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Creativity and Critical Thinking in the AI Age: A High School Perspective

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Article Info	Abstract
Article History 13 December 2024 Accepted: 28 March 2025	Educational institutions around the world have been integrating AI into their educational practices. Many studies and reports highlight both the advantages and disadvantages of this integration. This paper focuses on the positive aspects of AI in education, specifically through the lens of a high school geometry project at a technology-focused urban high school in New Jersey. The project was an innovative initiative created by a math teacher who used AI to verify that the project complied with copyright policies. The project consists of two slides: the first slide presents problem-solving and informal proofs of geometric examples, while the second slide features a piece of art in which students fill the drawing with triangles. Afterward, students remove the original drawing, transforming and coloring the triangles. Once the students complete both slides, they write a paragraph reflecting on their work in the second slide. Additionally, students upload their drawings to Gemini (an AI tool) to receive feedback. They then revise their designs based on this feedback and write a second paragraph, incorporating insights gained from the AI. Moreover, researchers compare and contrast the students' reflections to assess the impact of AI on enhancing creativity and critical thinking. Geometric art figures and paragraphs will be presented in a Google Form for respondents to choose which student's paragraph is better (the one without and the other with AI assistance). Finally, researchers collect and analyze anonymous Google Form responses from teachers, verifying the positive impact of AI on creativity and critical thinking in education.
Keywords Teacher Students Geometry Project Creativity Critical thinking Triangles Interpretation Solving Proving AI	

Introduction

The geometry project "Integrating AI" at a technology-focused urban high school in New Jersey provides considerable evidence of the positive aspects of AI's role in shaping the quality of education in the AI age. AI in this project highlights positive outcomes such as amplifying creativity, inspiring critical thinking, providing quick feedback, and being available at any time, among others. We have already mentioned some of the advantages of AI in education, such as inspiring creativity and summarizing existing materials (College of Education, 2024). On the other hand, using AI requires adherence to ethical policies and has limitations regarding the accuracy of information. Consequently, users of AI must verify information through other reliable sources, such as Google Scholar, Edutopia, and others, to ensure accuracy.

A math teacher at a technology-focused urban high school in New Jersey strove to create and assign a project to

his students that would involve critical thinking and creativity in their geometry classes. Math projects for high school students can turn abstract concepts into practical, hands-on experiences, providing an interactive way to deepen understanding and foster creativity (Inspirit AI, n. d.). On the other hand, creating math projects requires adherence to ethical policies to avoid plagiarism and to meet criteria for incorporating mathematical concepts. As a result, the teacher conducted research on three AI platforms (Gemini, ChatGPT, and Merlin AI), but AI has its limitations. It is essential to always verify the accuracy of AI-generated output (Information Technology, 2023). Therefore, the teacher also researched articles on Google Scholar and ResearchGate to ensure his geometry project did not violate any ethical policies while promoting creativity and critical thinking.

After conducting thorough research on the validity of the project, the teacher assigned the second geometry project to three geometry classes. This project provides students with an overview of the design problem they are to address, the products and performances expected of them, the timeline, guidelines for collaboration, and the criteria for assessment (Edutopia, 2002). The project consists of two slides for each group. On the first slide, students must solve and/or prove the congruence or similarity of triangles. According to the correspondence conception, two objects are considered congruent if their corresponding parts belong to two triangles known to be congruent (Lo et al., 2024). On the second slide, students must design an existing piece of art using triangles via Google Slides. They may also use math AI tools like GeoGebra and Desmos Geometry. Students work in groups of up to four members and submit only one project, which will be graded with all group members receiving the same grade. The project must be completed by the end of the second marking period.

The teacher created a great creative project in geometry with the assistance of technology, especially assistance of AI platforms. The Photo-Math Project provides students with rich contexts to pose a problem by relating it to a photo; students need to interpret the situation, organize data relevant to their problem and discover the relationships (Christouet et al., 2005; Akdogan, 2023). Students have a great opportunity to amplify their critical thinking and creativity skills through this project.

The students' task equips them with the skills to complete the first slide by solving and/or proving mathematical problems, modifying photos or drawings by covering them with triangles, coloring the triangles, and interpreting the meaning of their work both with and without AI assistance. The aim of this paper is to analyze and evaluate the students' interpretations with and without AI assistance. Evaluating novelty is often subjective and context-dependent—"you simply know it when you see it" (Hua et al., 2022). For a better evaluation, the researchers will seek assistance from AI to gain more information on evaluating two different paragraphs of the text. Exploring the possibilities offered by artificial intelligence (AI) can provide fresh insights that advance our understanding of how novelty and new ideas are evaluated (Deichmann et al., 2024). The students' interpretations will dictate the influence of AI in creativity and critical thinking of students in this geometric project.

The geometry project, which integrates AI, highlights the positive aspects of AI in enhancing students' creativity and critical thinking. Cervini P., C. F., P. K., & M. W. V. A., (2024) discusses AI in problem solving, claiming, "Despite its recent popularity, AI is only successful in solving problems with very specific features." The paper focuses on the benefits of AI when students use it wisely as a tool to solve mathematical problems and explore

new methods for solving, proving, or designing mathematical examples. Beyond personalized teaching, AI performs valuable functions such as homework assessment, test grading, research paper organization, report management, and even generating presentations and notes (LeewayHertz, n.d.).

In this project, Gemini helps students incorporate geometric art into chatbots and provides feedback on their work. The students rated the AI feedback slightly more positively than the human feedback, even though both were constructive and identified the same number of errors (Wu, 2021). Students used both Gemini and ChatGPT to receive feedback. After solving mathematical problems, they uploaded their solutions to Gemini for assessment. They could then analyze the feedback and, if necessary, correct any mistakes. By revising their solutions and modifying the geometric art, students enhance their creativity and critical thinking skills. Furthermore, the system's positive impact on sustained engagement throughout the project highlights its potential as a valuable resource for augmenting the learning process (Swarguari, 2023).

Method

A geometry teacher at a technology-focused urban high school in New Jersey designed a project for the second marking period to emphasize the significance of triangles in the real world and their influence on art. The teacher instructed three classes, including three geometry classes. The teacher decided to create 15 groups across all three classes, with five groups in each class. Each group was assigned to complete two slides in a presentation. The first slide required an informal proof using congruence of triangle postulates and/or similar triangle theorems. The second slide involved a piece of art that students would fill with triangles and color according to their preferences. It is worth noting, however, that each individual project was expected to be wholly distinctive—a product of creative endeavor, never witnessed before (Baez et al., 2024). Furthermore, students were instructed to apply elements of rigid and non-rigid transformations, such as vertical or horizontal translation, reflection, rotation, and dilation. These transformations had been previously taught to the students.

As a proponent of creativity and a supporter of students' critical thinking, the teacher wanted to ensure that the second slide, incorporating art, demonstrated creativity. The benefits for high school students of applying technology in education include the ability to draw figures to scale and obtain quick, accurate answers to mathematical problems (Pillana et al., 2024). However, He was concerned about whether placing triangles on a drawing figure would violate any copyright rules and, most importantly, whether this project would assist students in developing their creative skills. To address these concerns, the teacher selected three AI platforms: Gemini, ChatGPT, and Merlin AI. He posed his questions to each AI platform, and their responses are presented below.

Teacher asked Question to AI:

I took a piece of drawing, then I added triangles to it to slightly alter the design. Finally, I colored the triangles with different colors. Did I manifest elements of creativity?

The Gemini Answer:

Absolutely! Taking an existing piece and adding your own unique touch by incorporating triangles and color demonstrates creativity. Here's how:

- Original Idea: You didn't just copy the drawing; you saw an opportunity to transform it.
- Problem-Solving: You identified a way to modify the design using geometric shapes.
- Experimentation: You played with different colors to see what worked best.
- Unique Expression: The final piece is now yours, reflecting your personal style.

Every creative act, no matter how small, is a manifestation of your unique perspective and ability to think outside the box. So, yes, you definitely exercised your creativity!

Chat GPT Answer:

Creativity isn't always about coming up with something entirely new from scratch—it can also involve reimagining or transforming something existing in innovative ways. What you did is a clear example of creative expression!

Merlin AI Answer:

Yes, your actions demonstrate elements of creativity. Taking an existing piece of art, reinterpreting it by adding geometric shapes (triangles), and then further enhancing it through color choices showcases creative problem-solving and aesthetic expression.

Based on the responses from the AI platforms, the teacher was confident that the new project met the conditions for creative elements and critical thinking. The answers helped the teacher approach the project creatively, provided significant facts that assured the teacher of its suitability, and challenged students to analyze and complete the project by applying critical thinking skills. Even as AI becomes more advanced, it still requires the intervention of real people to check for data inaccuracies, biases, logical inconsistencies, and even suggestions that may violate ethical standards (Carucci, 2024). The teacher was aware of AI's limitations regarding data accuracy, so he conducted independent research on Google and posed a question on ResearchGate to obtain accurate information.

An answer that the teacher received on Research Gate is as follows (the respondent's answer with initial L. C.): "It depends on many factors. My suggestion is to give credit to the author, request permission to reuse the drawing, and/or ensure that the modification changes the look, feel, and intent of the original. Additionally, just because something is on the internet does not mean it is in the public domain. Publishing copyrighted material on the internet does not make it public domain. I suggest reading this link from the US Copyright Office: <https://www.copyright.gov/engage/visual-artists/>."

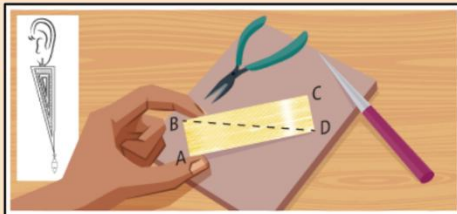
Furthermore, the teacher asked the same question on ResearchGate, as well as on three AI platforms, and

conducted research on appropriate art and copyright law. According to Prutzman (2016, p. 1), "A derivative work is defined as 'a work based upon one or more preexisting works,' including 'any other form in which a work may be recast, transformed, or adapted.' 17 U.S.C. § 101.

8. Allie cuts two triangles from a rectangular piece of metal along the dashed line to make earrings. How can Allie show that the earrings are the same size and shape?

P3 - Group # 3

A **rectangle** is a quadrilateral in which all the angles are equal and the opposite sides are equal and parallel. There are many rectangular objects around us. Each rectangle shape is characterized by two dimensions, its length and width. The longer side of the rectangle is known as the length and the shorter side is known as the width.



Statements	Reasoning
1. $AB \cong CD$	Parallelogram has opposite sides congruent
2. $BC \cong AD$	Parallelogram has opposite sides congruent
3. $\angle A \cong \angle C$	All angles of rectangles are equality
4. $\triangle ABC \cong \triangle ADC$	SAS Postulate

Figure 1. Example of the First Slide – Solving and informally Proving the Congruence or Similarity of Triangles. The Second Slide involves the Transformation of Triangles. The questions and the picture are taken from SAVVAS (2018), while the solution was done by students at a technology-focused urban high school in New Jersey.

