primary disability : Learning Disability

Description of the residency:
Students created a 3-dimensional character using fabric, yarn, and found objects. Students wrote a poem about their character using Fibonacci number sequence (1, 1, 2, 3, 5, 8, 13). Students read their poem out loud in front of the class. Classroom teacher expanded the residency by teaching students about the occurrence of Fibonacci numbers in nature and, since these projects will be traded with students in Greece, she taught them about how Fibonacci numbers are used in Greek architecture.

Learning Goals:
- Students will learn to work with new art materials and work intuitively to create an original art doll.
- Students will each use their art doll as writing prompt to create a poem based on Fibonacci numbers.

English:
CLE 3001.1.1 Demonstrate control of Standard English through grammar usage and mechanics (punctuation, capitalization, and spelling).
CLE 3001.2.1 Demonstrate critical listening skills essential for comprehension, evaluation, problem solving, and task completion.
CLE 3001.2.6 Deliver effective oral presentations

Art:
Content Standard 1.0: Media, Techniques, and Processes Students will understand and apply media, techniques, and processes.
Content Standard 3.0: Evaluation Students will choose and evaluate a range of subject matter, symbols, and ideas.
Content Standard 6.0: Interdisciplinary Connections Students will make connections between visual arts and other disciplines.

Adaptations made due to disabilities:
Peer tutors, use of keyboards as alternative to writing, discussion of terms to clarify understanding, use of open-ended questions to help organize thoughts, setting limits to control impulsivity.
Maryville HS Character for Fibonacci poem Residency

Building the basic structure

Digging for props to create a character
Adding props to make a character

Sample poem formatted using Fibonacci numbers: 1,1,2,3, 5,8,13

Writing poems

Reciting in front of class
Student story

Teaching Artist: Bailey Earith

Program Title: Poetry Based on Created Character and Formatted using Fibonacci Numbers
Grade Level: 9-12
School and Location: Maryville HS, 825 Lawrence Ave., Maryville, TN 37803

Dates of Residency: 9/17/12-9/20/12
Number of Sessions: 4
Approximate Date of Story: 9/20/12
Does this student involved have a disability? Yes

_X_ Check the box to give permission to share this story (including the student’s first name) in materials, interviews, and online.

Austin is actively involved in Special Olympics. The character he created, with the help of a peer tutor is of a Special Olympian who won a medal in bowling. His poem, based on the Fibonacci number sequence, is about a bowler named John.

John’s Medal By Austin
Strong
Boy
Gold medal
Holds bowling balls
Push the ball straight down.
He knocks down all the pins at once.
John is going to work hard so he can win more medals.
Assessment Criteria
Completed art doll shows basic structure and form and is personalized with features to help tell a story.
Written poem shows proper structure and format.
Written poem is neat and legible.
Written poem shows creativity and use of art doll as writing prompt/inspiration.
Student will read their finished poem to the class in a proper volume and enunciation.

How does the story relate to learning outcomes, program goals, and/or state education standards?
Austin met the above listed criteria. He crafted a unique doll character, wrote a poem using the assigned Fibonacci format, typed it, and presented it orally in front of the class.

Tennessee Curriculum Strands
English:
CLE 3001.1.1 Demonstrate control of Standard English through grammar usage and mechanics (punctuation, capitalization, and spelling).
CLE 3001.2.1 Demonstrate critical listening skills essential for comprehension, evaluation, problem solving, and task completion.
CLE 3001.2.6 Deliver effective oral presentations.
Art:
Content Standard 1.0: Media, Techniques, and Processes
Students will understand and apply media, techniques, and processes.
Content Standard 3.0: Evaluation
Students will choose and evaluate a range of subject matter, symbols, and ideas.

Golden Ratio Residency
Teaching Artist: Debra Tayloe

Art Form: Visual Art
Grade or Age Level: K-3
Primary disability: Varied

Description of the residency:
Students using the concepts of sequencing and repetition to understand change and sequence in nature by first constructing individual art pieces and assembling their week’s work together into one larger art piece thereby creating an indoor garden installation. Each student created two types of flowers using the assigned Fibonacci sequence method as it applied to petal growth/assemblage, as well as a couple of free form tissue flowers using color and texture; each created a small book using sequential retelling of the “The Tiny Seed” through visual means only and created 2 butterflies, a cocoon and a bird from various papers.

Learning Goals:
Tennessee Curriculum Standards
Literature: 0101.8.6 Derive meaning while reading by employing the following strategies:
Predict what will happen next.
Create mental images.
Using illustration to gain meaning.
Relating knowledge from personal experience, and/or other text.

Visual Arts
Content Standard 1.0: Media, Techniques, and Processes
Students will understand and apply media, techniques, and processes.
Content Standard 3.0: Evaluation
Students will choose and evaluate a range of subject matter, symbols, and ideas.
SPI
3.2.1 Identify subject matter and symbols in the student’s own art.
3.3.1 Identify subject matter and symbols in others’ art.
Content Standard 6.0: Interdisciplinary Connections
Students will make connections between visual arts and other disciplines.
6.2 Identify connections between visual and language arts.
   Identify connections between visual and mathematics.
   Identify connections between visual and science.
Learning Outcomes:
Developing a beginning understanding that Seeds, Flowers, Sunshine & Butterflies are part of cycles in Nature
Making connections between Fibonacci Sequence and the sequencing found in flowering plants.
Making connections between concept components and image making as telling the story. Create through engagement of visual, aural and tactile modalities
Take part in a cooperative effort to create an Art Installation based on Natural Environment through interacting with art elements, the surrounding space, the installation and each other.

