MATH 10-C3 FINAL PROJECT

Mathematics in key breakthroughs in discoveries, inventions, and innovations

GROUP 1

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WRITE-UP

I. Idea Generation

Mathematics is a result of the mind's curiosity. From the age of nothingness to one of higher knowledge, mathematics and man's desire to find answers have led us to a world where ideas have come to life. Although mathematics is very general, it has proven its purpose as a beneficial tool across many fields that you can incorporate in almost everything. Our lessons in Math 10 were full of these different mathematical concepts, from the basic to the advanced. Most of these concepts were important discoveries that changed the world and have contributed to significant innovations that led us to our progressive future.

We wanted to incorporate some of these lessons related to mathematical discovery into the final output and decided to tie it together with the Rubik's cube as the central concept. The Rubik's cube itself is a relevant innovation, contributing to the world of puzzles and critical thinking with its unique construction as a geometrical riddle comprising concepts of permutations and combinations in its algorithms. In our lives and our pursuit of understanding our world, we encounter problems we need to solve, like the Rubik's cube. And while it is not always easy, we can manage to line up the missing pieces and complete the image that eventually may lead us to life-changing breakthroughs. With these ideas in mind, we were able

to create a cohesive output that covers math as a tool relevant to the world and the beauty of math's life lessons beyond technicality and computation.

II. Tasking

The group members decided to showcase the astonishing talents of each individual in order to express our diverse views towards mathematics. There were three main outputs: 1) interactive Rubik's cube with artworks for the six (6) faces, 2) two creative poems, and 3) final website for compilation. Since the Rubik's cube has six faces, three of our members were assigned two faces each so that the artists of the group had the opportunity to display their artistry. Two members were also assigned to create one creative poem each. Tasks for the write-ups and websites were also distributed. The table below shows the contributions of each member:

Member	Tasks
AGUILAR, MARIA CARMELA	● Rubik's Cube Artwork ○ Yellow face (Math in space exploration) ○ White face (Math in technology and computers) ● Write-up proofreading
ALBA, AARON	● Creative Poem (Title: Puzzling world) ● Website creation
ALEJANDRO, CHARYL JAN	● Creative Poem (Title: One Twist at a Time) ● Write-up content
DATINGUINOO, JUDE ANGELO	● Rubik's Cube Artwork ○ Orange face (Mathematics in Nature) ○ Green face (Permutations and

	Combinations) ● Write-up content
MATIAS, NEIL JOHANN	● Rubik's Cube Artwork ○ Blue face (Algorithms) ○ Red face (Geometry)

III. Math Concepts Incorporated

The group aimed to use the math concepts of the Rubik's cube and other discoveries that changed the world and let us progress towards a technologic and systematic way of living. These concepts are present in the artworks and the poems.

Rubik's Cube creator Ernö Rubik had a goal in mind: to help his students have a new way of thinking about three-dimensional geometry. However, he faced a new problem while jumbling the cube—realigning the colors back into each dedicated face. After six months of solving, he successfully fixed the cube. This discovery and creation of a simple-looking device yet complicated puzzle changed the game of problem-solving.

Its historical influences trace back to the Chinese Yuan Dynasty with the Jiugong map, a pattern-changing game with a premise of a zero-dimensional third-order cube containing nine squares. This game was the historical concept of the modern cube. A configuration formed by the combination of n-numbers (in an n-order square) results in a magic square constant, making up the sum of the numbers in each row, column, and the diagonal lines of the cube. The concept then turned into a one-dimensional third-order cube called the rearranging Jiugong, with eight movable pieces in nine places. The puzzle spread into the West and influenced Sam Lloyd's 15 chess, similar to the Rearranging Jiugong but in a fourth-order cube. More alterations followed with the game concept shifting to changing dimensions rather than order. After a few more years, it went through more alterations with higher-order and the ability to rotate the faces in different directions. Today, the modern Rubik's cube has more complicated layers and different shapes, and designs.