The teacher creatively selected 15 examples from the Internet related to the curriculum (rigid and non-rigid transformations, similar triangles, and congruent triangles). By carefully choosing and structuring the theme, educators can significantly enhance the effectiveness of PBL (Project-Based Learning) in developing the creative skills necessary for students to thrive in the 21st century (Yu, 2024). The first slide focuses on solving and proving similar or congruent triangles, while the second slide addresses rigid and non-rigid transformations. The first slide encourages students to develop problem-solving skills (critical thinking), while the second slide provides examples to stimulate creativity in applying triangle transformations.

This paper focuses on one example: slide 2 from Group #2's presentation in the period 3 geometry class. Ten slides were selected as the best out of 15 total Google Slides. This case study aims to generalize results to broader situations. As noted by Cherry (2024), the purpose of a case study is to learn as much as possible about an individual or group so that the information can be applied more broadly.

This case study examines 11 different groups involved in a geometry project to generalize results when students and educators utilize AI effectively. In this context, "using AI wisely" means that educators and students complete the work step-by-step without relying on AI until they encounter significant challenges. For example, they should

independently verify rules to avoid intellectual property violations. After completing their own work, they can then use AI to:

- Verify their results on the first slide - problem solving in the real world.
- Check for any significant differences in their geometric constructions with triangles.
- Revise their interpretation of geometric art in the second paragraph (after writing the initial interpretation without AI assistance).

The research is based on the blending of human resources (students, educators, and researchers' work) with AI platforms. AI, as a tool, plays a crucial role in assisting educators and students in all aspects of education, but AI is just a tool. Tools can help, but only if we select and use the correct tool appropriately (Value Transformation, n.d.). The intention of this paper is to demonstrate how AI can be used appropriately when needed and to examine its impact on students' understanding of the project.

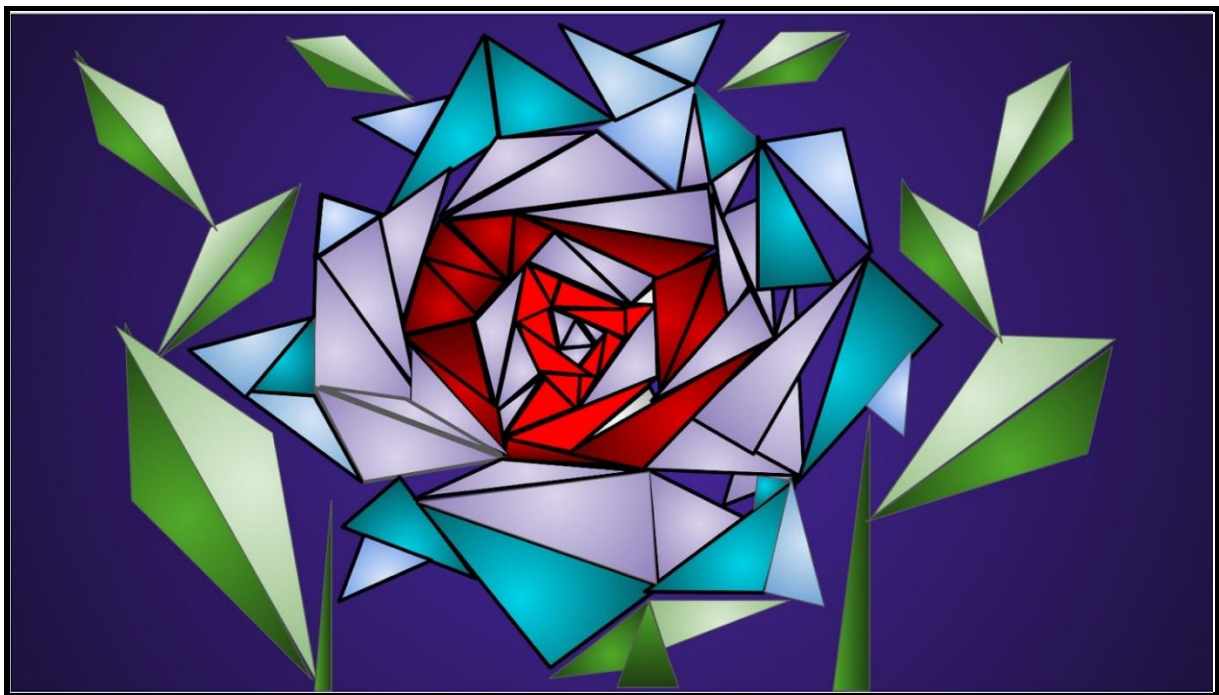


Figure 2. The Image Consists of Various Geometric Shapes, Primarily Triangles; the Sharp Edges and Angular Forms Contrast with the Organic, Flowing Nature of a Real Rose; adapted from Redbubble (n.d.).

Table 1. Students' Interpretation of Period 3 - Group 2 regarding the Geometric Art (the second slide): The first row contains the students' statements without AI assistance, and the second row contains the revised students' statements with the assistance of AI.

Period 3 - Group 2	Understanding Geometric Art through Students Interpretations
Paragraph 1 Students' interpretation of their work	The image appears to be a rose. It is made up of a variety of colors and multiple triangles with different shapes and sizes making up the flower. There are also triangles formed together in the shape of a rhombus to make leaves with two shades of green to emphasize the figure. In addition, the shading off the colors of each triangle creates an effect which makes the rose seem more realistic and easier to visualize. To conclude,

Period 3 - Group 2	Understanding Geometric Art through Students Interpretations
	the rose stands out more because of its background's color contrasting the figure.
Paragraph 2 Students' interpretation of their work with the assistance of AI	The image appears to be a rose. It is made up of a variety of colors and multiple triangles with different shapes and sizes making up the flower. There are also triangles formed together in the shape of a rhombus to make leaves with two shades of green to emphasize the figure. In addition, the shading off the colors of each triangle creates an effect which makes the rose seem more realistic and easier to visualize. The rose stands out more because of its background's color contrasting the figure. In addition, while utilizing contrasting colors of the triangles to form the rose, the center of it, also known as the bud, is formed into the shape of an "et" (@). By doing this, the image demonstrates a juxtaposition between nature and technology and how both can interact with each other and create beauty. Nowadays, we use technology for everything and at times it feels like we are replacing the natural world with it. Although this feeling is understandable and relatable, there are still ways that despite the advancement in technology, we are still connected to the real world. We still need our environment and nature to live, even when we believe depending on devices will help us more. Therefore, it is important to preserve the world's natural beauty, because without it, we wouldn't be who we are today. Our environment is what keeps us happy and healthy, and although technology helps us with minimal tasks, we will always require our natural and beautiful Earth.

(Source: Field Survey, 2024)

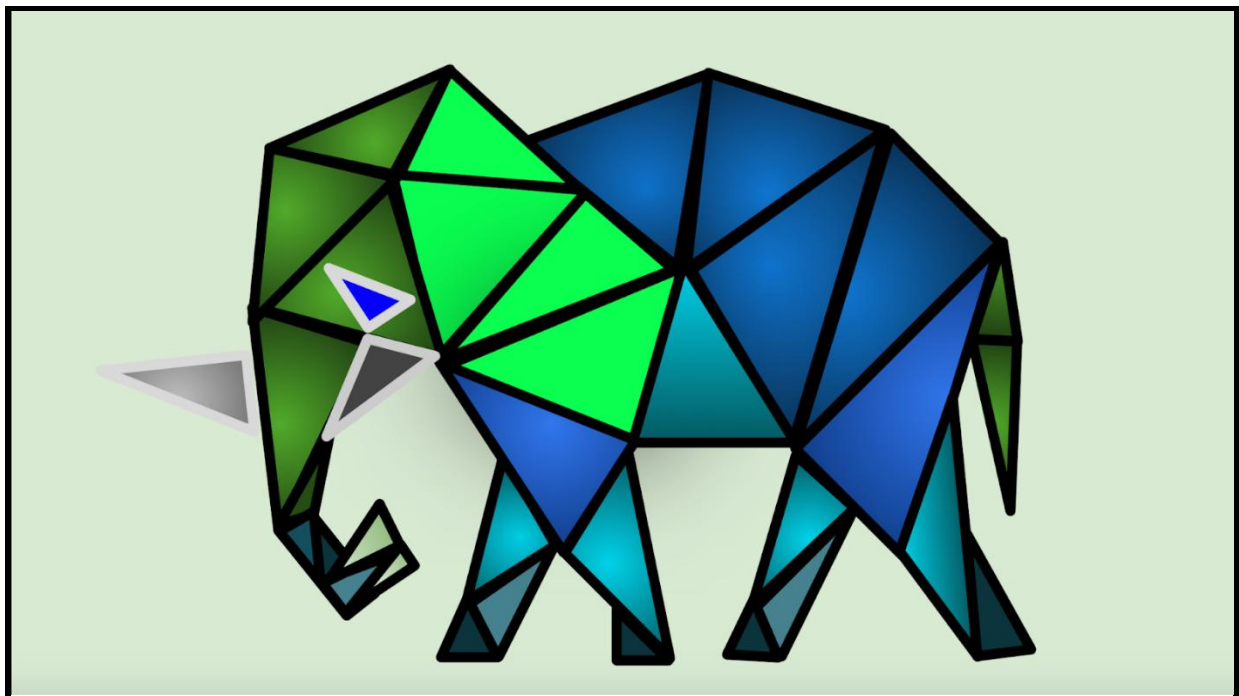


Figure 3. This Image Portrays an Elephant in a Geometric, Abstract Style. The use of triangles and vibrant colors creates a modern, stylized representation of the animal; adapted from Dreamtime (n.d.).

Table 2. Students' Interpretation of Period 2 - Group 1 Regarding the Geometric Art (the second slide): The first row contains the students' statements without AI assistance, and the second row contains the revised students' statements with the assistance of AI.

Period 2 - Group 1	Understanding Geometric Art through Students Interpretations
Paragraph 1 Students' interpretation of their work	In the image constructed, an elephant is able to be seen. We, as a group, made this image by shaping and resizing the given triangles, in order to fit the description of the original image. This image is 2d, with length and width. Using the triangles, our group utilized dilations, rotations, translations to create the elephant.
Paragraph 2 Students' interpretation of their work with the assistance of AI	The image we made as a group shows a geometric elephant which was made from different shapes, but mostly triangles. The elephant was created to represent glass, which had shades of blue, green, and yellow. However, when we redid it as a group, we just colored it blue and black. Overall, the shapes are resized and moved in order to make the elephant look more artistic, having a puzzle type of appearance. Thus, giving the elephant a more modern, abstract feeling, which turns it into a beautiful, colorful work.

