PART V: Literature & Mathematics

AGE RANGE: 13-15

TOOL 47: DECRYPTING WITH THE FIBONACCI SEQUENCE IN "THE DA VINCI CODE" BY DAN BROWN

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TheArtOf Maths

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Educator's Guide

Title: Decrypting with the Fibonacci Sequence in "The da Vinci Code" by Dan Brown

Age Range: 13-15 years old

Duration: 2 hours

Mathematical Concepts: Golden Ratio, Fibonacci Sequence, Pascal's Triangle.

Artistic Concepts: Literary analysis, thriller novel, cryptology, conspiracy theories.

General Objectives: To discover the mathematical concepts presented in the book and learn how to build math reasoning in everyday life.

Instructions and Methodologies: The students will explore math through literature, by applying it to real-life situations and learning from the book. Your class will discover the different math concepts hidden in the novel.

Resources: This tool provides online resources for you to use in your classroom. The topics addressed in these resources will help you find other materials to personalize and give nuance to your lesson.

Tips for the educator: Learning by doing is very efficient, especially for young learners with learning difficulties. Always explain the practical use of each math concept.

Desirable Outcomes and Competences: At the end of this tool, the student will be able to:

- Understand what the Golden Ratio is;
- Understand how the Fibonacci Sequence works;
- Decrypt codes using the new learnt math concepts.

Debriefing and Evaluation:

Write 3 aspects you liked about this activity:	1. 2. 3.
Write 2 aspects that you have learned	1. 2.
Write 1 aspect for improvement	1.

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Introduction

Reading can help us understand the world around us in a way we didn't expect. Books are thus valuable resources for learners to explore new topics and concepts hidden within the story. Some of the authors use mathematics in their plots, which students often don't really focus on though they will be more likely to understand a topic they have already read about.

Seeing the characters reflect on mathematical problems and concepts makes the reader want to understand those concepts and solve those problems with them in the same way as readers often try to guess the end of a story. Here, they will learn new things just by following the characters' reasoning and path.

Therefore, teaching students the mathematics that hide behind their favorite books can be a great added value to a math course, by giving learners a more immersive and real-life sense of the possible uses of mathematics.

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"Da vinci code" by Dan Brown

[1]1. Synopsis

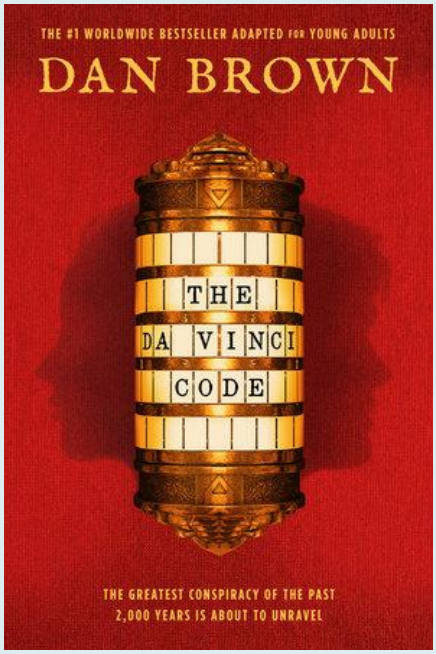

Figure 1: Cover of the book "The da Vinci Code" by Dan Brown

This mystery thriller novel written by Dan Brown in 2003 tells the story of a murder investigation. The curator of the Louvres is murdered and the only clue he leaves in his last moments is a message written in invisible ink that the main character, Robert Langdon, will need to decode. The letters of the message are anagrams of Leonardo da Vinci and Mona Lisa, but the numbers are a mixed Fibonacci sequence. Langdon's favourite number is the golden number and he gave a lecture in which he showed the many real-life examples of its presence around us. Robert will work closely with the deceased's granddaughter, Sophie Neveu. The rest of their adventure is a series of codes to decrypt in order to find out the truth about the Holy Grail and the curator's murder.