In deeper technicality, the modern Rubik's cube is a 3x3x3 model that has six faces with different colors. The center square piece is immovable, while the surrounding squares are free

to move. An algorithm is needed to realign the colors to their respective sides since altering one face affects the rest of the cube. We can consider the Rubik's cube as a group in abstract algebra, with its solution algorithms. The Rubik’s cube is also connected to concepts of permutation/combination and geometry.

Permutations and combinations are applicable in describing the Rubik's cube. It has six different colors, and each color is repeated exactly nine times. Thus, the cube can be considered an ordered list with 54 elements having numbers between one and six, each number meaning a color being repeated 9 times. We can rotate the 6 faces of the cube so we can define 6 basic operations or permutations which rearrange the ordered list in a certain way. By repeating and combining these permutations, we can define new permutations, which rearrange the list in another way. With 42 quintillion possible configurations, this puzzle proves its complications with maths application. Through permutations and combinations, you can map out how many possible configurations a set can have, such as in dice. But you may also use this to find the oddity of getting a specific and desired result, like pulling a King of hearts in a standard deck of playing cards. There are about 52 cards in a deck which means you have a one out of 52 chance or 1.92% chance of pulling exactly King of hearts.

Moreover, permutation and combination are the two most fundamental parts of probability. They let you tinker with statistics, which has a lot of uses in real-life situations. Such examples are how many possible combinations you can make in license plates with variables of letters and numbers, both of which may have repetitions. While a Rubik’s Cube has more configurations compared to dice, it is still possible to finish a cube with only 20 moves. God’s Number (20 moves), for a Rubik’s cube enthusiast, is the maximum number of moves you need to complete a cube. The term God’s number was coined since one who can find the easiest and shortest sequence of moves to solve any scrambled sequence would be a thousand times better than a regular person, and for a cube with a total of 43 quintillion possibilities, it is as if a deity was the one who solved it.

This concept of permutation and combination can be seen in the Green Face artwork and the literary poem "One Twist at a Time." The poem is associated with mathematics through combinations and trial-and-error as it delves into problem-solving methods in which multiple attempts are made to reach a solution. The process is trying the method, observing if it works and if it does not, trying a new method/solution that will fit into the problems, as expressed in the poem.

Aside from permutations and combinations, the design of the cube can also be connected with geometry, the branch of mathematics that governs the position of angles, sizes, shapes, and dimensions of objects. As seen with the development of the concept of the Rubik's cube, its shape and form matter in order for it to work. The advanced Rubik's cubes like the hexagon cube provide more challenges as you have to solve around a more complex shape.

Geometry has aided a lot of advancements such as architecture and structure stability and even in generating applications that let you render 3D models of structures as a building guide. Video games shifted from different dimensions such as 2D worlds to 3D rendered games, adding more depth and ambiance. Geometry also plays a very significant role for geographic information like the GPS as the system uses a form of geometry like that used to calculate right triangles. This system includes the position of the satellite, the location of GPS on Earth identified by longitude and latitude, and the distance from that specific location to the place on Earth that equates to the position of the satellite in the sky. Calculations related to geometric math are also necessary for the trajectory of a space vehicle's journey and entry point into a planet's atmosphere, as seen with the Yellow Face artwork. Geometry enables not only an efficient and effective way of ejecting a spacecraft out and into a planet but also enables travel to a further distance with the ability to know where such a heavenly body is and how far it is from the Earth. The Orange and Red Face artworks also contain geometry concepts, with the Orange theme focused on the Fibonacci sequence and the Red, on geometry as a body of math. The poem "Puzzling World" and White Face artwork then focused on technology, while the Blue Face theme focused on algorithms.