(Source: Field Survey, 2024)

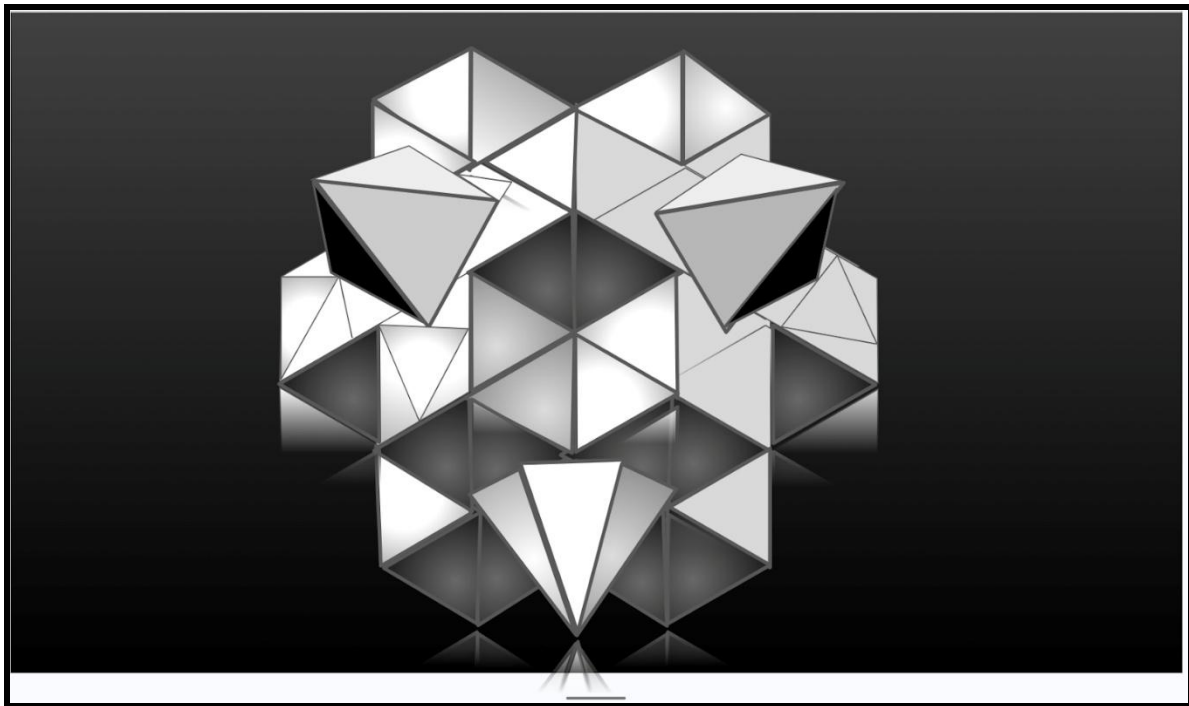


Figure 4. The Contrast of Colors and the Arrangement of Shapes Create a Sense of Visual Rhythm and Harmony, while the Heart-like Shape Evokes Themes of Love, Unity, and Connection; adapted from Koler (n.d.).

Table 3. Students' Interpretation of Period 2 - Group 4 regarding the Geometric Art (the second slide): The first row contains the students' statements without AI assistance, and the second row contains the revised students' statements with the assistance of AI.

Period 2 - Group 4	Understanding Geometric Art through Students Interpretations
Paragraph 1	This method that is being applied is the congruent postulate theorem, same side interior

Period 2 - Group 4	Understanding Geometric Art through Students Interpretations
Students' interpretation of their work	and exterior angle theorem. Additionally, the four triangles in the center of the image illustrate the postulates because all the triangles have the same angles, same lengths, and are all congruent.
Paragraph 2 Students' interpretation of their work with the assistance of AI	The geometric pattern in the image shows a combination of rigid and non-rigid transformations to achieve its intricate design. The arrangement stems from a fundamental triangular unit, systematically repeated and transformed across the composition. Rigid motions such as translation organize the triangles into a grid-like structure, while rotations and reflections add dynamic orientations and symmetry. Variations in depth are likely achieved through non-rigid motions like dilation, where some triangles are scaled to appear larger or smaller, creating a three-dimensional illusion. The bold use of black and white accentuates the triangular shapes, enhancing the visual impact of symmetry, repetition, and contrast. Ultimately, these transformations create a visually, and mathematically compelling pattern.

(Source: Field Survey, 2024)

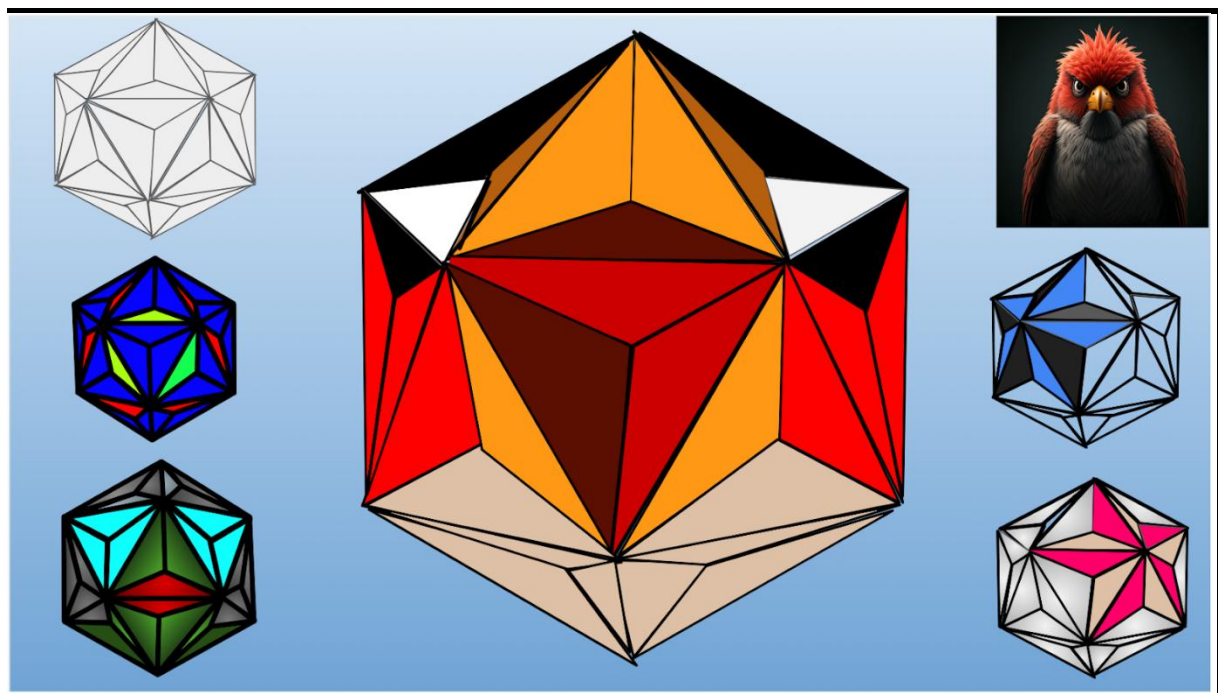


Figure 5. Generating Different Figures by Altering Colors in a Black-and-white Figure, resulting in Distinct Variations; adapted from Symmetry (n.d.).

Table 4. Students' Interpretation of Period 2 - Group 3 regarding the Geometric Art (the second slide): The first row contains the students' statements without AI assistance, and the second row contains the revised students' statements with the assistance of AI.

Period 2 - Group 3	Understanding Geometric Art through Students Interpretations
Paragraph 1 Students'	When we first looked at the shape, all of us thought of different things. Cabio thought that it looked like a bird. I thought that it looked like a star fruit. Sempron saw stars.

Period 2 - Group 3	Understanding Geometric Art through Students Interpretations
interpretation of their work	Although we all saw different things we used our creativity to make our own coloring to create what we thought.
Paragraph 2 Students' interpretation of their work with the assistance of AI	Without any coloring the shape wasn't very clear to us, but then as we colored, we only colored specific faces and turned it into a 3D looking star. We then realized that everyone would see that, and we wanted to make it unique, something that no one would expect. Cabio then said that the front of the shape looked like a bird's beak. Therefore, giving us our end product, the red angry bird.

(Source: Field Survey, 2024)

Note: The names "Cabio" and "Sempron" are fictional and used to protect the privacy of students, while also preserving the originality of their interpretations of geometric figures.

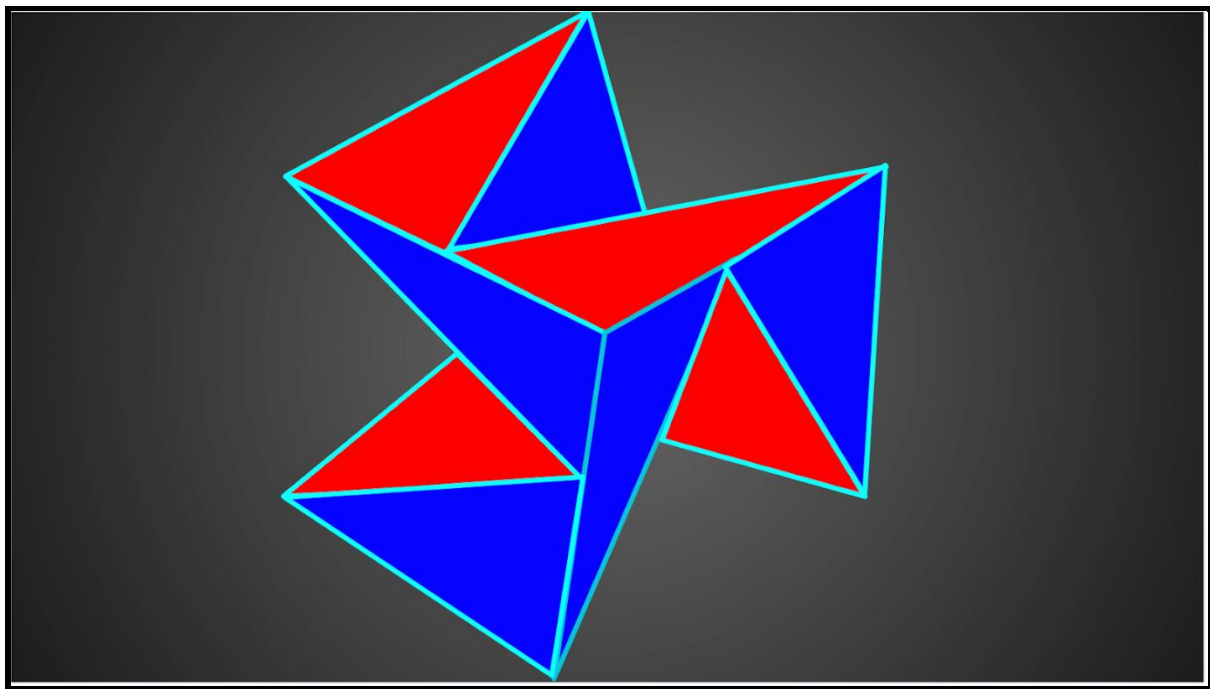


Figure 6. The Image is a Complex, Three-dimensional Shape that Appears to be made up of Several Intersecting Pyramids or Triangular Prisms; adapted Bizzi (n. d.).