Adaptations made due to disabilities:
Use of pre-cut form rather than template scissor cutting to construct some forms. Adhered to same routine each day in presenting activities in order to aid the feeling of predictability and safety in learning environment and to curb impulsivity ie: read book allowing students to tell part of the story on each page, chanting and/or body movement, create art forms, body movement, create art forms. Very simple safe materials and tools were used in as imaginative a way as possible to accommodate fine motor difficulties and give each student a sense of success.
TN State Standards for First Grade Elementary students were used in a classroom composed of K-3 students.
Student story

Teaching Artist: Debra Tayloe

Program Title: Garden Installation based on Eric Carle’s “The Tiny Seed” using Fibonacci Sequence as it appears in Nature
Grade Level: K-3
School and Location: Medina Elementary School, 227 N. Second St. Medina, TN 38355

Dates of Residency: 10/15/12-10/19/12
Number of Sessions: 5
Approximate Date of Story: 10/19/12
Does this student involved have a disability? Yes
_x_ Check the box to give permission to share this story (including the student's first name) in materials, interviews, and online.

Tell the story
Is there a photo or image of student work that relates to the story? Please indicate that in your description

“Michael” is a 3rd grade student with a very quick mind who is able to form definite concepts yet with limited ability to communicate them verbally. He was quite enthusiastic about anything repetitive including reading our Eric Carle book, body movements, chanting, and the routine of the classroom schedule. The verbal rhythm game with the word Fibonacci caught his complete attention as well as the tactile sensation of rhythmically using his entire hand to tap, tap, tap his collage pieces onto his artwork. He is a natural with numbers and enjoyed the discovery of mentally understanding sequencing and its correlation with a visual representation of such. He was easily excited when given the opportunity to recognize specifics and name colors, shapes and line types. “Michael’s” limited fine motor skills required that a classroom aid assist him with the hands on cutting and assembling some parts of projects. He had definite ideas about how he wanted to carry out creating his own vision and used various means of giving directives toward that end ie: various words, sounds and body language to express how he wanted his artwork assembled. He was very insistent in expressing his desire concerning “where to place things” in his handmade sequence book (pictured) wanting certain line shapes placed symmetrically in the pattern he envisioned. A true mathematician and artist!
Assessment Criteria

Responded enthusiastically to counting out loud and clapping to Fibonacci sequential numerical aspects of artwork and images discussed in “The Tiny Seed”.
Applied his knowledge through visual representation.
Completed assemblage of flowers based on the Golden Ratio numbers 5 and 3.

Completed assemblage of a small book sequencing visual forms as story.

His work exhibited a definite correlation with visual, verbal, aural and tactile experiences prompted through classroom activities.

How does the story relate to learning outcomes, program goals, and/or state education standards?
Michael met the above listed criteria. He created two different types of flowers using the assigned Fibonacci sequence method; created a book using sequential retelling of the “The Tiny Seed” through visual means; created 2 butterflies and a cocoon using sequencing and repetition to understand change and sequence in nature and added his work to the class cooperative effort
in which each student helped construct an indoor garden installation piece by assembling their week’s work together into one larger art piece.

Tennessee Curriculum Strands

**Literature:** 0101.8.6 Derive meaning while reading by employing the following strategies:
Predict what will happen next.
Create mental images.
Using illustration to gain meaning.
Relating knowledge from personal experience, and/or other text.

**Visual Art:**
**Content Standard 1.0:** Media, Techniques, and Processes
Students will understand and apply media, techniques, and processes.
**Content Standard 3.0:** Evaluation
Students will choose and evaluate a range of subject matter, symbols, and ideas.
**SPI**
3.2.1 Identify subject matter and symbols in the student’s own art.
3.3.1 Identify subject matter and symbols in others’ art.
**Content Standard 6.0:** Interdisciplinary Connections
Students will make connections between visual arts and other disciplines.
6.2 Identify connections between visual and language arts.
   Identify connections between visual art and mathematics.
   Identify connections between visual art and science.
Golden Ratio Project
Greek Mythology and Greek Mask Workshop
Teaching Artist: Pam Weston

Art Form: Visual Art: Painting: Sculpture: Mask Making

Grade or age level: 6th through 8th grade

Primary disability: Autism

Description of the workshop:

Students generated the 3rd through the 10th terms of two different Fibonacci sequences, given the first two terms and the definition of the sequence. Students then generated a sequence of quotients of consecutive terms of the Fibonacci sequence to approach the Golden Ratio. Students used graph paper to illustrate the Fibonacci sequence as a progression of squares. Students transferred the Fibonacci sequence illustrations to encaustic board.

Students selected a character from Greek mythology to portray in a mask. Students shared their character’s role in Greek mythology and discussed how they might reflect those features in the character mask. Students folded paper, measured, and sketched to create a 2-dimensional image with facial features in proper proportions. Students created a 3-dimensional mask of a character from Greek mythology using plaster cloth, paper clay, rope, twine, raffia, and found objects.

Students adorned their masks and painted them using encaustic paint. Students painted the illustrated encaustic board and labeled the board with the name of the character portrayed by their mask.