IV. Lessons Learned

Math 10 has helped us change our views on mathematics as a subject and a tool for exploring the world. It allowed us to appreciate the bigger picture of its importance to our society as we dug deeper into different mathematical concepts and methods on how various problems arrive at their solutions. Through this final project, we were able to express our talents and different viewpoints through our artworks and poems and see how math can inspire art. Despite having differences towards how we should carry out the activity, we still managed to agree and establish a common ground to unite all of our ideas into one. Combining our concepts into a single project added to its uniqueness as it portrayed various perspectives and approaches to math. Regardless of hectic schedules, the group was able to submit relevant ideas as needed,

resulting in the most appropriate, advantageous, and aesthetically beautiful outcome. Individually, the members imparted their ability to apply various mathematical concepts connected to the Rubik's cube. Finally, each individual's views have successfully blended to make a harmonious reflection of how much they have learned in this course throughout the semester.

Aside from our learned experiences with the project making itself, we also discovered a lot about Rubik's cube, the math behind the famous puzzle, its breakthroughs, and the life lessons it provides. We learned how It can be used to visualize surface area and volume and provide a familiar 3-D model of a solid. It is also possible to use fractions, ratios, and proportional reasoning in solving and understanding the Rubik's Cube. We especially saw its connections with permutation and combination. We learned about its global popularity as a puzzle such that they hold competitions on who can complete it the fastest and found out that some even add more challenges to the already-challenging puzzle by solving it blindfolded, one-handed, and many more, leading to more discoveries and understandings about math.

Similarly, most of the challenges that we encounter in life can be likened to an unsolved cube. Most of the time, the correct pieces are jumbled and we cannot make sense of the situation. We face challenges that seem impossible despite how simple other people put it, like how the cube is a simple shape but is actually a complex process that requires combinations to untangle it. Even the big mathematicians who were trying to answer their questions stumbled across difficulties. But just as the Rubik's can be solved by algorithms, our real-life problems can also be solved. While it seems impossible, if one knows what sequences of moves to do, a challenging puzzle becomes easy and trivial once a certain algorithm is learned. There are certain steps we have to follow, and sometimes we have to do trial and error, but what matters is progress is done and the goal is kept in focus.

Like forming a Rubik's cube, we continue to make choices that twist our lives, hoping to get it right the more we tinker with it. We have to critically and logically go over our decisions and assess where it may take us to do things right. We just need to look at a bigger picture in order for us to really appreciate the beauty in these possibilities, differences and phases. For us to achieve breakthroughs, whether it be a new mathematical application or even just learning more about ourselves, we have to move with knowledge and confidence, just as we solve the Rubik's puzzle. Eventually, we learn how to piece ourselves and our path together—we become more whole, like a fixed Rubik's cube with completed phases (or faces) in life.

V. Main Outputs

Rubik's Cube Artwork Descriptions

Blue — *Algorithms.*

"You'll never know what tomorrow may hold," they say. "The future will always be unpredictable and sometimes it's better to just let things be." However, although left with many possibilities of what is to come, one could argue that the next sequence of events can be predicted. This then leads us to the utility of studying patterns, thus resulting in the concept of algorithms. From the everyday routines of each person to larger scopes like predicting the following possible data during this pandemic, we can observe the workings of algorithms.

The very idea of an Algorithm is to input a set of rules/instructions that step-by-step define how a work is to be executed to get the expected results (Introduction to Algorithms, 2019). A simple and good example would be solving the Rubik's cube as it follows a specific set of rules to complete the puzzle. This concept has become the foundation of modern society, utilizing algorithms in technologies like programming, finger-print scanning, and other advanced devices we consider essential today.

Red — *Geometry.*

Since early 3100 BCE, it has already been discovered that ancient Egypt and Mesopotamia have already been using some form of mathematical rules and techniques helpful in surveying land areas, constructing buildings, and measuring storage containers ("Geometry | mathematics," 2019). Until now, we can still observe the importance of geometry as we can see its application in arts, architecture, agriculture, medicine, and even the natural environment around us. Geometry is the visual study of shapes, sizes, patterns, and how they fit together in space. Geometry is responsible for giving video games a realistic look to the landscape and the characters that inhabit the game's virtual world. Besides helping computer designers build virtual realities, geometry's applications in the real world include architecture, computer-aided manufacturing, medicine, biology, physical sciences, and much more.