Table 5. Students' interpretation of Period 2 - Group 2 regarding the geometric art (the second slide): The first row contains the students' statements without AI assistance, and the second row contains the revised students' statements with the assistance of AI

Period 2 - Group 2	Understanding Geometric Art through Students Interpretations
Paragraph 1 Students' interpretation of their work	The project is multi-triangular and has distinctive features all around the shape. The triangular shape is a polyhedral and has red and blue colors all around it light blue color.
Paragraph 2 Students' interpretation	Our figure is made up of many triangles and makes a three-dimensional illusion. Our personal figure is the triangular shape is a polyhedral and has red and blue colors

Period 2 - Group 2	Understanding Geometric Art through Students Interpretations
of their work with the assistance of AI	all around its light blue color. The figure shows a degree of symmetry. Overall, all the triangles with the colors make a strong illusion and a great figure.

(Source: Field Survey, 2024)



Figure 7. The Image Appears to be a Stylized Portrait of a Person, likely a Woman, Created using a Geometric Technique known as Triangulation or Low-poly art.; adapted from Image Inspiration (n.d.).

Table 6. Students' Interpretation of Period 3 - Group 3 regarding the Geometric Art (the second slide): The first row contains the students' statements without AI assistance, and the second row contains the revised students' statements with the assistance of AI

Period 3 - Group 3	Understanding Geometric Art through Students Interpretations
Paragraph 1 Students' interpretation of their work	The image is a picture of a woman, but it's made up of lots of little triangles and other shapes. It looks like a stained-glass window. The colors are mostly black, gold, and red.
Paragraph 2 Students' interpretation of their work with the assistance of AI	This image shows a human face made up of many small triangles, a style called low-poly art. The face is built using light and dark colors within these triangles to create depth and detail. The bright red lips, dark eyes, and black hair stand out against the golden background, making the face the focus. The sharp angles of the triangles give the image a modern and edgy look. It shows how geometry can be used creatively to turn simple shapes into expressive artwork. The golden gradient in the background adds warmth and enhances the overall elegance of the design. The combination of bold colors and geometric precision creates a striking and visually captivating comp.

(Source: Field Survey, 2024)

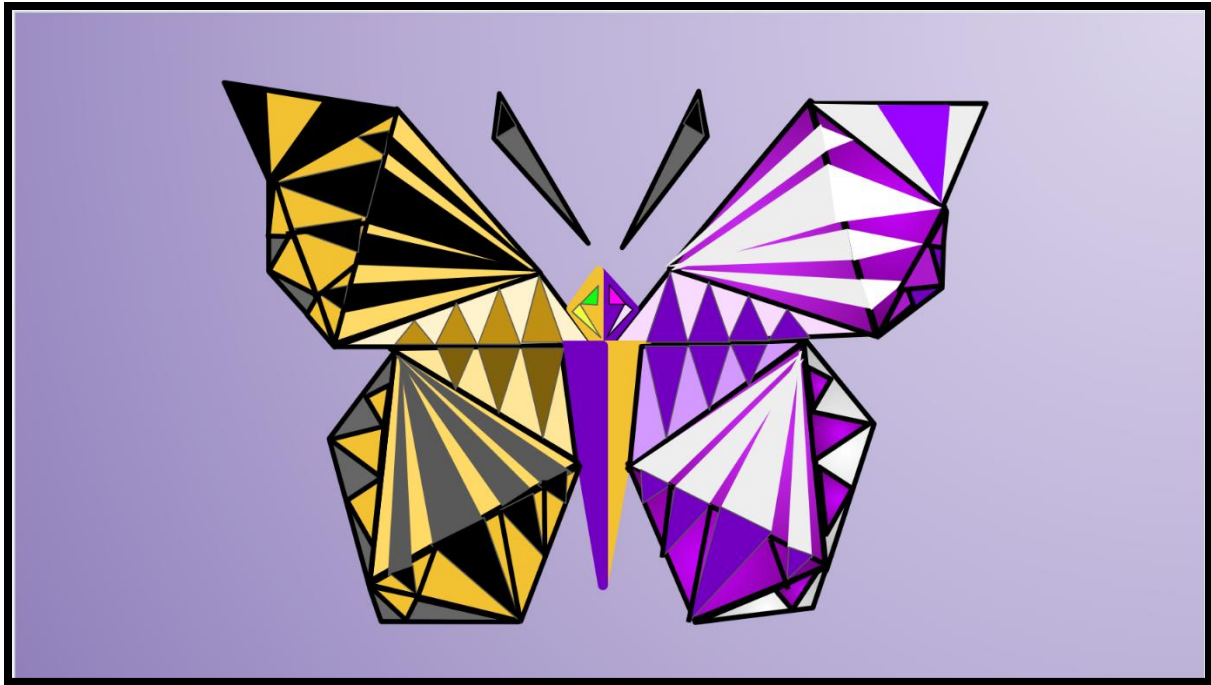


Figure 8. The Image is a Visually Striking and Thought-provoking Representation of a Butterfly. It combines traditional symbolism with modern design elements to create a unique and intriguing piece; adapted from Possible Art (2022).

Table 7. Students' Interpretation of Period 3 - Group 1 regarding the Geometric Art (the second slide): The first row contains the students' statements without AI assistance, and the second row contains the revised students' statements with the assistance of AI.

Period 3 - Group 1	Understanding Geometric Art through Students Interpretations
Paragraph 1 Students' interpretation of their work	In our work, we used geometric shapes to create an artwork of a butterfly with a contrast of colors on each side. As this whole work is made of triangles, the formation makes it unique and eye-catching albeit simple through the usage. It presents the rigid beauty that can be made using only geometric shapes. Using the triangles, our group utilized dilations, rotations, and reflections to create the butterfly. The dilations help add small details to the image, rotations assist in the control and layout, and through reflections, the image can fully develop and show two symmetrical sides. This image showcases the harsh contrast of colors on the opposite sides of the color wheel. The image consists of colors such as yellow, black, purple, and white. Yellow and purple are complementary colors, while black and white are opposites. The colors are used to show the preimage and the reflected image, or prime image. Our project demonstrates that artwork and images can be made using only triangles.
Paragraph 2 Students' interpretation of	In our work, we used geometric shapes to create an artwork of a butterfly with contrasting colors on each side. As this whole work is made of triangles, the formation makes it unique and eye-catching albeit simple through the usage. It

Period 3 - Group	Understanding Geometric Art through Students Interpretations
1	
their work with the assistance of AI	<p>presents rigid beauty that can be achieved using only geometric shapes. Using the triangles, our group utilized dilations, rotations, and reflections to create the butterfly. Also known as tessellation, this process involves the placement, fitting, and repetitive shapes used to create the project. The dilations help add small details to the image, rotations assist in the control and layout, and through reflections, the image can fully develop and show two symmetrical sides. This type of symmetry is known as bilateral symmetry, defined as two mirrored halves centered around an axis. The use of this helps aid in the realistic form of a butterfly found in the world. This image showcases the harsh contrast of colors on the opposite sides of the color wheel. It also consists of colors such as yellow, black, purple, and white. It also includes some accents such as neon green and pink. Yellow and purple are complementary colors, while black and white are opposites. The colors were chosen specifically in order to give off a strong impression but to display the preimage and the reflected image, or prime image. Our project demonstrates that artwork and images can be made using only shapes. Our artwork also resembles styles found in other works, such as stained glass and cubism.</p>

(Source: Field Survey, 2024)

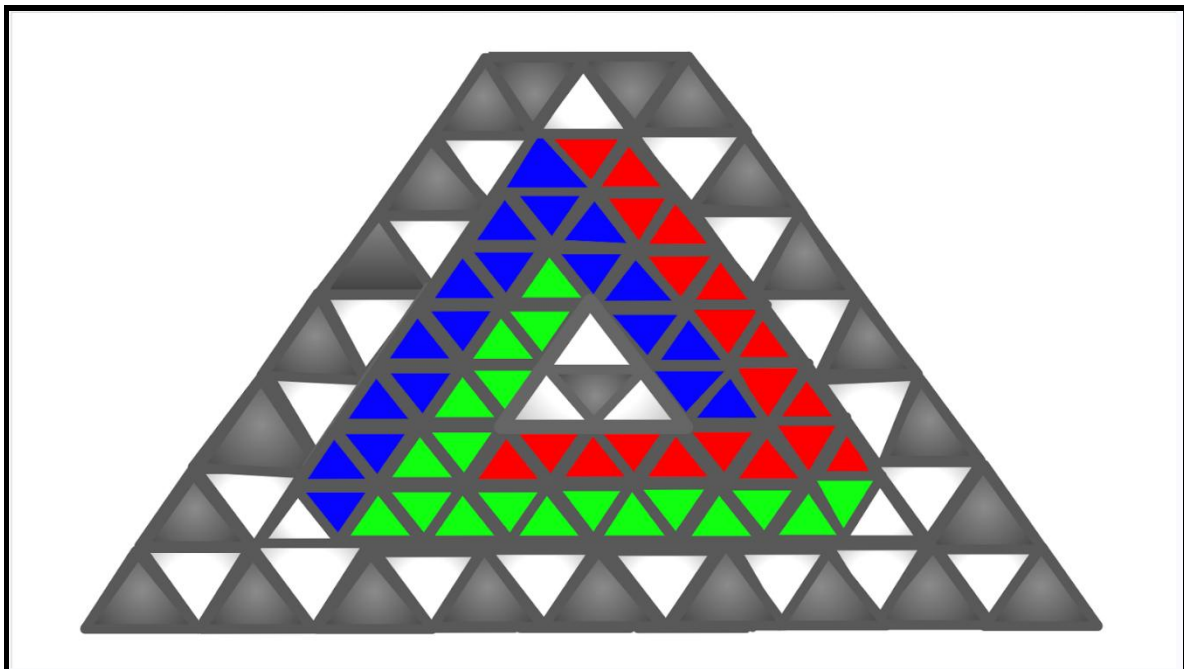


Figure 9. The Penrose Triangle, also known as the Penrose Tribar, the Impossible Tribar, or the Impossible Triangle, is an Optical Illusion consisting of an Object which can be depicted in a Perspective Drawing but cannot exist as a Solid Object in Ordinary Three-dimensional Euclidean Space; adapted from Kevin & Kaia (n.d.).