2. The Context

Before we go deeper in the story, it is important to know about the context in which it was written. The author's name is Daniel Gerhard Brown. He started off as a musician in Hollywood. Later on, he moved to New Hampshire and he became a language teacher. He started writing in 1993 while he was on holiday in Tahiti. He found inspiration in the thriller genre and was very interested in cryptography and conspiracy theories. "The Da Vinci Code" became very controversial as he said to have used real historical facts in his books, while many scholars disagreed. Nonetheless, the book became a bestseller when it was released in 2003.

[1] Retrieved and modified from : https://www.penguinrandomhouse.com/books/549656/the-da-vinci-code-the-young-adult-adaptation-by-dan-brown/9781524715823/

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3. Cryptography and Conspiracy Theories

Brown's novel was based on a theory which says that the Merovingian kings were the descendants of Jesus and Marie Magdalene. The Priory of Sion, a secret society that Pierre Plantard said to have created in 1956 was based on a fictional religious history around the bloodline of the French Merovingian kings. This society's conspiracy theories were revoked by experts, but some conspiracy theorists still believe that there is a hidden secret behind it that we haven't decrypted yet.

Glossary

Curator: the person who is in charge of the art collection in a museum.

The Louvres: the world's largest museum located in Paris and established in 1793.

Anagram: a word that contains the same letters as another word but in a different order.

Leonardo da Vinci (1452-1519): one of the most famous Italian artists from the Renaissance who studied art, mathematics, architecture and many other fields throughout his life.

The Mona Lisa(1503-1506): painted by Leonardo da Vinci, it is the most valuable painting in the world. It is still displayed at the Louvres, in Paris.

Cryptology: is the study of all codes, their writing and solving.

Conspiracy theories: are theories that someone is responsible for an even that doesn't yet have an explanation.

Merovingian Kings: were the kings of the Franks, the people of what is now France during the Middle Ages, from the 5th century AD to the 8th century AD.

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The math behind The da Vinci Code

The decoding of the hidden message is quite difficult when you don't know already about some mathematical concepts. Those concepts are the Fibonacci Sequence and the Golden Ratio. They were widely used by Renaissance artists in their work. Some of them, such as Leonardo da Vinci, even studied them before using them in their paintings.

The Golden Number

The Golden number is a rather unique number in mathematics. It is approximately 1,618 and is often used in art and architecture. We use the Greek letter φ (phi) to refer to it.

The golden ratio is the use we make of this number in different disciplines.
Imagine we cut a line in two different parts a and b. When we use the golden ratio, the whole length divided by the long part is equal to the long part divided by the short one.

Figure 2: Line divided according to the Golden Ratio

To make it short, remember this formula:

$$\varphi = \frac{a+b}{a} = \frac{a}{b} = 1,618$$

The golden ratio can then be applied to a rectangle, called the Golden rectangle. As it was seen as the most perfect shape, many Renaissance artists and architects used it in their work.
As we have done it with the line ab, let's divide a rectangle AB into 2 different parts: a square A and a rectangle B in which all sides of the square and the long sides of the rectangle have a length of a and the short sides of the rectangle a length of b.

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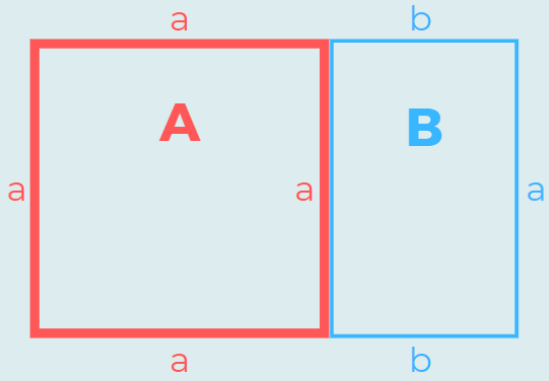