Students also learned about and participated in discussion about the history of the Fibonacci sequence, the ancient uses of encaustic, and Greek mythology from the creation story through several generations.

Expanding the lesson, students also learned to distinguish a transcendental number from a rational number using the decimal representation of that number and were exposed to the concept of a mathematical limit.
Learning Goals:

Students will learn to generate the Golden Ratio as a number and as a proportion of a length.

Students will learn about and utilize the symmetry of and the various proportions that occur in the human face to plan construction of a realistic mask.

Students will learn about the history of encaustic and will use encaustic as a medium for design transfer and as a paint capable of taking on multiple textures with the use of various tools and application of numerous techniques.

Students will learn about various characters from Greek mythology and create a mask representing that character.

Visual Art

Standard 1.0 Media, Techniques and Processes: Students will understand and apply media, techniques, and processes.
CLE 1.1 Demonstrate an understanding of the application of current media, techniques, technologies, and processes.
CLE 1.2 Demonstrate an understanding of the safe and responsible use of art media and tools.
CLE 1.4 Reflect on the qualities and characteristics of a variety of media.

Standard 2.0 Structures and Functions: Students will use knowledge of both structures and functions.
CLE 2.1 Demonstrate an understanding of the elements of art and the principles of design.
CLE 2.2 Demonstrate critical thinking skills in addressing visual arts assignments.
CLE 2.3 Demonstrate an understanding of various sensory and expressive qualities in a work of art.
CLE 2.4 Apply problem-solving skills to create solutions to a specific visual art task.

Standard 3.0 Evaluation: Students will choose and evaluate a range of subject matter, symbols, and ideas.
CLE 3.1 Recognize and use subject matter, themes, and symbols in works of art.
CLE 3.2 Demonstrate knowledge of contexts, values, and aesthetics that communicate intended meanings in artworks.
CLE 3.3 Reflect on the effective use of subject matter, symbols, and ideas.
**Standard 4.0 Historical and Cultural Relationships:** Students will understand the visual arts in relation to history and cultures.
CLE 4.1 Demonstrate an understanding of the historical and cultural contexts of artwork.
CLE 4.3 Compare and contrast the characteristics of artwork in various eras and cultures.
CLE 4.4 Reflect on how cultural factors of time and place influence the meaning of artworks.

**Standard 6.0 Interdisciplinary Connections:** Students will make connections between visual arts and other disciplines.
CLE 6.1 Demonstrate an understanding of similarities between visual arts and other academic disciplines.
CLE 6.2 Discover how unique qualities of visual art compliment student’s total learning.

**Mathematics**

**Standard 1 Mathematical Processes**
GLE 0606.1.1, GLE 0706.1.1, GLE 0806.1.1 Use mathematical language, symbols, and definitions while developing mathematical reasoning.
GLE 0606.1.2, GLE 0706.1.2, GLE 0806.1.2 Apply and adapt a variety of appropriate strategies to problem solving, including estimation, and reasonableness of the solution.
GLE 0606.1.3, GLE 0706.1.3, GLE 0806.1.3 Develop independent reasoning to communicate mathematical ideas and derive algorithms and/or formulas.
GLE 0606.1.5, GLE 0706.1.5, GLE 0806.1.5 Use mathematical ideas and processes in different settings to formulate patterns, analyze graphs, set up and solve problems and interpret solutions.
GLE 0606.1.6, GLE 0706.1.6, GLE 0806.1.6 Read and interpret the language of mathematics and use written/oral communication to express mathematical ideas precisely.
GLE 0606.1.7, GLE 0706.1.7, GLE 0806.1.7 Recognize the historical development of mathematics, mathematics in context, and the connections between mathematics and the real world.
GLE 0606.1.8, GLE 0706.1.8, GLE 0806.1.8 Use technologies/manipulatives appropriately to develop understanding of mathematical algorithms, to facilitate problem solving, and to create accurate and reliable models of mathematical concepts.

**Standard 2 Number & Operations**
GLE 0606.2.3 Understand and use ratios, rates and percents.
GLE 0706.2.3 Develop an understanding of and apply proportionality.
GLE 0606.2.4 Understand and convert between fraction, decimal, and percent forms of rational numbers.
GLE 0706.2.4 Use ratios, rates and percents to solve single- and multi-step problems in various contexts.
GLE 0806.2.1 Extend understanding of the real number system to include irrational numbers.

**English**

**Standard 2 Communication:** Listening and Speaking
GLE 0601.2.1, GLE 0701.2.1, GLE 0801.2.1 Demonstrate critical listening skills essential for comprehension, evaluation, problem solving, and task completion.
GLE 0601.2.6, GLE 0701.2.5, GLE 0801.2.5 Understand strategies for expressing ideas clearly and effectively in a variety of oral contexts.
GLE 0601.2.8, GLE 0701.2.7, GLE 0801.2.7 Participate in work teams and group discussions.

**Standard 4 Research**
GLE 0601.4.2, GLE 0701.4.2, GLE 0801.4.2 Gather relevant information from a variety of print and electronic sources, as well as from direct observation, interviews, and surveys.

**Social Studies**

**Standard 1.0 Culture:** Culture encompasses similarities and differences among people including their beliefs, knowledge, changes, values, and traditions. Students will explore these elements of society to develop an appreciation and respect for the variety of human cultures.
LE 1.01 Understand the nature and complexity of culture.