Table 8. Students' Interpretation of Period 7 - Group 5 regarding the Geometric Art (the second slide): The first row contains the students' statements without AI assistance, and the second row contains the revised students' statements with the assistance of AI

Period 7 - Group 5	Understanding Geometric Art through Students Interpretations
Paragraph 1 Students' interpretation of their work	There is a big triangle made out of smaller, different-colored triangles. The colors are green, red, blue, black, and white. The triangles are dilated and rotated to form the bigger triangle. It resembles the Google Drive logo and stained glass. There is a smaller triangle inside the giant one. The biggest triangles are the white and black ones, which borders the smaller, inner, colorful one. Inside the smaller triangle, there is an even smaller triangle. The smallest triangle is black and white, and also bordered by the other two triangles.
Paragraph 2 Students' interpretation of their work with the assistance of AI	There is a big triangle made out of smaller, different-colored triangles. The smaller triangles are arranged in a repeating pattern within the larger triangle. The colors are green, red, blue, black, and white. The colors are complementary. The colors are also repeating a pattern. The use of shading creates an illusion. It resembles the Google Drive logo and stained glass. There is a smaller triangle inside the giant one. The biggest triangles are the white and black ones, which border the smaller, inner, colorful ones. Inside the smaller triangle, there is an even smaller triangle. The smallest triangle is black and white and is also bordered by the other two triangles. Colors greatly influence the overall aesthetic and emotional impact of the Penrose Triangle.

(Source: Field Survey, 2024)

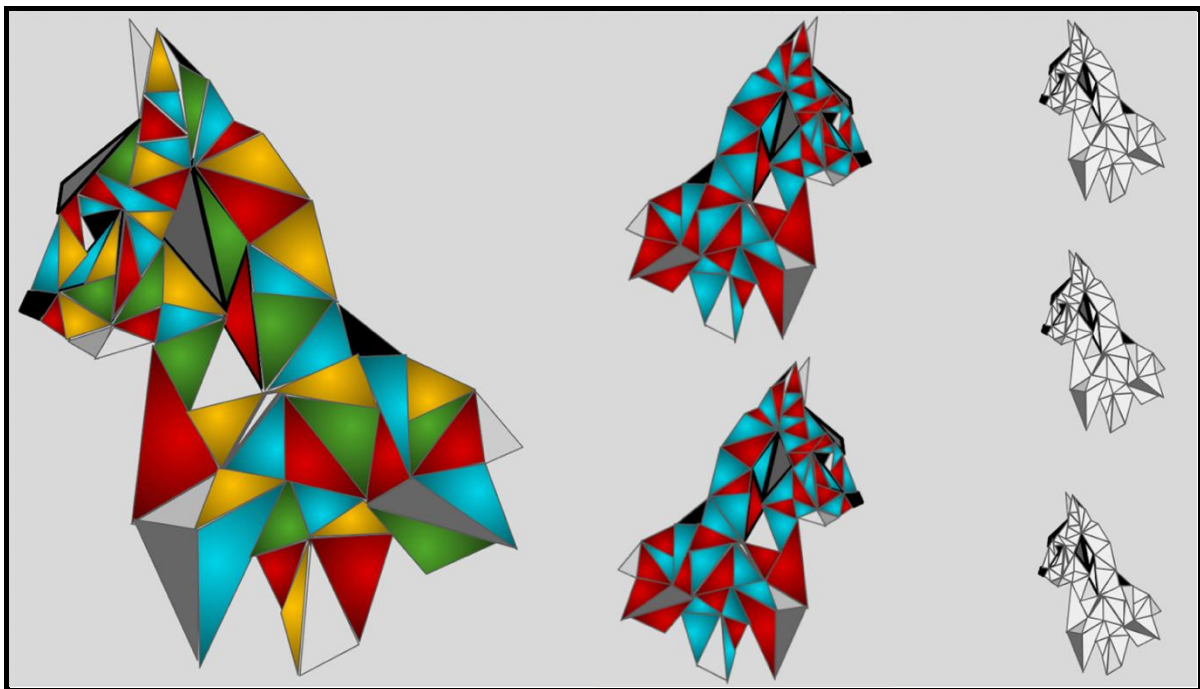


Figure 10. This Image presents a Geometric Representation of a Cat's Head using a Technique called "Low-poly Art," where a Complex Image is broken down into Simple Shapes, primarily Triangles. This style gives the image a fragmented, almost pixelated appearance; adapted from Vector (n.d.).

Table 9. Students' Interpretation of Period 7 - Group 3 regarding the Geometric Art (the second slide): The first row contains the students' statements without AI assistance, and the second row contains the revised students' statements with the assistance of AI.

Period 7 - Group 3	Understanding Geometric Art through Students Interpretations
Paragraph 1 Students' interpretation of their work	During the project we had given the whole project with most being reflections of the original figure of cats. It was mostly making the x and y either negative or change into the front. After, we colored It to give it color and created more vivid pictures of cats.
Paragraph 2 Students' interpretation of their work with the assistance of AI	The cats in the picture are made from giant triangles of varying length and sizes to make the drawing of a cat. The triangles are sharp and angular. The colors used on the cats are different colors and are not repeating unlike the 2 medium and 3 smaller cats, The colors are very bright and are used from the gradient palette. Overall, there are 6 cat heads all different in size and in color. One cat is in many different colors and the 2 smaller medium ones are with repeating colors blue and red and are smaller than the giant cat head. Then there are smaller one that are mainly, black, white, and grey. Its a playful and creative way of art showing reflection.

(Source: Field Survey, 2024)

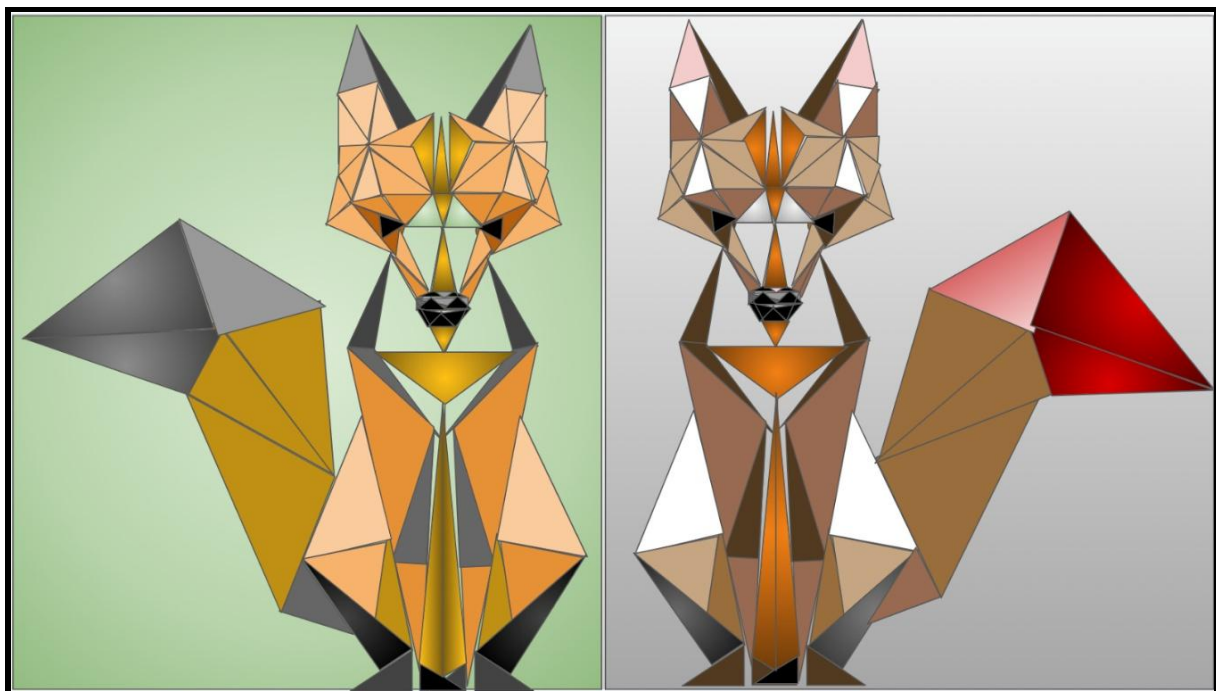


Figure 11. This Image depicts Two Foxes in a Geometric, Abstract Style. The use of triangles and varying shades of gray, brown (light and dark), black, orange, and purple creates a modern, stylized representation of the animals; adapted from Jamiz (n.d.).

Table 10. Students' Interpretation of Period 7 - Group 1 regarding the Geometric Art (the second slide): The first row contains the students' statements without AI assistance, and the second row contains the revised students' statements with the assistance of AI.

Period 7 - Group 1	Understanding Geometric Art through Students Interpretations
Paragraph 1	The image of the fox is reflected along the y-axis. Or one can also say it was translated by

Period 7 - Group 1	Understanding Geometric Art through Students Interpretations
Students' interpretation of their work	a certain number and then reflected along its center. Additionally, it's color was changed.
Paragraph 2 Students' interpretation of their work with the assistance of AI	The figure is made up entirely of triangles that create the image of the fox. The colors are opposite on both sides. The left side is bright and colorful, but the right side is dark. This could be interpreted as foxes have a light and dark side inside of them. The foxes are an exact mirror of each other and reflect off each other. The image shows signs of reflection and contrast to portray two foxes. The image can be interpreted as two foxes that are the same but also different. Or it could be interpreted as one fox that has two different sides. The use of balance and symmetry gives the feeling that both sides are alike but just with a reflection.

(Source: Field Survey, 2024)

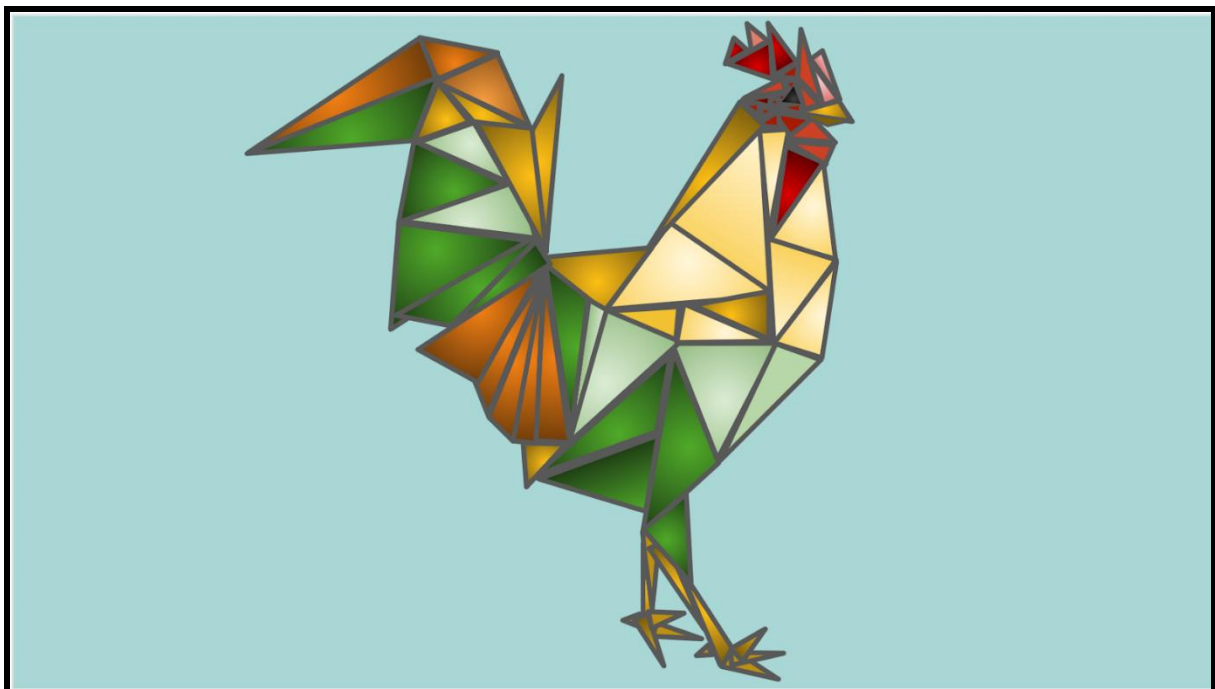


Figure 12. This Image depicts a Rooster in a Geometric, Abstract Style. The use of triangles and varying shades of green, yellow, red, and black creates a modern and stylized representation of the rooster.; adapted from TickleHead (2018).