Orange — *Mathematics in Nature.*

Who would have known that even a plant in nature could be connected to mathematics? The sunflower has been linked to many mathematical concepts, one being the golden angle or golden ratio. The sequence of the seeds follows a golden angle which makes up the pattern of a Fibonacci sequence. According to a study by Prusinkiewicz and Lindenmayer (1990), the golden angle is approximately 137.5°, and the seeds seem to follow this. Since the angle is considered irrational, it means no seed has a neighboring one at the exact angle from the center. The result of this arrangement would be a spiral pattern of sunflower seeds. Other than that, the sunflower has been used in a Lemma. A Lemma is a “mini theorem” or something that has been proven true but isn’t major enough to become a theorem. If you make sets of numbers with each having a shared number and plot it, each set would look like petals, where the middle has the shared or common number between the sets.

Green — *Permutations and Combinations.*

Sometimes it is better to know what the future may hold and prepare for different scenarios than know nothing at all. The concept of permutations enables us to learn different combinations and sequences of variables, have a finite number of scenarios, and find the oddity of getting the desired result. In mathematics, permutation refers to the arrangement of all members of a set into various sequences or orders. Combination, on the other hand, is a way of selecting items from a collection where the order of selection does not matter. Like in a Rubik’s cube, there are 43 quintillions, 252 quadrillions, 3 trillion, 274 billion, 489 million, 856 thousand. The number of combinations is a lot, but by following specific steps, there will be a much shorter and fewer moves way to finish a cube. Items like cards, marbles, dice, and license plates have been one of the many examples being used in order to show us how many combinations work and how it affects the oddity of pulling desired combinations.

White — *Math in technology and computers.*

The white face shows that behind computer programs and technology is mathematical language. Binary numbers (on and off) are the primary language of computers (Binary Numbers and Binary Math, 2018), a simplified alternative to the typical decimal number system. With binary, we can communicate with computers that they then interpret to lead us to the technology that aids us in life (Mikke, 2019). It is also notable to mention that fundamental math like

algebra, calculus, statistics, and discrete math is the foundation of the principles of computer science—the maths that led us to a technology-driven world.

The binary text in the artwork translates to an actual paragraph: *The history of computer science is heavily anchored on mathematical concepts. Math is no doubt a part of the breakthroughs in computer technology, from smartphones to the internet algebra, discrete math, linear algebra, and network theory are some of the base concepts used in computer science. Without them, we would not be able to convert or analyze behavior into computer systems, and we would not have the technology we have today.*

Yellow — *Math in space exploration.*

Inspired by Euler's method and the math behind the US Apollo space program to the moon, the yellow face artwork shows how even scribbles of seemingly nonsensical mathematical computations can open doors to great discoveries. Mathematician Katherine Johnson contributed to this space exploration breakthrough by using Euler's method to find the exact solution for a differential equation needed in connection with satellite reentry (Luwisha, 2018; Bryant et. al., 2017). Despite Euler's method labeled "crude" and "old" math, Johnson's work proves that even math at its most basic level can lead us to greater heights.

Poems and Author's Notes

Puzzling world (Aaron)

Cars are beeping, machines are grinding
Urban streets are filled and crowded
Information at our fingertips
Communication in an instant
Living in our modern world is truly puzzling

The conveniences that we take for granted,
Comes with a very steep price
The challenges that we need to solve
Grows more difficult at each passing day,

Preparing is needed since these challenges are truly puzzling

Global warming and climate change
Turning our planet into a giant blazing oven
Calculated and predicted using mathematics
Models and simulations our new tools for guessing
Peeking into the probable future is truly puzzling

Populations soaring like a rocket launch
Resources are needed more than ever
Optimizing our consumption is a must
To prevent us from running out of sustenance
Continuing our expansion and progress in this world is very puzzling

Technological advancements and progress
Fruits of mathematical endeavors and curiosity
Learning math can sometimes be complex
Its utility in our lives is still evident
A very useful tool to make this world a lot less puzzling.