Figure 3: Rectangle divided according to the Golden Ratio

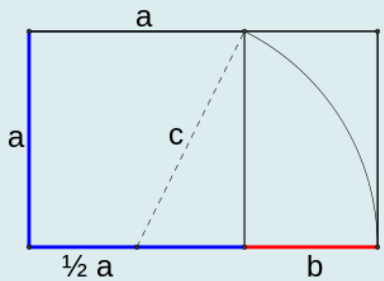
To have the perfect rectangle, we will use the same formula. Imagine for instance that the square A is 2cm x 2cm. If we want to find the side b:

- We know that $\frac{a}{b} = 1{,}618$
- We also know that a = 2
- We can say that $\frac{2}{b} = 1{,}618$
- And that 2 = b x 1,618
- If we isolate b, we have: b = $\frac{2}{1{,}618}$
- So, b = 1,236

Let's check the result using both formulas:

- $\frac{2 + 1{,}236}{2} = 1.618$
- $\frac{2}{1.236} = 1{,}618$

You can also use a compass and ruler to draw the perfect rectangle:



1. Place your compass' needle point in the middle of the bottom side
2. Open your compass to touch the opposite angle
3. Draw a curve from the prolongation of the bottom side to its opposite angle.

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4. Draw the rectangle B from the start of the curve to the prolongation of the top and bottom sides of square A

The Fibonacci Sequence

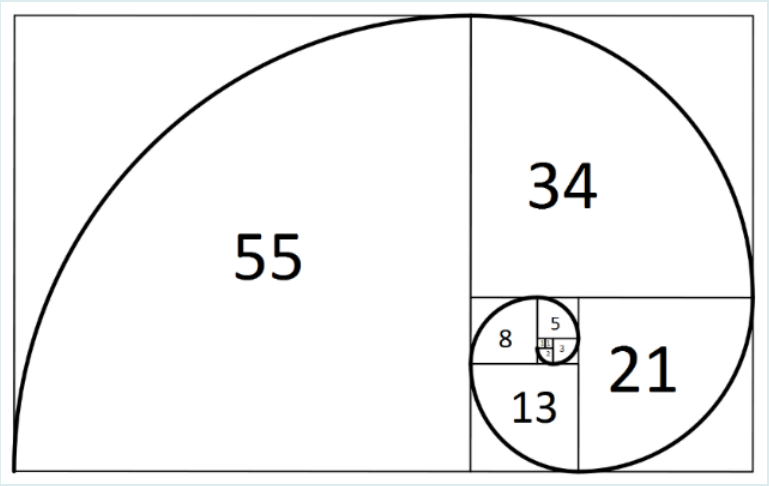
The Fibonacci Sequence is a series of numbers where the next number is found by adding the two previous ones.
0+1=1→ 1+1=2 → 1+2=3 → 2+3=5 → 3+5=8 → 5+8=13 …

The Golden ratio is often associated with the Fibonacci Sequence.

What are the next three numbers?

__8+13=21_____
__13+21=34_____
__21+34=55_____

When we make squares with those widths, we get a nice spiral:



[2]

Figure 4: Representation of the Golden Ratio using Fibonacci's Sequence

Look at how, if we add the sides of squares 5 and 8, we obtain the side of square 13.

Also note that the ratio in the formed rectangles becomes very close to phi.

In the rectangle formed by squares 21 and 13:

a = 21

b = 13

[2] Retrieved from: https://codegolf.stackexchange.com/questions/53369/fibonacci-spiral

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Let's apply the formula:

$\frac{a}{b}$ =1,615

Let's take the next golden rectangle formed by squares 34 and 21:

a = 34

b = 21

$\frac{a}{b}$ =1,619

The results are not exactly the golden number, but they are very close, which shows how Fibonacci's Sequence is connected to the golden ratio!