Table 11. Students' Interpretation of Period 2 - Group 3 regarding the Geometric Art (the second slide): The first row contains the students' statements without AI assistance, and the second row contains the revised students' statements with the assistance of AI

Period 2 - Group 3	Understanding Geometric Art through Students Interpretations
Paragraph 1 Students' interpretation of their work	The rooster is built with various triangles of different sizes and multiple colors. For the rooster, there are all different types of triangles such as isolates, scalene, and equilateral. For instance, it has a color like gold to symbolize good luck, wishes, and happiness. Additionally, the color red demonstrates fierce passion (never giving up). Furthermore, its green color represents pride,

Period 2 - Group 3	Understanding Geometric Art through Students Interpretations
	success, and power. Moreover, oranges show bravery and honesty. In the end, the rooster depicted in the picture has a deeper meaning while incorporating math, using the different translations to make up its form.
Paragraph 2 Students' interpretation of their work with the assistance of AI	By using various triangles and other geometric shapes, it creates a mosaic-like effect. Sharp and angular lines give the rooster a modern and abstract feel. Not only that, but its vibrant colors like yellow, red, green, and brown contribute to the abstract impression while showcasing the rooster's natural plumage. Although employing geometric abstraction, the rooster's features like its comb, wattles, and tail feathers are still visible. Moreover, the shapes and features capture the rooster's proud and alert posture. In the end, the rooster depicted in the picture has a deeper meaning while incorporating math, using the different translations to make up its form. For the rooster, there are all different types of triangles such as isolates, scalene, and equilateral.

(Source: Field Survey, 2024)

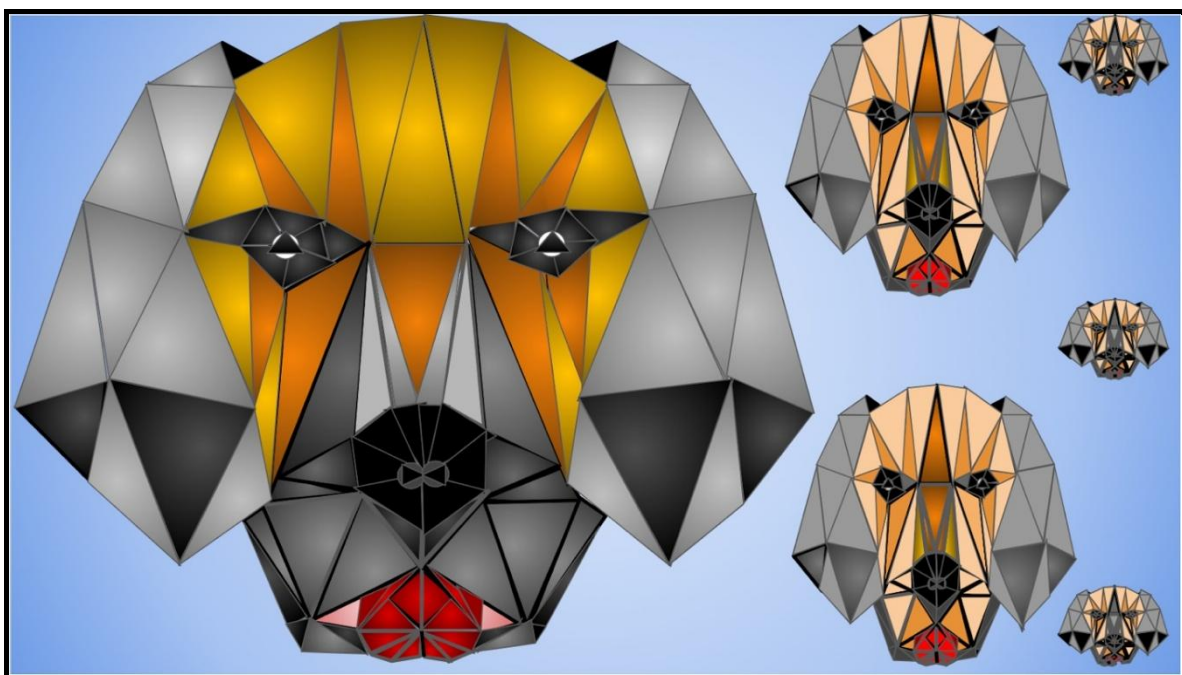


Figure 13. The Image is a Geometric Illustration of a Dog's Head. The artwork is created using a low-poly style, which means it is composed of many small, flat triangles that create a faceted, almost pixelated look. Adopted from Freepik (n. d.).

Table 12. Students' Interpretation of Period 7 - Group 2 regarding the Geometric Art (the second slide): The first row contains the students' statements without AI assistance, and the second row contains the revised students' statements with the assistance of AI

Period 7 - Group 2	Understanding Geometric Art through Students Interpretations
Paragraph 1 Students' interpretation of their work	<p>The image of the dog is a beautiful one since it perfectly portrays the concept of geometry.</p> <p>The symmetry itself is what makes the image so appealing to every mathematician at heart.</p> <p>The colors are the main component of the image and therefore give life to it. It perfectly represents the face of a dog since it is so detailed with the eyes and the shading. Every</p>

Period 7 - Group 2	Understanding Geometric Art through Students Interpretations
	triangle in the image is perfect as it captivates the viewer and sparks a further love towards geometry. Which is why I personally love geometry since it is all about perfection.
Paragraph 2 Students' interpretation of their work with the assistance of AI	These kinds of geometric drawings help me understand geometry at a higher level. With the simple use of symmetry and triangles it teaches me a lot about angles. Every triangle in the image is perfect as it captivates the viewer and sparks a further love towards geometry. The image of the dog is a beautiful one since it perfectly portrays the concept of geometry. The symmetry itself is what makes the image so appealing to every mathematician at heart. Furthermore, it also teaches me that everything can be made of simple shapes like triangles. Geometry is the use of geometrical figures, so this image teaches me a lot about it. In life it is important to learn geometry for the sole fact that triangles can make up everything like this image.

(Source: Field Survey, 2024)

Results

In general, AI has both positive and negative effects on creativity and critical thinking. Nonetheless, this paper will focus on the positive aspects. AI has limitations in terms of its educational capabilities. It is necessary to be cautious and take the required precautions to ensure that robots and artificial intelligence never dominate situations without human supervision, particularly in matters of education (Tao et al., 2019). Educators and students should use AI solely as a tool to make the teaching and learning process more effective and accessible for everyone. Regarding the positive aspects or benefits of AI in education, the researchers of this study found the following results based on the methods section by analyzing the students' interpretations.

Table 13. Results of AI on Creativity and Critical Thinking in a Case Study of a Geometry Project, reflected in the Teacher's and Students' Work as they complete the Project

List of Results	Results of AI Influence on Creativity and Critical Thinking – Case Study in a Geometry Project in three Classes
1	Students should use AI wisely to fully benefit from it in their academic growth.
2	AI assists students with various mathematical models, allowing them to combine these models and generate new, creative mathematical solutions.
3	AI provides high school students with various ideas and elevates critical thinking by challenging them to select the optimal ideas to create new creative designs or solve desired mathematical problems.
4	AI also provides students with feedback, enabling them to revise their mathematical solutions and check whether their work is correct or incorrect.
5	By correcting their mistakes and learning new skills through AI, students enhance their critical thinking and can apply these skills to solve similar mathematical problems.
6	AI, by providing students and the teacher with data, information, and feedback during the geometry project, helps them gain confidence and engage in a deeper learning process, which leads to creativity and critical thinking.

List of Results	Results of AI Influence on Creativity and Critical Thinking – Case Study in a Geometry Project in three Classes
7	AI enhances students' creativity and critical thinking by helping them analyze geometric figures and interpret them clearly, using rich vocabulary to explain details in depth.

(Source: Field Survey, 2024)