**Standard 3.0 Geography** (grades 6 and 7): Geography enables the students to see, understand and appreciate the web of relationships among people, places, and environments. Students will use the knowledge, skills, and understanding of concepts within the six essential elements of geography: world in spatial terms, places and regions, physical systems, human systems, environment and society, and the uses of geography.
LE 3.04 Understand the physical and human characteristics of place.

**Standard 5.0 History** (grades 6 and 7): History involves people, events, and issues. Students will evaluate evidence to develop comparative and causal analyses, and to interpret primary sources. They will construct sound historical arguments and perspectives on which informed decisions in contemporary life can be based.
LE 5.2 Recognize that places change over time.

**Adaptations made due to disabilities:**

Use of visual supports and enumerated lists, scheduled breaks for preferred activities, permitted individual-initiated individual breaks, two to one participant to adult ratio when using heating devices, provided calculator, and set absolute limits of adult only use of hot air devices.
Greek Math, Mythology, and Masks Workshop

Timeline

1) Generating Fibonacci sequences and quotient sequences to approach the Golden Ratio.

2) Construct an illustration of the Golden Ratio with a sequence of Fibonacci squares.

3) Make a 2-d basis for the face which reflects the specified proportions.
4) Using the 2-d model to construct a base for the 3-d mask.

5) Introduction to Greek Mythology
6) Selecting a character to portray.

7) Constructing the Face, Plaster and Adornments
8) Preparing the encaustic board for design transfer by burnishing.

9) Burnishing to transfer the Fibonacci squares design.

10) Constructing the Face, Paper Clay and Other Adornment
11) Learning about the history of encaustic while it's warming up.

12) Applying gesso or a base coat of encaustic medium.
13) Paint the name plate of Fibonacci squares with encaustic.

14) Paint the mask with encaustic
Student Story & Mask Creation

Teaching Artist: Pam Weston

Program Title: Greek Mask Making Workshop
Grade Level: 6-8
School and Location: Marcella Center for the Arts & Education, 117 Washington Road, Sweetwater, TN 37874

Dates of Residency: 10/19/12 and 10/20/12
Number of Sessions: 2
Approximate Date of Artwork Creation: 10/20/12
Does this student involved have a disability? Yes

_x_Check the box to give permission to share this story (including the student’s first name) in materials, interviews, and online.

Tell the story.
Sam is an emerging artist who likes to build 3-dimensional models in addition to the more traditional art forms of painting and drawing. Sam spends much of the summer months working in the family vegetable garden, but when he’s not gardening or making art, weather permitting, he can be found on the water with his father who lives on houseboat.

Sam’s decision to create a mask of Poseidon, child of Earth and Time, and god of the ocean was a natural one. Sam also created a ‘name plate’ for his mask using his Fibonacci squares design.
Assessment Criteria

The completed mask reflects the Golden Ratio proportion in the basic head and in the rectangle formed from corners placed in the pupils of the eyes and the corners of the mouth.

The completed mask has ears that are placed so that they begin at a point on a horizontal line through the outer edge of the eyebrows and continue to a horizontal line through the tip of the nose, reflecting proper placement and proportion.

The choice of materials used for hair, ears, and adornment visually convey the character’s role in Greek mythology.

The structure of the mask is sturdy and provides support for the material used to define the features and adornment.

The name plate provides a graphical representation of the Fibonacci sequence approximating the Golden Ratio.

The encaustic on the mask and the name plate manifest varying textures reflecting the use of multiple techniques.

How does the story relate to learning outcomes, program goals, and/or state education standards?
Sam met the above listed criteria. He planned the features of his character mask using the proper proportions and positions of various features, selected materials and techniques that conveyed his character’s nature, graphically approximated the Golden Ratio with a sequence of Fibonacci Squares design that he created, shared his creation for the purposes of an exhibition of the masks from the workshop, and will participate in a public performance and exhibition related to the masks in December.

**Tennessee Curriculum Strands**

**Visual Art**

Standard 1.0 Media, Techniques and Processes: Students will understand and apply media, techniques, and processes.
CLE 1.1 Demonstrate an understanding of the application of current media, techniques, technologies, and processes.
CLE 1.2 Demonstrate an understanding of the safe and responsible use of art media and tools.
CLE 1.4 Reflect on the qualities and characteristics of a variety of media.

Standard 2.0 Structures and Functions: Students will use knowledge of both structures and functions.
CLE 2.1 Demonstrate an understanding of the elements of art and the principles of design.
CLE 2.2 Demonstrate critical thinking skills in addressing visual arts assignments.
CLE 2.3 Demonstrate an understanding of various sensory and expressive qualities in a work of art.
CLE 2.4 Apply problem-solving skills to create solutions to a specific visual art task.

Standard 3.0 Evaluation: Students will choose and evaluate a range of subject matter, symbols, and ideas.
CLE 3.1 Recognize and use subject matter, themes, and symbols in works of art.
CLE 3.2 Demonstrate knowledge of contexts, values, and aesthetics that communicate intended meanings in artworks.
CLE 3.3 Reflect on the effective use of subject matter, symbols, and ideas.

