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Approaching Artificial Intelligence in Designing Visual Aids for Teaching Mathematics at High Schools

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ABSTRACT

Today, artificial intelligence has been widely applied in many areas of society, especially in Education. AI tools, increasingly designed to be smarter, have been helpful for many teachers in their instructional tasks. This report presents some research findings on the application of AI tools in designing visual aids for teaching Mathematics at the high school level. Some ideas from the report may suggest trends in applying AI tools to the teaching process in education.

Keywords: Visual aids, Artificial Intelligence, Teaching Mathematics, High School.

1. Introduction

Artificial intelligence is now being widely applied and has become a crucial factor driving the development of various fields, ranging from socio-economic sectors to scientific research (Jiang et al., 2022). In particular, in the field of education, the rapid advancement of artificial intelligence has profoundly transformed traditional teaching and learning methods (Huang et al., 2021). The application of artificial intelligence in teaching has brought significant benefits for both educators and learners in accessing new knowledge (Gocen & Aydemir, 2020).

Kuvondikovna & Hakima (2024) highlighted that the integration of visual aids into classroom teaching is essential to stimulate learners' thinking and creativity. Particularly, when teaching conceptual knowledge, the application of visual aids such as images, videos, and graphics has facilitated rapid and effective knowledge acquisition by learners (Sarkar, 2022). The use of artificial intelligence in education

has been studied in subjects such as Chemistry (Baum et al., 2021), Physics (An et al., 2024), Biology (Mnguni et al., 2024), and Mathematics (Opesemowo & Adewuyi, 2024). Globally, numerous studies have explored the application of artificial intelligence in mathematics education, such as in the United Kingdom (He, 2024), South Africa (Engelbrecht & Borba, 2024), Southern Philippines (Melchor et al., 2023), the Kingdom of Saudi Arabia (Wardat et al., 2023), South Korea (Choi, 2022) and Canada (Richard et al., 2022).

This report proposes the use of certain artificial intelligence tools to design visual aids for teaching Mathematics at the high school level. Insights from the report could guide trends in the application of artificial intelligence in high school education in particular and education in general.

2. Literature Review

2.1. Artificial Intelligence (AI)

Artificial Intelligence (AI) is the capability of computers or robots to perform tasks driven by human intelligence, creativity, and insight (Copeland, 2023). Popenici et al. (2017) define Popenici et al. (2017) define AI as a computer system capable of performing human-like actions such as learning, information processing, data synthesis, self-error detection and correction. Aldosari (2020) suggests that AI is an advanced application of information systems aimed at understanding human intelligence and simulating it in programmed devices to accomplish tasks requiring significant thinking, reasoning, and cognition.

Artificial Intelligence in Education (AIEd) refers to the implementation of AI-supported educational tools and programs in classrooms with the aim of enhancing the educational experience (Hwang et al., 2020). Additionally, AIEd personalizes the learning experience by providing specific materials or learning pathways tailored to the diverse needs of individual learners (Christudas et al., 2018).

2.2. Visual Aids

Visual aids are powerful tools that can be utilized to support instructors in presenting complex and abstract information clearly and comprehensively, enhancing the effectiveness of classroom activities (Pateşan et al., 2018). According to Macwan (2015), visual aids are tools that vividly illustrate concepts, transforming abstract ideas into concrete and comprehensible forms, thereby sparking learners' curiosity and interest in exploration.

According to Hamdani (2011), visual aids are a combination of sound and images. The advent of visual aids has made the delivery of teaching content and materials from educators to learners more accessible, comprehensive, and efficient. Furthermore, visual aids consist of materials and devices that stimulate auditory and visual senses to support teaching, facilitating learning by engaging multiple sensory channels (Madhuri, 2013).

2.3. The process of designing visual aids using artificial intelligence tools

Step 1: Open your web browser and type “<https://chatgpt.com/g/g-ELGwi2scu-manim>” into the search bar (Figure 1), then press Enter (Figure 2).