The Summary of 31 - Responses (Results) in the Google Form

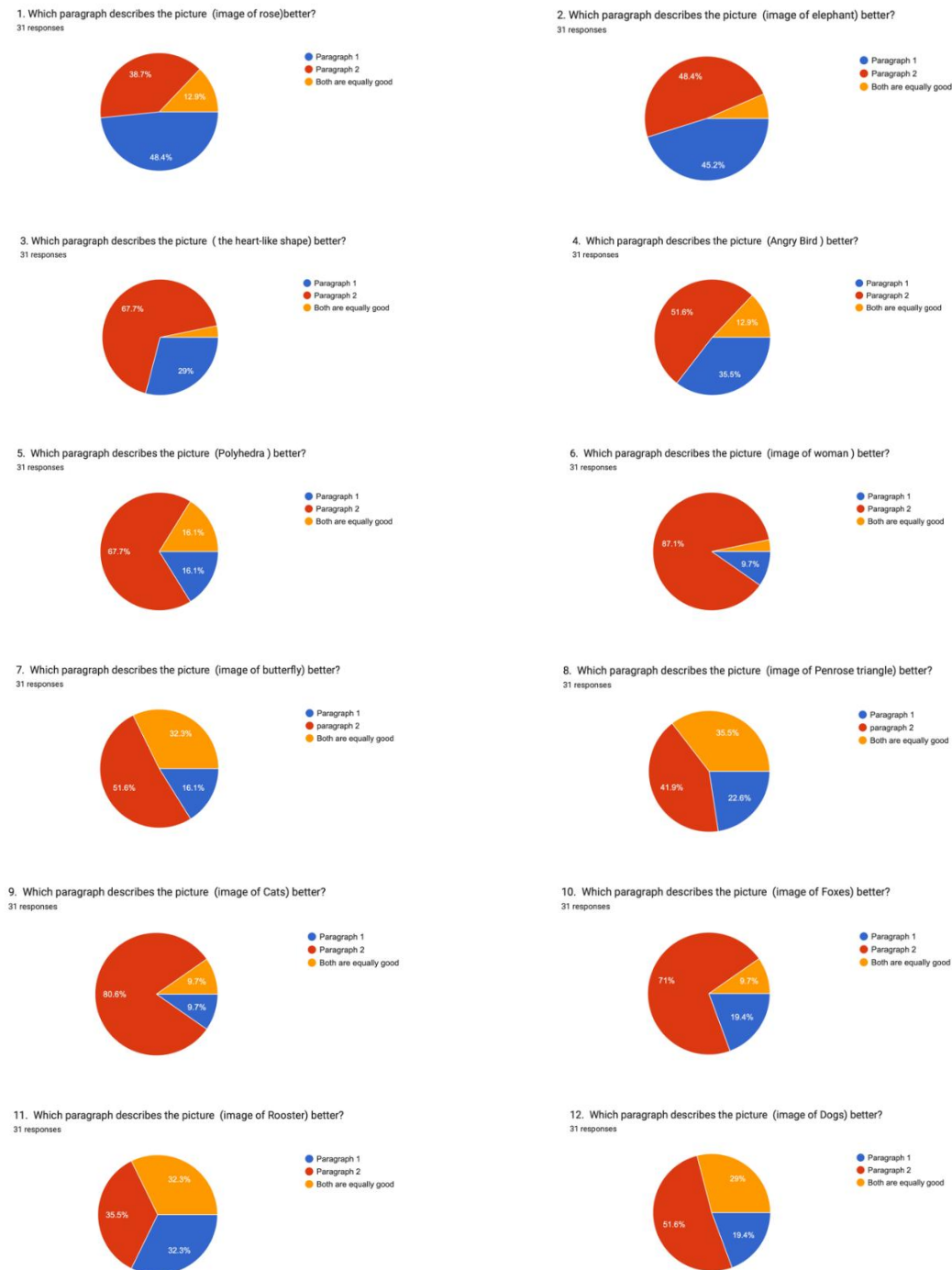


Figure 14. Results from 31 Respondents in a Google Form based on 12 Different Pictures presented in a Pie Chart. Results are taken directly from the responses summary in Google Forms.

Each group of students interpreted their geometric figure in two paragraphs. The first paragraph contained the students' interpretation without the use of AI assistance. The teacher placed each picture in Gemini and asked it to describe each figure. Then, the teacher pasted all AI comments about the descriptions into a Google Doc. He distributed the document to the students, who then selected the description of their geometric figure generated by Gemini. Unlike traditional AI, Gemini communicates with images as well. This means it can analyze the content of images and videos alongside textual data, providing a more comprehensive understanding of your query (Syracuse University Libraries, 2024). Moreover, students analyzed Gemini's description of the geometric figures, gaining more advanced information from the AI, and subsequently wrote their second paragraph. The second paragraph was much better written than the first one, with a more in-depth description.

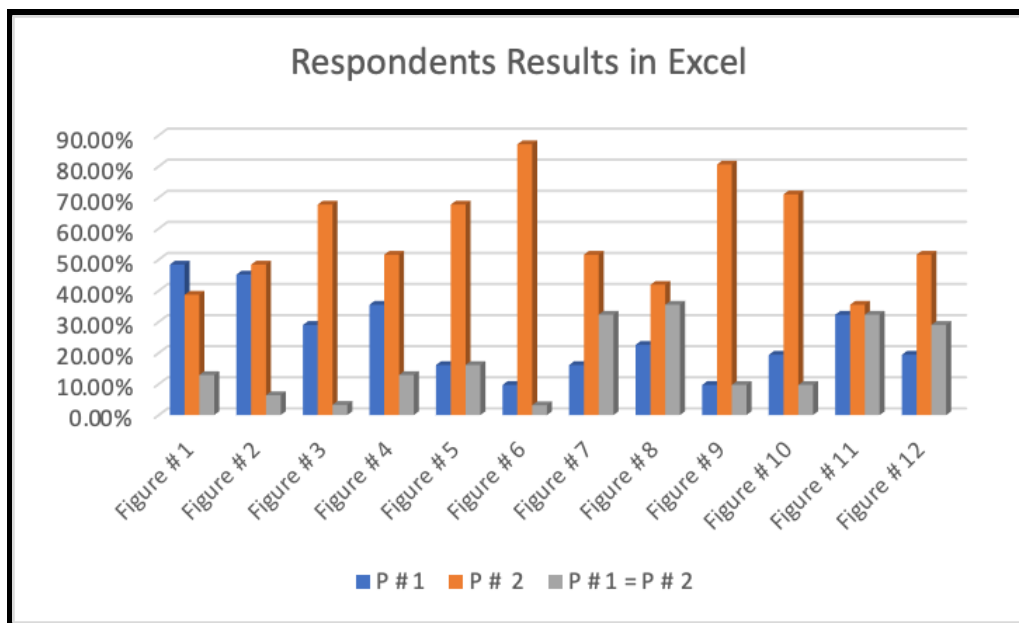


Figure 15. Results of the Google Form (31 respondents, with answers organized in paragraphs of 12 geometric figures) converted into a Bar Graph using Excel.

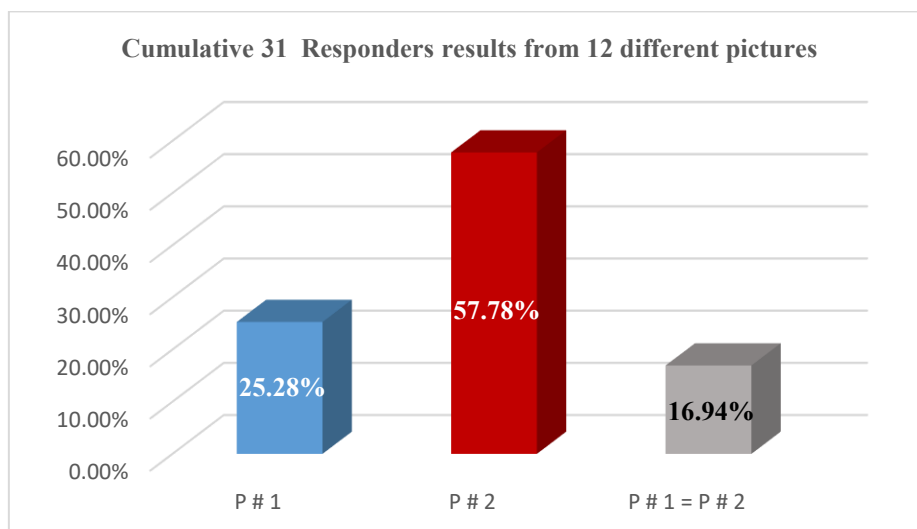


Figure 16. The Sum of All Results from 31 Respondents, organized into Paragraphs of 12 Geometric figures across Three Groups: Paragraph #1, Paragraph #2, and Paragraph #3.

Table 14. Results of the Number of Respondents selecting Paragraphs (percentages converted into numbers representing the number of participants selecting a paragraph in a given figure). Data adapted for easy use in the

ANOVA test

Results of the number of respondents selecting paragraphs	Paragraph 1	Paragraph 2	Both Paragraph the same
Figure 1- Image of rose	15	12	4
Figure 2 - Image of elephant	14	15	2
Figure 3 - Image of the heart-like shape	9	21	1
Figure 4- Image of angry bird	11	16	4
Figure5- Image of polyhedral	5	21	5
Figure 6- Image of woman	3	27	1
Figure 7- Image of butterfly	5	16	10
Figure 8- Image of Penrose Triangle	7	13	11
Figure 9- Image of cats	3	25	3
Figure10- Image of foxes	6	22	3
Figure11- Image of the roosters	10	11	10
Figure12- Image of dogs	6	16	9

(Source: Field Survey, 2024)

In Table 14 - 1, three groups are compared, with percentages of 48.40%, 38.70%, and 12.90%, and each group has 31 respondents.

- Option 1 (48.40%):
 $0.484 \times 31 = 15$ respondents
- Option 2 (38.70%):
 $0.387 \times 31 = 12$ respondents
- Option 3 (12.90%):
 $0.129 \times 31 = 4$ respondents

In this way, the percentages are converted into the number of respondents who selected each preferred option. The resulting data were then entered into the table to create Table 14. Now, instead of using percentages, we have raw counts (15, 12, and 4 respondents) in the first row (in the same way the rest of the rows have been created), which can be compared using an ANOVA test.

Table 15. Comparing the Mean of Results in Paragraph 1, Paragraph 2, and Both Paragraphs by using ANOVA

Test - Single Factor

SUMMARY				
Groups	Count	Sum	Average	Variance
Paragraph 1	12	94	7.83333333	15.969697
Paragraph 2	12	215	17.9166667	26.8106061
Paragraphs 1 and 2	12	63	5.25	13.8409091
ANOVA				

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1075.16667	2	537.583333	28.4831416	6.5037E-08	3.28491765
Within Groups	622.833333	33	18.8737374			
Total	1698	35				

(Source: Field Survey, 2024)

Table 16. Comparing the Mean of Results in Paragraph 1 and Paragraph 2, by using ANOVA Test - Single Factor

SUMMARY						
Groups	Count	Sum	Average	Variance		
Paragraph 1	12	94	7.83333333	15.969697		
Paragraph 2	12	215	17.9166667	26.8106061		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	610.041667	1	610.041667	28.519745	2.3199E-05	4.3009495
Within Groups	470.583333	22	21.3901515			
Total	1080.625	23				

(Source: Field Survey, 2024)

Table 17. Comparing the Mean of Results in Paragraph 1, Paragraph 2, and Both Paragraphs by using ANOVA Test - Single Factor

SUMMARY						
Groups	Count	Sum	Average	Variance		
Paragraph 1	12	94	7.83333333	15.969697		
Paragraph 1 and 2	12	62	5.16666667	14.1515152		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	42.6666667	1	42.6666667	2.83299799	0.10648498	4.3009495
Within Groups	331.333333	22	15.0606061			
Total	374	23				

(Source: Field Survey, 2024)

Discussion

The teacher and students utilized art design, Google Slides, Google Docs, GeoGebra, and AI to create the geometry project, gather information about intellectual property policies, and construct geometric figures consisting of triangles. Additionally, students interpreted these geometric figures in two paragraphs. The teacher instructed students to use tools in Google Slides to complete the geometric figures. The teacher's goal was to create a new and creative geometric project designed to challenge students in solving and proving examples of congruence and similarity in triangles. The aim was also to encourage students to deepen their learning.

Improvements and creativity are needed to make the learning process more engaging and help develop students' critical thinking skills (Suryawan, 2023). Students' creativity and deep learning are reflected in their work through rigid and non-rigid transformations of triangles. Their critical thinking is evident throughout the process, especially when solving and proving the congruence or similarity of triangles and interpreting geometric figures. By the end, they shaped images like professionals, giving their presentations a unique and polished look (Lanoue, 2024). Upon completing the geometric project, students wrote two paragraphs reflecting the meaning of their geometric abstract figure. The first paragraph involved students' interpretations without using AI, while the second utilized AI assistance.