Author's Note

Aaron Alba

My inspirations in writing this poem are innovation and human advancement. Technology made possible by mathematics has helped us accomplish tasks beyond our physical capabilities. It is an invaluable tool that shaped our modern world and will continue molding our future. One of my main takeaways from the course is that math started to be developed because of its utility. It helped us describe quantities that are greater than the number of our fingers could have expressed. Math became our mental extension and is very useful for solving challenging problems. Until now, it is a driver of innovation and is used for unraveling the universes' nature and mysteries. It is our means of understanding and living in this very puzzling world.

One Twist at a Time (Charyl)

In the middle of uncertainties, rotating
right to left
from top to bottom, bottom to top
left to right.
So many turns and twists,
trials and errors,
lots of possibilities.
Don’t know where to move,
musing to which one is apt
‘cause others will strife.
Every move I do
has opposed emotions,
unlike complexions.

There’s painted yellow
red, blue, white, orange and green
What should I do?
Try, try, and try.
Taking possible opportunities,
hoping to find the right locus.
Sometimes it takes time,
but that’s totally fine.
It’s about discovering oneself
to where you belong.

After coming out of the maze, little
did I know,
it’s just only a point to

what I thought.
Here’s evolution, inventions
from a three-by-three-by-three
to larger four-by-four-by-four
and five-by-five-by-five ones.

It seems overwhelming
‘cause it’s an avant-garde
to the eye of the beholder.
But, even though it's tough to
find a way back,
find a way to dealt with new
techniques and patterns, new
combinations and permutations.
Leaving outside comfort zones
takes pride and bristles
to arrive in the best position.

Finally, I landed up to where I belong,
to the right position, right decision.
From thousand clueless ups and downs,
cube unsolved in disarray,
spends time and effort,
worked through night and day
to clinch great success.

I am the resolved Rubik’s Cube,
full of complexities and mystery.
But at the end of the day,
it’s up to you to ferret out, conquer
the facile mechanism to puzzle out.
Therefore, I dare you to take the game.
The game of life.

Author's Note

Charyl Alejandro

This poem is intended for those who are in the middle of chaos, for those who are struggling to find their self-worth and purpose in life, for those who are pressured to please the society where they belong, for those who are still in the process of self-discovery, for those who are overwhelmed and for those who are still searching for the right and perfect position that will make themselves fulfilled. Despite these challenges that you are facing right now, it is okay to discover and work with yourself at your own phase and time. It is okay to take a thousand clueless ups and downs, trials and errors, working through night and day. As long as you try to find new ways to deal with uncertainties, everything is totally fine. At the end of the day, everything will be resolved. Everything will achieve great success. Always remember that nothing worth having comes easy. Everything is worth a try.

References

Animesh, C. (2018, December 13). Calculating the number of permutations of the Rubik's cube. Medium. Retrieved December 13, 2021, from https://medium.com/@chaitanyaanimesh/calculating-the-number-of-permutations-of-the-rubiks-cube-121066f5f054

Applications of permutations and combination in real life. (2021, July 21). KXAN36 - Austin Daily News | Breaking Business & Financial News & Headlines from Austin Texas. Retrieved December 13, 2021, from https://www.kxan36news.com/applications-of-permutations-and-combination-in-real-life

Binary Numbers and Binary Math. (2018, July 12). Engineering and Technology History Wiki. https://ethw.org/Binary_Numbers_and_Binary_Math

