Information Literacy, a New Mandate: Undergraduate Assignment for Open-Ended Research and Creative Design

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Abstract

Long gone are the days of a math professor's contribution being only to mathematics. Today, typical mission statements include goals of writing across the curriculum, higher order thinking, and always creativity and self-expression. This writing assignment focused on developing information literacy, the art of finding meaning and authenticity in the deluge of information that is available today. Like other components peripheral to math education, information literacy weaves techniques of analytical thinking and decision making into a standard curriculum.

Students were presented video clips on the golden ratio to pique interest and were required to submit a mini-research paper on the history, validity, and incorporation of the golden ratio. This paper requires students to assess their sources (Internet sources encouraged) for bias and defend the use of the source. Students were then asked to design a chandelier that incorporated the golden ratio and was subject to material constraints.

Introduction of the Project

In the spring of 2011, college level trigonometry students were introduced to Phi, or the Golden Ratio, via 15 minutes of video clips from the movie *The Da Vinci Code* and from the television series *Criminal Minds*. The students had two assignments:

(1) **Research:** Write a research paper on Phi (3 pages).
(2) **Design:** Design a chandelier, subject to material constraints, which incorporates Phi.

Students were not told the details of the second project until the first project was collected. The wait may have been unnecessary, but I did not want it to influence the scope of the first paper.

Research

Students were encouraged to discuss any aspect of Phi that they found interesting. Questions were provided to guide discussion and included the following:

- How old is the number?
- Where (geographically) did it first show up? Where else?
- What is the cultural significance of this number and in what cultures is it found?
- What are some geometric properties associated with this number?
- What are some examples of this number in art?
- When/where have you discovered this number?

Incorporation of Information literacy

Many institutions are now placing emphasis on *information literacy*: the art of finding meaning and authenticity in the deluge of information that is available today. To achieve that end, emphasis was placed on the works cited. The requirements were:

1. Use at least four sources.
2. Include at least one scholarly article, at least one book, and no more than one website (which cannot be Wikipedia).
3. Arrange sources in the works cited *in order of importance to the paper.*
4. Describe the possible bias of each source in the works cited and why you used the source.

Let us walk through these requirements and their intent. The sources could include the *The Da Vinci Code* (book or movie) or the *Criminal Minds* episode shown in class. Students were also encouraged to find any other documentaries available on Phi. Surprisingly, no students used videos as sources.

Students were encouraged to begin their research on Wikipedia so as to have a basic understanding of Phi, and to view the references at the end of the Wikipedia article as a starting point for other resources. While Wikipedia includes millions of articles, it contains some articles that are not fact-checked. This potential source of error, and what could happen to the greater body of knowledge if such errors and omissions were propagated as common and correct facts, were discussed in class.

Books dedicated solely to Phi were placed on reserve at the reference desk so that all students could have access, but it was noted that many other texts in the library, which may be more readable, contained a discussion of—or references to—Phi. Reference desk and research librarians were happy to help students find articles, and students were invited to use these resources *after* reading at least the Wikipedia entry. This requirement allowed the librarians to quiz the student on what other keywords could be searched instead of "Phi," which (as you can imagine) returns mostly very technical scholarly articles. Articles at the students' level came from searches such as "The Golden Proportion AND Architecture." Articles that required the students to sort through the popular hype and investigate the mathematics are listed below in References.

I found that arranging the sources in order of importance (which was suggested to me by a research librarian) was a clever way to require the students to further assess and defend their use of a source. Requirements 3 and 4 really are inseparable: If a source was clearly biased, why did it have the level of impact it did on your paper? How can you trust the information provided? Some classroom discussion was devoted to this. Students may have wanted to use a source precisely because it was so outlandish (there are several pseudo-religions based around Phi, for example), but they had to include that disclaimer in their work.

Classroom Discussion Introducing Design

After the papers were submitted, the class shared what they had learned from their research papers, and we watched the YouTube video *Nature by Numbers*, a nice visual representation of the nested or incremental inclusion of the golden ratio in natural constructions. One theme that emerged from the research was that when nature and art incorporate the golden proportions, the result is something that is often perceived to be more "aesthetically pleasing," a loose phrase by which the students meant that, without being able to put a finger on it, many people would just agree that an object (like a face or a tree) that conforms to the ratios of Phi is more beautiful. The second assignment was to use what they learned about the Golden Proportion to design a chandelier.