The sequence can be written in mathematical notation by noticing this:

n =	0	1	2	3	4	5	6	7	8
x_n =	0	1	1	2	3	5	8	13	21

The term number 7 is called n_7 =13

You can remember this rule:

$x_n = x_{n-1} + x_{n-2}$

Where:

x_n is the term number "n"

x_{n-1} is the previous term (n-1)

x_{n-2} is the term before that (n-2)

As the Fibonacci Sequence is very close to the golden ratio, we can use phi to find any number of the sequence with this formula:

$$x_n = \frac{\varphi^n - (1-\varphi)^n}{\sqrt{5}}$$

If we look at the numbers of the sequence, we can identify an interesting pattern:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	1	1	2	3	5	8	13	21	34	55	89	144	233	377	610

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We notice that:

- $x_3 = 2$ and that every third number is a multiple of two (2; 8; 34; 144; 610)
- $x_4 = 3$ and every fourth number is a multiple of three (3; 21; 144)
- $x_5 = 5$ and every fifth number is a multiple of five (5; 55; 610)

Let's look at the ratios (r) between the numbers:

R1	R2	R3	R4	R5	R6	R7	R8
1	1	1,5	1,666	1,6	1,625	1,615	1,619

We notice that the **odd ratios** (R1, R3, R5, R7) are always **under** the golden number, while the **even ratios** (R2, R4, R6, R8) are always **above** it.

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TASK

Time to decrypt some codes!

Here is the secret message Langdon has found next to the curator's body:

13-3-2-21-1-1-8-5

O, Draconian devil!

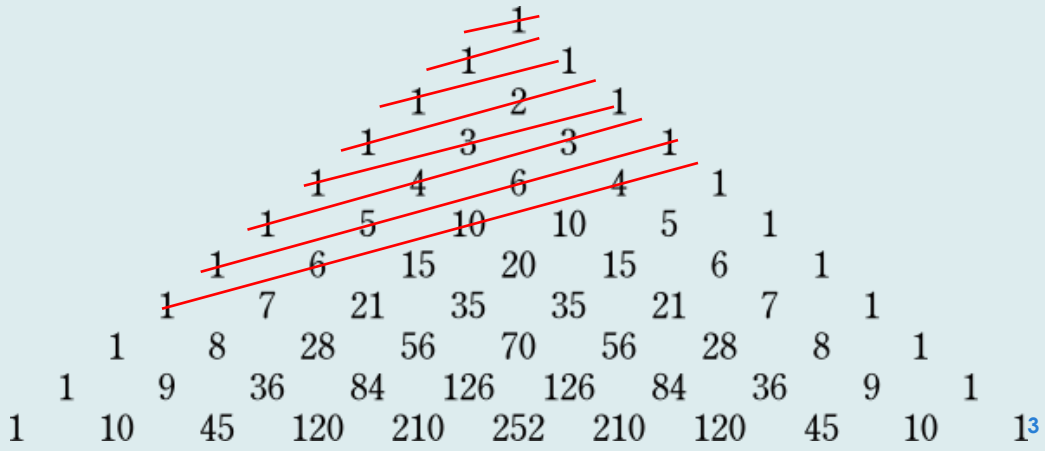
Oh, lame saint!

a) Can you find the hidden message using anagrams?

b) Find the Fibonacci Sequence that is hidden in the figure below, **Pascal's Triangle**.

Here are a few hints:

- Think of word searches to search for the numbers
- You can draw lines on the triangle



Explain how you found the answer:

[3] Pascal's triangle by Kazukiokumura (CC BY-SA 3.0)

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LEARN MORE...

The Mathematics in The da Vinci Code:
https://www3.nd.edu/~hahn/pdf%20files/Ch3-MathDaVinci.pdf

Presentation of the mathematics in The da Vinci Code:
https://prezi.com/cljictxzvjz9/math-in-movies-the-da-vinci-code/

Some fact about the Golden Number in The da Vinci Code:
https://compasstech.com.au/ARNOLD/davinci/davinci2.htm

A bonus riddle inspired on Leonardo da Vinci's work by Ted-ED:
https://www.youtube.com/watch?v=lRfdMiURV4s

An article about the mathematics in The da Vinci Code:
http://discovermagazine.com/2004/jun/cracking-the-da-vinci-code

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