Brenner, L. (2018, April 27). *How Is Geometry Used in Real Life?* Sciencing. https://sciencing.com/geometry-used-real-life-8698204.html

Bryant, J., Jain, P., & Trott, M. (2017, February 24). *Hidden Figures: Modern Approaches to Orbit and Reentry Calculations—Wolfram Blog*. Wolfram Blog. https://blog.wolfram.com/2017/02/24/hidden-figures-modern-approaches-to-orbit-and-reentry-calculations/

Combination - Definition, Formula, and Practical Example. (n.d.). Corporate Finance Institute. https://corporatefinanceinstitute.com/resources/knowledge/other/combination/

5 Types of Math Used in Computer Science. (n.d.). Computer Science Degree Hub. https://www.computersciencedegreehub.com/lists/5-types-of-math-used-in-computer-science/

Geometry | mathematics. (2019). In *Encyclopædia Britannica*. Retrieved from https://www.britannica.com/science/geometry

God's number - Looking for the optimal Rubik's cube solution. (n.d.). Rubik's Cube and Twisty Puzzle Wiki - Ruwix. Retrieved December 13, 2021, from https://ruwix.com/the-rubiks-cube/gods-number/

How Is Geometry Used in Real Life? (2018). Retrieved from Sciencing website: https://sciencing.com/geometry-used-real-life-8698204.html

Introduction to Algorithms. (2019, March 28). Retrieved from GeeksforGeeks website: https://www.geeksforgeeks.org/introduction-to-algorithms/

Introduction to Geometry | SkillsYouNeed. (n.d.). Retrieved from www.skillsyouneed.com website: https://www.skillsyouneed.com/num/geometry.html

Khan, S., Williams, C., Khim, J., & Ross, E. (n.d.). *Euler's Method*. Brilliant. https://brilliant.org/wiki/eulers-method/

Luwisha, N. (2018, November 20). *Euler in maths and engineering*. The Aperiodical. https://aperiodical.com/2018/11/eulers-method-in-structural-engineering/

Mathematics of the Rubik's cube. (n.d.). Rubik's Cube and Twisty Puzzle Wiki - Ruwix. Retrieved December 8, 2021, from https://ruwix.com/the-rubiks-cube/mathematics-of-the-rubiks-cube-permutation-group/

Mikke. (2019, July 15). *Binary Code Explained Step-by-Step: How Does Binary Work?* Mikke Goes Coding. https://mikkegoes.com/computer-science-binary-code-explained

Overview of Rubik's cube and reflections on its application in mechanism. (2018, August 27). Chinese Journal of Mechanical Engineering. Retrieved December 13, 2021, from https://cjme.springeropen.com/articles/10.1186/s10033-018-0269-7

Permutation and combination (Definition, formulas & examples). (2021, March 16). BYJUS. Retrieved December 8, 2021, from https://byjus.com/maths/permutation-and-combination/

Trial And Error definition | Psychology Glossary | alleydog.com. (n.d.). AlleyDog.com. https://www.alleydog.com/glossary/definition.php?term=Trial+And+Error

The age-old sunflower conjecture may soon be solved. (2019, October 27). Popular Mechanics. Retrieved December 7, 2021, from https://www.popularmechanics.com/science/math/a29579746/sunflower-math-problem/

The golden ratio in sunflowers | The lasting journey to life long learning. (2015, November 20). Retrieved December 7, 2021, from https://blogs.glowscotland.org.uk/glowblogs/njoldfieldeportfolio1/2015/11/20/the-golden-ratio-in-nature-and-art/

Using permutations to calculate probabilities. (2021, June 25). Statistics By Jim. Retrieved December 13, 2021, from https://statisticsbyjim.com/probability/permutations-probabilities/

Van, D. (2019, May 28). *Using Rubik's Cubes to Teach Math*. Retrieved from Edutopia website: https://www.edutopia.org/article/using-rubiks-cubes-teach-math