Figure 1

Design

Students were asked to incorporate Phi into the design of a lighting fixture, subject to a single constraint: the students were required to incorporate an antique, two-person saw (Figure 1) that I displayed in class. Students could cut apart the saw, exclude portions, and use any other materials they wished (even multiple saws like the one provided). The requirement that all students include a common ingredient may appear *Iron Chef* inspired, but it was intended to (1) give students a starting point on a very open-ended problem, (2) introduce the concept of constraints, which nearly all projects include.

Students were asked to turn in a formal paper detailing their chandelier, containing two or three paragraphs summarizing what Phi is, why it is noticed in art and architecture, and detailing how the student incorporated Phi into their design. A detailed schematic of the chandelier was required, and it was expected that someone would be able to build the chandelier given the student's schematic. My directions to the students included the following:

Please do not just say, "I would make a spiral." You need to determine how large that spiral is, how many times it would wrap around, what the spacing would be between your spirals, etc. Your drawing should include dimensions, where and how you would attach it to a wall or ceiling, dimensions of any other materials you would like to incorporate, where you would include lights and even what kinds of lights.

Assessment Considerations

Papers were not graded on grammar or structure unless errors were excessive to the point of hindering the reading of the essay. Together, the projects were worth a test grade, each project worth 50 points. In order to emphasize information literacy gained in the first assignment, 25 points were awarded for discussion of biases in the sources. In order to encourage application and discussion of what was learned in the second assignment, 35 of the points were solely based on how much, how well, and how precisely the student incorporated Phi into their design. As Euclid's original description of the golden ratio was a comparison of two ratios (the smaller piece to the larger piece is in the same proportion as the larger piece to the whole piece), students could earn more points by demonstrating this "nesting" of ratios. For example, if a student's only incorporation of phi was that two measurements were in a 1:phi ratio, the student only received 15/35. In future assignments, to clarify my expectations for the writing, I would discuss online resources (like Crannell, 1994) to improve student understanding of the grading process.

Student Responses

The announcement of the research paper was met with polite, muffled groans and eye rolling, but also with definite enthusiasm because many students found the topic out of the ordinary and they were allowed to discuss whatever aspect they found most interesting. The announcement of the design project was met with eye popping, open-mouthed confusion (which made me cackle with glee and drum my fingers in an evil villain way!). My engineering students were the quickest on the uptake, and several provided very detailed CAD drawings of their final project, though a computer drawing was not required. Unfortunately, my most confused students were unable to ask questions other than, "You want a chandelier? With a saw?" (repeat 5 times), but it seems that the assignment eventually registered.

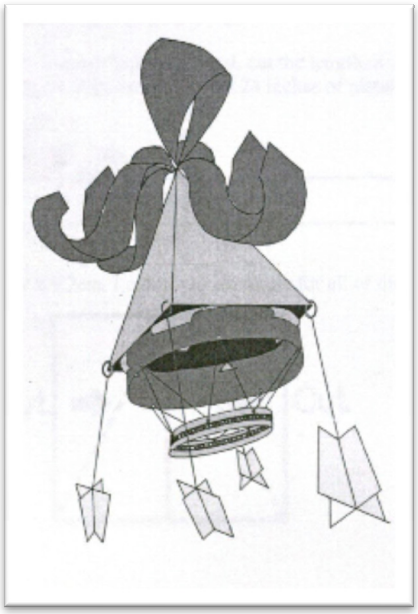

Figure 2

Included here are two final designs for the chandelier. Figure 2 is *Jester Chandelier*, created by Sovanchamrong Yos, an engineering major. Figure 3 is *Phi Chandelier*, created by Dana Stanfill, a mathematics education major. In Figure 2, the student's description of the *Jester Chandelier* would have allowed for perfect construction, with instructions like the following excerpt: "…I poke five holes in the cylinder object. Then tie strings to each and attach it to a smaller cylinder with the same hole. The smaller cylinder has lights like Christmas lights. (In the next step), I drilled a hole into the corner of the pyramid made with the saw and I take four key ring holders attached to the holes. (Next), I tie a string to each key ring. On the string it would have an "X" looking mirror attached to it…" The saw is used for the larger ring.