Standard 4.0 Historical and Cultural Relationships: Students will understand the visual arts in relation to history and cultures.
CLE 4.1 Demonstrate an understanding of the historical and cultural contexts of artwork.
CLE 4.3 Compare and contrast the characteristics of artwork in various eras and cultures.
CLE 4.4 Reflect on how cultural factors of time and place influence the meaning of artworks.

Standard 6.0 Interdisciplinary Connections: Students will make connections between visual arts and other disciplines.
CLE 6.1 Demonstrate an understanding of similarities between visual arts and other academic disciplines.
CLE 6.2 Discover how unique qualities of visual art compliment student’s total learning.
Mathematics

Standard 1 Mathematical Processes

GLE 0606.1.1, GLE 0706.1.1, GLE 0806.1.1 Use mathematical language, symbols, and definitions while developing mathematical reasoning.
GLE 0606.1.2, GLE 0706.1.2, GLE 0806.1.2 Apply and adapt a variety of appropriate strategies to problem solving, including estimation, and reasonableness of the solution.
GLE 0606.1.3, GLE 0706.1.3, GLE 0806.1.3 Develop independent reasoning to communicate mathematical ideas and derive algorithms and/or formulas.
GLE 0606.1.5, GLE 0706.1.5, GLE 0806.1.5 Use mathematical ideas and processes in different settings to formulate patterns, analyze graphs, set up and solve problems and interpret solutions.
GLE 0606.1.6, GLE 0706.1.6, GLE 0806.1.6 Read and interpret the language of mathematics and use written/oral communication to express mathematical ideas precisely.
GLE 0606.1.7, GLE 0706.1.7, GLE 0806.1.7 Recognize the historical development of mathematics, mathematics in context, and the connections between mathematics and the real world.
GLE 0606.1.8, GLE 0706.1.8, GLE 0806.1.8 Use technologies/manipulatives appropriately to develop understanding of mathematical algorithms, to facilitate problem solving, and to create accurate and reliable models of mathematical concepts.

Standard 2 Number & Operations
GLE 0606.2.3 Understand and use ratios, rates and percents.
GLE 0706.2.3 Develop an understanding of and apply proportionality.
GLE 0606.2.4 Understand and convert between fraction, decimal, and percent forms of rational numbers.
GLE 0706.2.4 Use ratios, rates and percents to solve single- and multi-step problems in various contexts.
GLE 0806.2.1 Extend understanding of the real number system to include irrational numbers.

English

Standard 2 Communication: Listening and Speaking
GLE 0601.2.1, GLE 0701.2.1, GLE 0801.2.1 Demonstrate critical listening skills essential for comprehension, evaluation, problem solving, and task completion.
GLE 0601.2.6, GLE 0701.2.5, GLE 0801.2.5 Understand strategies for expressing ideas clearly and effectively in a variety of oral contexts.
GLE 0601.2.8, GLE 0701.2.7, GLE 0801.2.7 Participate in work teams and group discussions.
Standard 4 Research
GLE 0601.4.2, GLE 0701.4.2, GLE 0801.4.2 Gather relevant information from a variety of print and electronic sources, as well as from direct observation, interviews, and surveys.

Social Studies
Standard 1.0 Culture: Culture encompasses similarities and differences among people including their beliefs, knowledge, changes, values, and traditions. Students will explore these elements of society to develop an appreciation and respect for the variety of human cultures.
LE 1.01 Understand the nature and complexity of culture.
Standard 3.0 Geography (grades 6 and 7): Geography enables the students to see, understand and appreciate the web of relationships among people, places, and environments. Students will use the knowledge, skills, and understanding of concepts within the six essential elements of geography: world in spatial terms, places and regions, physical systems, human systems, environment and society, and the uses of geography.
LE 3.04 Understand the physical and human characteristics of place.
Standard 5.0 History (grades 6 and 7): History involves people, events, and issues. Students will evaluate evidence to develop comparative and causal analyses, and to interpret primary sources. They will construct sound historical arguments and perspectives on which informed decisions in contemporary life can be based.
LE 5.2 Recognize that places change over time.
**Golden Ratio Project**
**Percussion Residency**
**Teaching Artist: Bob Stagner**

**Art Form:** Music: Percussion

**Grade or age level:** 9th through 12th grade

**Primary disability:** Learning Disabilities

**Description of the workshop:**
Using the model of the Golden Ratio in musical composition, we created and performed our own original percussion pieces. Starting with a simple improvisation and defining the Ratio as it applies to tempo, pitch, rhythm and dynamics, we then built on our composition. Student players were assigned in a number in the sequence and were conducted by a fellow student.

Step 1: Introduction to the Golden Ratio and Music

Step 2: Building Vocabulary – Making Sounds

Step 3: Assigning Numbers and Instruments to Players

Step 4: Build Song – Create Piece

**Tennessee Curriculum Strands:**
Students will learn to play simple percussion instruments.
Students will compose and conduct using Fibonacci numbers.
Standard 2.0 – Play Instruments
Standard 2.1 – Develop skill in reproducing steady beat
Standard 2.2 – Explore playing long/short and fast/slow sounds
Standard 2.3 – Play high and low sounds
Standard 3.0 – Improvising
Standard 3.1 Play a percussion instrument in an improvised accompaniment
Golden Ratio Percussion Workout Timeline

Building basic vocabulary.

Assigning pitch, rhythm and dynamics to each player in sequence.