The teacher conducted research on three AI platforms, several websites, and ResearchGate to determine whether the project was unique. He critically analyzed the information to decide whether to assign the project to his geometry classes. In fact, he applied critical thinking throughout his creative work on the project. Critical Thinking (CT) refers to the critical analysis and assessment of a problem to make an informed decision (Marzuki et al., 2021). The teacher decided to assign the project in two Google Slides, with students writing two paragraphs about the interpretation of the geometric figure on the second slide. The first paragraph involves writing about the second slide based on the students' observations of their work, without relying on AI information. Artist's AI transforms the way artists approach their work, acting as a creative assistant that supports and augments their artistic journey (AI Artist, 2024). The second paragraph focuses on students' interpretation of the geometric figures with the assistance of Gemini. AI significantly contributed to the teacher's creativity and critical thinking regarding the geometry project.

All AI responses to the teacher's questions were similar and had a significant impact on the creative geometry project. In general, AI plays multiple roles, particularly regarding the researcher's role as an incredible assistant. Gemini AI, as an executive function, displays art figures and interprets their meaning. Demis Hassabis, CEO and Co-Founder of Google DeepMind, states regarding Gemini (2023), "Its state-of-the-art capabilities will significantly enhance the way developers and enterprise customers build and scale with AI." The method of answering questions about Gemini emphasizes four factors that support the teacher's ideas. Gemini's response encouraged the teacher to work on this project by stating facts about transforming the figure with triangles, coloring shapes, and, finally, saying, "The piece of art is now yours, reflecting your personal style." This compelled the teacher to begin creating the geometry project.

The geometry teacher planned extensively and took several actions to create the project. He thought critically and creatively about both the project and its implementation. Generally, creative thinking is correlated with critical thinking and problem-solving (Birgili, 2015). Scriven (1976) stated, "Critical skills go hand in hand with creative ones" (p. 37). Only by understanding the relationship between these two essential constructs can educators enhance their students' ability to utilize both creative and critical thinking (Baker & Rudd, 2001). The geometry teacher understood this relationship clearly.

The first slide in Figure 1 presents an example, which serves as a sample among other examples on the first slide. The first slide allows only limited room for creativity; on the other hand, the examples require critical thinking to

solve the mathematical problem in multiple steps and to informally prove the congruence or similarity of triangles. In the process of proof, students must be able to extract important information from the theorem, especially the hypotheses and conclusions (Masfigatin & Maharan, 2019). Solving or proving the congruence of triangles (Figure 1) requires significant critical thinking. Students' critical thinking should be applied when analyzing or proving geometric relationships in the project based on reasoning. Reason is the ability to consciously make sense of things and apply logic (Mingla, 2020). As Mingla (2020) states in her work, *Proofs and Logical Reasoning in Mathematics Promote Critical Thinking*.

In the second slide, the teacher asked students to cover the drawing design with triangles using Google Slides tools. These tools allow students to rotate triangles in any direction (up to 360 degrees), translate them, and dilate them. However, Google Slides lacks a reflection tool. In this case, students must either create a new figure from scratch or use classic GeoGebra (which students used exclusively for reflection). Classic GeoGebra is easy to use. For example, regarding reflection, Kurt (2020) explains, "Select the object you want to reflect and then select the line of reflection." GeoGebra automates most of the work quickly, so students may not experience transformations as deeply as they would with Google Slides. Nevertheless, Google Slides stands out as a fundamental tool in the modern educational landscape, encouraging both students and teachers to explore beyond traditional learning methods (Khan, 2024). Therefore, the teacher asked the students to use Google Slides.

In the beginning, students struggled to place triangles in the desired positions to follow line designs and fill the empty spaces. Placing the triangles accurately requires both knowledge and skills. While knowledge provides a strong foundation of understanding, skills enable the practical application of that knowledge (Diem, 2023). The practical work of each student group taught them how to position the triangles in a specific way. They realized that by placing the hypotenuse along the longer side of the empty space in the drawing design, they could adjust the triangles to fit the desired positions. In this way, students created beautiful images.

The student's final product turned out to be very unique and creative, as mentioned by the student group in Table 4 for their geometric figure. We realized that everyone would see it, and we wanted to make it something unique—something no one would expect. The teacher was curious to test the level of originality in the student's geometric figure, so he placed the image into Google Images and Gemini chatbot. Neither platform could find the same image anywhere. Gemini preferred to check through the Google search engine. When the teacher searched the geometric figure on Google, it could not be found. Gemini explained that if Google's search engine cannot find an image, there are several reasons, one of which is that the image is heavily modified. If the image has been significantly altered (e.g., resized, cropped, or heavily filtered), it might be difficult for Google Images to recognize it. The teacher was then convinced that the students had modified the figure, making it unique with their creative work.

Students' statements when interpreting geometric figures used a relatively rich mathematical vocabulary. Regardless of the field, when given a real example, we need to observe, analyze, and identify parameters using the language of mathematics (Pllana, 2021). All groups, to the best of their knowledge, attempted to describe their interpretation using mathematical language to a large extent. In the first paragraph, students described the figures

without delving deeply into the analysis, so their interpretation was not as rich in vocabulary. Additionally, the teacher took pictures and placed them in the Gemini chatbot to describe the geometric figures. The teacher then provided students with Gemini's answers regarding the figures and asked them to use these AI-generated responses to write a second paragraph describing the figures. In the second paragraph, students offered a richer description, incorporating both mathematical and artistic vocabulary, and provided a clearer, more in-depth interpretation with the assistance of AI. The accuracy of AI in interpreting geometric figures is superior to that of students' interpretations. AI processes massive amounts of information, generates numerous simulations, and identifies patterns that would be impossible for humans to fully appreciate (Chatterjee, 2022). The supplementary AI description of the figure helped students offer a more in-depth interpretation and a clearer, longer explanation. The google form incorporates students' interpretations of 12 figures and it was distributed to teachers to select which students' paragraph describes geometric figures better. In the google form are included Picture of each students group with two paragraphs that participants can analyze and select their preferred answer There were two paragraphs, the paragraph of students with and without AI assistance for interpretation. Three questions in the google form asks participants to select one from three answers (Paragraph of student's interpretation without AI, Paragraph of student's interpretation with AI, and Both paragraphs that interprets figures are the same.

In the Google Form (Quantitative Research Method), 31 educators from different school districts participated. The total number of respondents who answered the 12 questions in Figure 2 was 215, with 31 respondents selecting Paragraph 2. Comparing the means (averages) of Paragraph 1, Paragraph 2, and Paragraph 1 and 2 in Table 15 through an ANOVA test shows that the F-statistic is greater than the critical F-value, therefore, the null hypothesis is rejected. This indicates that there is a significant difference between at least two of the means. Additionally, the p-value is less than 0.05, with $p = 6.5037\text{E-}08$ ($p = 6.5037 \times 10^{(-8)}$).

Comparing the mean values of Paragraph 1 and Paragraph 2 in Table 16 through an ANOVA test also shows that the F-statistic is greater than the critical F-value, leading to rejection of the null hypothesis. The p-value is again less than 0.05, with $p = 2.3199\text{E-}05$ ($p = 2.3199 \times 10^{(-5)}$). In Table 17, comparing the means of Paragraph 2 and Paragraph 1 and 2 through an ANOVA test shows that the F-statistic is less than the critical F-value, meaning the null hypothesis is **not** rejected. The p-value is greater than 0.05, with $p = 0.10648498$. Overall, the ANOVA test supports the idea that a student's paragraph with AI assistance enhances creativity and critical thinking. However, it is important to use AI wisely. The results in the students' paragraphs shown in Figure 14 (Geometric Figure 1) indicate that students' interpretation of figures is better without AI assistance. Conversely, other figures demonstrate the opposite trend.

The research case study sheds light on the power of AI to amplify creativity and critical thinking in high school education, provided it is used wisely and rationally. AI can provide vast amounts of information in a short period of time, but both teachers and students must be able to select and verify the information they need from multiple educational sources. AI is a sophisticated tool that requires considerable skill to use rationally, and when used effectively, it can offer significant benefits in fostering creativity, critical thinking, and expanding academic knowledge in general.

Conclusion

It is apparent that AI can serve as a copilot for education; however, it may also become a crutch. The idea presented in this paper focuses on testing AI as a copilot for teaching and learning. The geometry project is an excellent tool for measuring both students' and teachers' creativity and critical thinking by combining different ideas. Learners integrate various concepts, sometimes leading to conjectures or new and interesting findings (Pillana, 2019). By applying AI as both the teacher and the students in this geometry project, it becomes evident that AI can significantly enhance the quality of education. Not only can AI tools enhance creativity and productivity, but they can also provide educators with valuable insights into student learning and assist with time-consuming tasks (Dene Poeth, 2023). As a result of using AI wisely, it becomes a copilot that assists teachers and students in developing creativity and critical thinking skills.

The teacher's creativity in the project focused on using AI tools to generate a geometry project that reflects students' creativity and critical thinking. This was done through two Google Slides, which addressed a proof and geometric abstract art. Additionally, students were required to write two paragraphs in Google Docs: one paragraph describing the geometric figure without using AI, and the second describing the same figure with AI. The AI serves as a tool to assess both the teacher's and students' creativity by testing the figure in the Gemini and Magic School platforms. AI provides information about the new geometric figure modified by the students, helping to identify unique elements in the figure. It also informs students about the communication of geometric figures by combining different colors and components.

In Table 1, students describe the abstract geometric figure as symbolizing the harmony between technology and nature. The view presented is that technology should be seen as a tool, not the solution; humans will always be the solution to our problems, and nature will respond accordingly (TheBimMagazin, 2019). In Table 9, students explain how colors greatly influence the overall aesthetic and emotional impact of the Penrose Triangle. Each figure aims to maintain balance and symmetry, reflecting the beauty and harmony of creative elements.

AI expands students' thinking by helping them prove triangle congruence using various techniques. It provides new information, allowing students to observe geometric figures from different angles with critical thinking, view them from both natural and artificial perspectives, and maintain a balance between these perspectives. Above all, AI, by providing students and the teacher with data, information, and feedback during the geometry project, helps them gain confidence and engage in a deeper learning process, which leads to creativity and critical thinking.

Recommendations

The purpose of this paper is to explore the significance of AI in creating math projects that foster creativity, with a focus on enhancing students' creativity and critical thinking by using AI as a tool. This case study serves as an example of how teachers can design creative math projects tailored to students' needs, while aligning with their district's curriculum. In this research, the use of AI as a tool does not benefit all students equally. Some students,

particularly those who engage more relationally, are able to create unique pieces of art with geometric shapes, prove congruent triangles, and interpret geometric abstract art with rich vocabulary and detailed clarity. Nonetheless, the study is limited as it focuses solely on a high school geometry project. More case studies are needed to demonstrate the influence of AI, in combination with traditional education, on enhancing students' creativity and critical thinking.

Acknowledgment

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