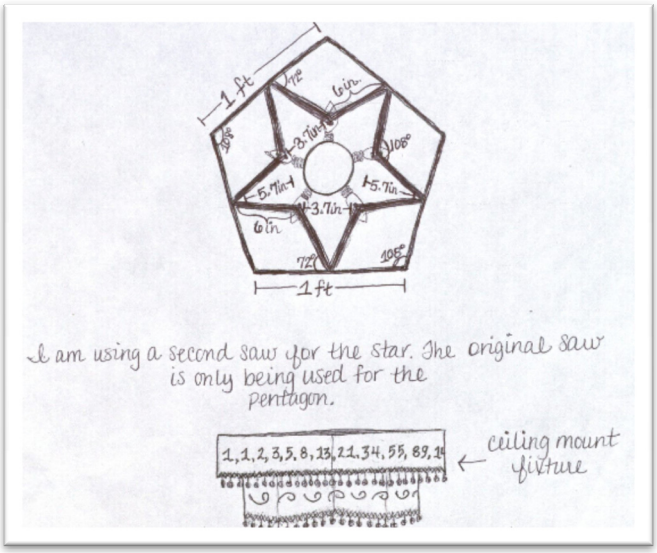

Figure 3

Figure 3 was accompanied by this student description of the diagram. "The golden pentagon has a golden pentagram suspended below it. Fibonacci numbers are etched into the pentagon so that the light can shine through. The pentagram has Fibonacci spirals etched into it. The spirals alternate directions…The chandelier is bronze with both brown tinted crystals and brown tinted stones hanging from it. The number of stones is to the crystals as the number of crystals is to the total number of stones and crystals. Crystals = 50, Stones = 31. Stones/Crystals = 31/50 = 1.612. Crystals/Total = 50/81 = 1.62. Phi = 1.618…"

Conclusions

Information literacy is an important topic, but was not fully achieved in this assignment. It is interesting to note that, if the students found that several sources confirmed a fact, the student concluded that the source had no bias—never checking whether the confirming sources all referenced a similar source. It should also be noted that no students made mention of any of the fallacies surrounding Phi, as seen for example in George Markowsky's article first published in 1992. This assignment did not address all of the needs of this newfound "illiteracy," but it did provide a platform for introducing the topic.

Both assignments resulted in papers that were fun to read and in which individual personalities came through. There was no "median student" research paper topic, as thesis statements covered the gamut: art, architecture, Greek versus Middle Eastern use of the math, music, nature, religion, and cool math. The majority of the chandelier designs resembled lighting fixtures you could find in any home improvement store, with the saw used as one decorative element.

This assignment would not have been as successful as it was without the staff of my university library. Scholarly articles are a dense forest of nonsense to newcomers (and even to those familiar with them), requiring one-on-one attention to learn how to locate and assess relevance. Few papers successfully used a relevant scholarly article, but the students were at least now aware of the existence of such articles and such databases. If I use a similar assignment again, I will require the students to get their articles (with relevant passages highlighted) approved by me or a research librarian. Additionally, it needs to be made clear to students that even if a journal article is found online in electronic format, it does not count as the website source. A very subtle and important issue exists here (and is the crux of the information literacy quest): just because something is online doesn't mean it is bad. The other side of the coin is that, just because something shows up in multiple places on the web that does not mean it is true.

References

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Karoline Pershell was an Assistant Professor of Mathematics at the University of Tennessee at Martin. Her research interests include combinatorial methods of understanding Heegaard diagrams for 3-manifolds and geometric group theory. Recently she has been a principal investigator on a National Science Foundation grant through EPSCoRE (Experimental Program to Stimulate Competitive Research), collaborating with a fuel cell developer. Karoline was invited to teach summer courses at Qingdao University (2012) and just completed a position as a Fulbright Visiting Lecturer at the University of Hyderabad, India (2013). Dr. Pershell is currently an American Association for the Advancement of Science Fellow with the Foreign Service Institute.

Karoline Pershell doing English outreach during her Fulbright at the University of Hyderabad.

Food for Thought

"The mathematician takes ideas that are valid in one area and transplants them into another, hoping that they will take and not be rejected by the recipient domain." Alain Connes, *Institut des Hautes Etudes Scientifiques.* As found in:
Tammet, D. (2012). *Thinking in numbers*, 270. New York: Little, Brown and Company.

"… we [humans] know about how to perceive concrete things and to perform actions, and we use that knowledge to both describe and also think about abstract concepts."
Bergen, B. K. (2012). *Louder than words: The new science of how the mind makes meaning*, 209. New York: Basic Books.