This satellite photo of Hurricane Sandy provides an excellent example of the Golden Ratio. For blind students, we used yarn to outline the photo.
Hillsboro students decoding the ratio. Player 1 was the leader; 0 would indicate rest.

Materials used also included number sequence in Braille.
Golden Ratio Project
Dance Residency
Teaching Artist: Danielle Clement

Art Form: Dance    Age Level: 12-28 years old    Primary disability: Down syndrome

Description of the residency:
Golden Ratio Dance Outline

Using the Golden Ratio model, we will create and perform an original dance piece. We will define the ratio as it compares to basic ballet arm positions. We demonstrate this forward and back. The space position of the dancers will also associate with the Ratio.

Learning Goals:

Students will learn concept of the ratio and how we can turn that into dance. The ability to recall the combination of the ongoing ratio series will be accomplished.
Golden Ratio Project
Creative Writing & Drama
Teaching Artist: Deanne Collins

Activity I – Drum /warm-up
Time: First time/10 minutes
Repeat the activity/3-4 minutes

Room Set up: Chairs in a semi circle

Objective: As a warm up to enhance Creative Thinking Skills and develop Listening skills,
Learn the Fibonacci Sequence

Equipment a Drum for each participant or a drum like item (see suggestions)

Posted on black board or strips of paper around the room
0,1,2,3,5,8,13,21….

Explain:
The way we get the next number is by adding the previous two number.
What would be the next number after 21? (ans: 34)

Do: Beat on the drum the sequence up to 21.
Begins with nothing (silence) The one beat boom, then one beat again, boom
Then two best Boom, Boom.

Point out: We can keep each beat the same length of time or we can establish the time of one
beat and fit the sequence of beats into the established time. If you fit them all into one
established time the 21 beats becomes incredibly fast.

Experiment with both ways. Pick the way the majority of class likes it (usually fitting all
the beats into an established length of time.)
Variations: Divide the class into three groups and do the sequence as a round. If going to 8 beats was the best they could do then the round should start at silence and run to only 8 beats. The second group coming in on the 3 beats of the previous group and the 3rd group coming in on the 3 beat of the 2nd group. Run through the sequence 3 times.

Help: You, as the instructor, clap or drum the steady underlying beat. You can help them come in and end with hand signals or a nod of the head.

BRIDGE: Using the drumming as a bridge slow down the beats and for every beat they say a random word. Does not have to make sense
Point out the difference between a word and a syllable.

Activity II– Trees by Joyce Kilmer
Time: First time/10 minutes
Repeat the activity/3-4 minutes

Room Set up: Desks and chairs

Objective:
To Recognize Fibonacci Sequence is poetry
To-Learn the Fibonacci Sequence
To recognize how the rhythm of a poem influences its meaning.

Equipment  blackboard or flip Chart with Trees printed for the class to see.
Posted on black board or strips of paper around the room
0,1,1,2,3,5,8,13,21….

Explain:
Review: The way we get the next number is by adding the previous two numbers.
What would be the next number after 21? (ans: 34)

Do: In pairs break up the poem Trees Into Fibonacci Sequence.
Does Trees follows the Fibonacci Sequence in words or syllables?

Point out: We can count the syllables or words as the beat

Experiment In pairs write the way you agree to fit TREES in sequence
Publish: Each pair presents how they would divide the poem. Let them share why they made certain decisions. Did the way it was divided help understand the content or message? Did it confuse the content and change the message?

BRIDGE
One group beats on the drum the sequence, while another group recites the poem TREES.
Begins with nothing (silence)

One way to divide the poem as Fibonacci Sequence

Trees
By Joyce Kilmer

1.I
1.think
2.that I
3. shall ne ver
5. see A poem love ly
8. as a tree. A Tree whose hungry

13.mouth is pres sed A gainst the earth’s sweet flow ing breast;

1.A
1..tree
2. that looks
3. at God all
5. day,And lifts her leafy
8. arms to pray;A tree that may in

13. Sum mer we ar A nest of ro bins in her ha ir;

1.Up
1.On
2. Whose bosom
3. Snow has lain
5. Who intimately lives with rain
13. Poems are made by fools like me but only God can make a tree.
Activity III –Add a line of 13
Time: 15 minutes
Discussion, presentation 10 minutes

Room Set up: Desks and chairs

Objective:
To Recognize Fibonacci Sequence in poetry
To-Learn the Fibonacci Sequence
To recognize how the rhythm of a poem influences its meaning.
To lay a foundation to write original poems.

Equipment blackboard or flip Chart with 3 different short poems printed for the class to see.
Posted on black board or strips of paper around the room
0,1,2,3,5,8,13,21….

Explain:
Review: The way we get the next number is by adding the previous two numbers. Review the Activity using Joyce Kilmer’s Trees.

Do: In pairs pick poem 1, 2, o3. Divide lines into Fibonacci Sequence. Add the final line.

Point out: We can count the syllables or words as the beat

Experiment In pairs write the last line to the poem.

Publish: Each pair reads their poem and adds the final line. Did the way it was divided help understand the content or message?

BRIDGE
One group beats on the drum the sequence, while another group recites the poem.
Begins with nothing (silence)
Add another verse or add a 21 beat line.

Use any short poem. Here are three suggested poems.
Short Poem: *Birds*
Birds, Birds Fly by In the sky. I oft wonder why and do birds ever cry in the sky?

