**This Research Outcome complements the content (S1) in the video.**

***Is maths used, intentionally or otherwise, in the creation of artworks that are visually appealing***

**Research Project - Outcome Report**

**Introduction**

Maths and Art are often viewed as completely opposite forces but as an admirer of both, I wanted to prove they are more connected than commonly understood. Maths is used in many famous artworks and the subtle effect of this is unfortunately, in most cases not recognised. Art is used to express Mathematical principles that mathematicians have difficulty explaining with just Maths and this is often seen as Art OR Maths, not a combination of both.(1) Using secondary sources, I believe I have proved that the connections are countless. American Mathematician Doris Schattschneider sums up these connect ions in her essay entitled "Mathematics and Art - So Many Connections", using five main categories: "Mathematics produces Art", "Mathematics generates Art", "Art illuminates Mathematics", "Mathematics inspires Art", "Mathematics constrains Art" and "Art engenders Mathematics" (2) I also researched the number *phi* and its connection to Art as the divine proportion and the golden rectangle, used by many artists to ensure their painting have pleasing proportions. (4)

**Phi and how it is used by artists**

Through my research I found that the Renaissance was a key period to my topic, in which Maths was commonly used to create Art.(5) Many famous artists used simple mathematical ideas such as 'linear perspective' and 'projective geometry' to make their creations more accurate or life­ like.(5) One more complex, but relevant concept that was also used by many artists, including one very prominent renaissance artist, is the number 'Phi'. Phi, like the more familiar number 'pi', is irrational, meaning its decimals go on forever.(6) The number, 1.6180339887 derives from the Fibonacci sequence and can be expressed accurately as $\frac{1}{2}$(1 + $\sqrt{5}$) (6)(7) Phi is described by Dan Brown in his fictional best seller 'The Da Vinci Code' as *‘…the most beautiful number in the universe*’ and *'God's building block for the world*.' (8) While much of his information about the number is far from accurate, it gives readers a very basic and somewhat exaggerated description of one of the most fascinating numbers. (9) While the use of the number 'phi' in famous artworks may not sound familiar, there are many other names and forms for it that are more commonly known. Phi and its different forms are also called, 'The Divine Proportion', 'The Golden Mean' or 'The Golden Rectangle' (7). The number is used most prominently as a proportion - phi to one. The Golden Rectangle is a rectangle with sides of dimensions Phi: 1.This proportion or scale is so special because it is broadly accepted as one of the most aesthetically pleasing proportions in the world. (7)

[1) Velochova,D.(2010). *Chaos in Maths and Art .* Retrieved from Journalof Applied Mathematics: http://www .journa l.aplimat.com/volume\_3\_20 10/Journal\_volume\_3/ Number\_1/Velichova-2.pdf

[2) Schattschneider,D. (2003). *Mathematics and Art* -- *Sa Many Connections.* Retrieved from Math Awareness Month: [http://www](http://www/) .mathaware.org/mam/03/ essay3.html

[4) Adams, C. (2004,June 18).*ls phi a mystical number as claimed in The Do Vinci Code?* Retrieved from The Straight Dope: http://www.straightdope.com/columns/read/2513/i s-phi-a-mystical-number-as-clai med-in-em-the-da-vinci-code-em

[5] Schattschneider, D. (2003). *Mathematics and Art* -- *Sa Many Cannectians.* Retrieved from Math Awareness Month: [http://www.mathaware.org/mam/03/essay3.](http://www.mathaware.org/mam/03/essay3) html

[6] Adams, C. (2004, June 18). */s phi a mystical number as claimed in The Da Vinci Code?* Retrieved from The Straight Dope: [http://www.straightdope. com/columns/read/2513/is-phi-a-mystical-number-as-clai](http://www.straightdope.com/columns/read/2513/is-phi-a-mystical-number-as-clai) med-in-em-the-da-vinci-code-em

[7] Various. (2014, May 12). *Golden Ratio.* Retrieved from Wikipedia: <http://en.wikipedia.org/wiki/Golden_ratio>

[8] Brown, D. (2003). *The Da Vinci Code.* United States: Doubleday.

[9] Adams, C. (2004, June 18).*ls phi a mystical number as claimed in The Da Vinci Code?* Retrieved from The Straight Dope: <http://www.straightdope.com/columns/read/2513/is-phi-a-mystical> -number-as-claimed-in-em-the-da-vi nci-code-em

The Golden Mean is used in nature with the most prominent example being the nautilus shell. (10) Its spiral formation and ratio of each spiral's diameter to the next is the divine proportion. The same results are found in many aspects of nature: from the placement of our facial features in relation to each other, to the growth of leaves on a branch..(11) `Because nature follows the rules of 'phi' so closely, Art also uses the same principle. The golden rectangle is used in many famous artworks such as, by Artist and Mathematician, Leonardo Da Vinci, in his artworks 'Mona Lisa' and 'The Last Supper'. The Mona Lisa has phi proportions in the shape of her face, proved when a box is drawn around her face. (11) The 'Golden Spiral' (created using the golden rectangle), frames the side of her face when drawn in the rectangle..(11) The last supper also has phi proportions in the ceiling of the painting, but also the main lines in the painting indicating the vanishing point and other major parts must have been drawn by Da Vinci before he started painting. (13) There is no other explanation for an artwork that is so large, and so precisely executed.

**Art is used by mathematicians or math-artists to explain mathematical concepts that can't be explained using formulas, and artists are inspired by maths**

There are some concepts in Maths that can't be explained effectively through just the use of formulas or algebra etc.(14) Some of these are ideas like 'infinity' or even more simpler like 'pattern' and 'shape'. There are many artists that have been inspired by these concepts, such as John Robinson, Helaman Ferguson and Salvador Dali but the most widely known example of these is M.C. Escher. (14)(15) Escher was a Dutch graphic artist born in 1898, *"...whose work contains a multitude of connections between mathematics and art.*"' (16)(14) He even struggled with Maths at school, which is perhaps why he turned to Art as an aid. His drawing of an endless staircase is a perfect example of using Maths to portray an idea. His 'circle limit' designs demonstrate everything from 'pattern' and 'tesselation' to 'infinity' and his artworks are possibly most accurately described as 'visual metaphors' for mathematical processes. (14) It is easy to create an artwork based on an algorithm, but it is much harder to find an algorithm that fits to a piece that is drawn manually. (16) Escher's artworks are often using such complex and unknown algorithms that it is near impossible to find the algorithm from his artwork.

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**Conclusion**

I feel that my research shows that the way society feels about Maths and Art should be rethought. My research shows that phi is an essential part of aesthetically pleasing proportions. Maths certainly has inspired artists such as M.C. Escher, and although my brain hemisphere hypothesis was proved wrong, it was a good hurdle to overcome in my research, and proved that our brain function does not define us. My outcome product clearly shows my key findings in a fun and entertaining way. My aim is that it could be used to aid teaching of these subjects to give students a broader understanding and a new way so look at them. The way that Maths is understood certainly changes the way artworks are created and experienced, and I hope the research I have conducted can help people to see that.

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