1. Birds,
2. Fly by
3. In the sky.
5. I oft wonder why?
8. And do birds ever cry in the sky?
13.

Short poem: John Paul
John Paul so tall, the son of a very rich gentleman. He liked to watch the stars at night,

1. John
2. Paul
2. so tall
3. The son of
5. A very rich gentle man
8. He liked to watch the stars at night…
13

Short Poem: Faith
Dying, death could be a simple test to see who is real.
To see who earns the light of faith,

1. Dying
1. Death
2. Could be
3. A simple test
5. To see who is real.
8. To see who earns the light of faith,
13.
Activity IV – Small Group Poem

Time: 15 minutes
Discussion, presentation 10 minutes

Room Set up: Desks and chairs

Objective:
To Recognize Fibonacci Sequence in poetry
To Learn the Fibonacci Sequence
To recognize how the rhythm of a poem influences its meaning.
To lay a foundation to write original poems.
To Write a Poem Using the Fibonacci Sequence.

Equipment  blackboard or flip Chart with 3 General Topics written on paper, folded in hat or bowl
Posted on black board or strips of paper around the room 0,1,1,2,3,5,8,13,21,….

Explain:
Review: The way we get the next number is by adding the previous two numbers. Review the Activity using Joyce Kilmer’s Trees.

Do:  Divide the class into 3 groups. Minimum of 5 in a group. Representative of each group draws a topic from the hat. One person in the group is the recorder and writes down all contributions to the poem.
First time around each person adds one word to the poem keeping in mind what position in the sequence it belongs and what message is or becomes.
Next time around same topic different point of view and each person adds one of the lines. Keep going as long as possible. When you reach the extreme of 21 or perhaps 34 the group can begin another verse starting with 0 and ending as in the previous verse.

Point out: We can count the syllables or words as the beat

Experiment  Try and go beyond the ordinary

Publish: Each group reads their poem. Answers questions and discusses the problems.

BRIDGE
One group beats on the drum the sequence, while another group recites the poem.
Begins with nothing (silence)
Add another verse or add a 21 beat line.
Some General Topics:

The Best Christmas Gift
Standing on a Ledge
Looking for a Reason
Injury
Lost and Found

Activity V- Individual Poems
    Time: 25 minutes
    presentation 10 minutes

Room Set up: Desks and chairs

Objective:
To Recognize Fibonacci Sequence in poetry
To-Learn the Fibonacci Sequence
To recognize how the rhythm of a poem influences its meaning.
To lay a foundation to write original poems.
To Write a Poem Using the Fibonacci Sequence.
To begin a collection of poetry.

Equipment  blackboard or flip Chart with
            Posted on black board or strips of paper around the room
            0,1,2,3,5,8,13,21,….

Explain:
Review: The way we get the next number is by adding the previous
two numbers. Review the discussions in previous classes

Do: Each student works individually on a poem. They may need help finding a topic. They can
look back at other topics used previously and present a different point of view. Encourage them
to pick something they know about and feel strongly about. Encourage them to write 3 verses.

Point out: We can count the syllables or words as the beat

Experiment Try and go beyond the ordinary

Publish: Each person reads their poem. Answers questions and discuss the motivation.
BRIDGE
One group beats on the drum the sequence, while another group recites the poem.
Begins with nothing (silence)
Add another verse or add a 21 beat line.

Journal Write the poem in a journal to begin a collection of poetry.
Learn about Haiku and compare the two styles.
Golden Ratio School Tour  
Designed for the Nashville Parthenon  
By Christian Kissinger  
Fall 2012

*(Tour would preferably begin outdoors).* Welcome to the Nashville Parthenon. We are going to begin this tour with a question. What do the Parthenon, the Mona Lisa, the chromatic musical scale and the movie “The Da Vinci Code” all have in common? *(Take a few responses).* They all were constructed off of a mathematical ratio called The Golden Ratio. The Golden Ratio is an irrational number, meaning that the digits go on indefinitely. However, it is usually rounded to equal approximately 1.618.

*(Hit anvil with hammer a few times).* How many of you have heard of the Pythagorean Theorem? The Greek philosopher/mathematician Pythagoras developed that popular mathematical theory. However, there is also a legend that states that one day Pythagoras heard hammers on anvils *(strike the anvil again)* and noticed a variation in the tones. From this discovery, Pythagoras used this ratio to create the musical scale, the idea behind octaves and other musical intervals. All of these ratios were based on the Golden Ratio. Music was very important to the Greeks. The Panathenaea (‘all-Athenian festival’) was Athens' most important festival and one of the grandest in the entire Greek world. Except for slaves, all inhabitants of the city and suburbs could take part in the festival. Even metics (resident aliens) and freed slaves could participate (up to a certain point). One of the important aspects of this festival was the musical and rhapsodic contests that resulted in prizes of crowns and cash. There are friezes, which are sculptured decorative bands on the exterior of a building, on temples in the Acropolis that depict this festival and the importance of music. The symbol for the Golden Ratio is the Greek letter phi \( \Phi \), the first letter of Phidias, the Greek sculptor who used the ratio in many of his sculptures, including the frieze on the Parthenon and the Athena inside. *(At this point, the tour guide has several options: 1) Walk around the outside of the Parthenon and look at the frieze that is on the Parthenon and discuss what it depicts, 2) simply suggest that the students view a frieze that was discussed by googling the British Museum at:* [http://www.britishmuseum.org/explore/highlights/highlights_objects/gr/c/central_scene_-_east_frieze.aspx](http://www.britishmuseum.org/explore/highlights/highlights_objects/gr/c/central_scene_-_east_frieze.aspx). 3) Ask DeeGee to bring out some of the Parthenon resources that includes a book, a scroll, or the Braille book that shows the frieze of the procession.*)
While we are outside, notice the many rectangles associated with the Parthenon. We have already talked about the Frieze, what others do you see? (Take time for some responses). The Golden Ratio can be found in many places in the Parthenon construction from the footprint of the building to various rectangles used in the decoration. However, the ratio does not stop there. The list of connections is numerous and some scholars say that this is by coincidence and others by design. The architects for the Parthenon were Iktinos (Ictinus) and Kallikrates (or Callicrates). They built the original Parthenon in approximately 10 years which is also the amount of time that it took to build the Nashville Parthenon.

Now, let’s go inside. As you can see, the statue of Athena dominates the interior of the Parthenon. Sculpture was a dominant visual art form of the Greeks. In some Greek sculptures, the navel (belly button) represents the mean of the golden ratio. The navel is positioned such that the ratio of the short half of the body to the long half of the body is equal to the ratio of the long half body to the whole body. The Greeks felt that creating a statue with these proportions created perfect physical symmetry and was the basis of beauty. This idea of using the ratio to create art was handed down through the ages and was a particularly strong influence on the artists of the Renaissance such as Leonardo Da Vinci. Da Vince used the ratio in many of his famous works such as “The Last Supper” and….can you tell me another one? I named it earlier. (Wait to see if someone says Mona Lisa….if not, then tell them). The secret behind the best seller novel and movie, “The Da Vinci Code” was all based on numbers. Part of this story refers directly to the Golden Ratio.

We are going to end our tour today by letting all of you use the Golden Ratio to do a little measuring on yourself. You will need a partner. Your partner will measure from the tip of your head to your belly button.

Activity

Partner being measured: Take off your shoes (highly recommended). Stand upright with your back against a wall. Put your feet together.

Partner taking measurements: Determine your partner’s total body height by measuring the distance from the floor to the top of your partner’s head. Record this number in the second column of the chart below under “Total Body Height”.

Partner taking measurements: Measure the distance from the floor to your partner’s navel. Record the height of your partner’s navel in the third column under “Navel Height”

Finding the Ratio: Divide the total body height by the naval height (see example below). Place this number in the fourth column. Take this number to the 3rd decimal. See example below.
Trade roles and repeat steps

<table>
<thead>
<tr>
<th>Name of Partner</th>
<th>Total Body Height</th>
<th>Navel Height</th>
<th>Ratio of Total Body Height Navel Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


$60'' \div 37'' \approx 1.62$
December 5th Performance/Presentation

On December 5th, a public performance/presentation took place in which young people with and without disabilities used the various art forms of dance, music, poetry and visual arts to explain the Golden Ratio. A DVD of that performance/presentation can be found at the Nashville Parthenon. The information below is a description of what took place at this event.

Opening Remarks
   Christian Kissinger

Proclamation
   From the Office of the Nashville Mayor Karl Dean

What is the Golden Ratio
   MTSU

The Golden Ratio and Music
   MTSU

Musical Performances
   Overton High School

The Golden Ratio and Architecture
   MTSU

Dance Performance
   Movement Connection Dance Company

The Golden Ratio and Literature
   MTSU

Literature Performances
   Top Two Winning Poems of Golden Ratio Poetry Contest by Sign Club Co.
   Pandora’s Box created at the Tennessee School for the Blind

The Golden Ratio and Art
   MTSU

Presentation of Masks
   VSA Tennessee HANDPRINTS Visual Arts Program
Support

Thanks to the following for their support. This project would not have been possible without their efforts as programs partners or funds for residencies, printing or the performance.

Golden Ratio Partner/Participating Organizations:
- Athens Art Center, Athens, TN
- Disability Law & Advocacy Center of Tennessee
- HANDPRINTS (a program of VSA Tennessee)
- Hillsboro High School
- Maryville High School
- Medina Elementary
- Middle Tennessee State University Organizational Communication
- Middle Tennessee State University Fundamentals of Communication
- Movement Connection Dance Company (a program of VSA Tennessee)
- Nashville Parthenon
- Overton High School
- Princeton Art Gallery, Johnson City, TN
- Sign Club Co.
- Technology Access Center
- Tennessee Arts Commission
- Tennessee Department of Education, Division of Special Education
- Tennessee Performing Arts Center
- Tennessee School for the Blind
- VSA Hellas, Athens, Greece
- VSA Tennessee
Supporters of Golden Ratio Residencies
Autism Society of East Tennessee, Down Syndrome Association of Middle Tennessee, East Tennessee Foundation, Mr. George G. Conner Jr., Mark Antonini, Mark Holcomb, Tennessee Department of Education Division of Special Education

Supporters of the Golden Ratio Evening Presentation
Affinia
Merrol Hyde Magnet School Poseidon Pillar
Middle Tennessee State University ORCO Class
MIRATEK
Publix Supermarket Charities
Tennessee Performing Arts Center
Tennessee Speed Sport
Eddie and Lori Kissinger
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