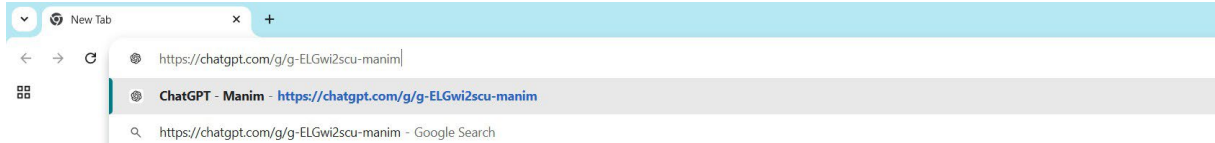


Figure 1. Search ChatGPT on the web browser

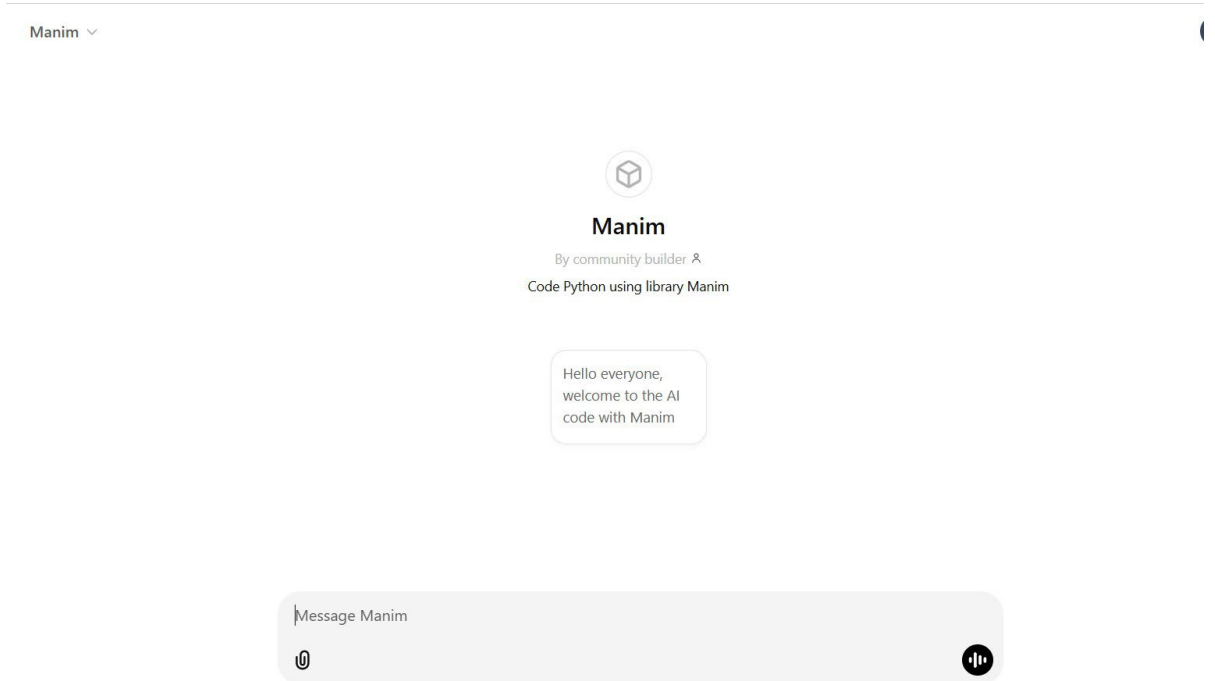


Figure 2. ChatGPT interface

Step 2: Enter your detailed requirements and descriptions into the ChatGPT editor to create visual content using the open-source Python library Manim.

Here, our team will use the command: “Code to create a unit circle (trigonometric circle) with the x -axis, y -axis, and special angle values using Manim.”. Then, ChatGPT will return the corresponding code (Table 1).

```

from manim import *
class UnitCircle(Scene):
    def construct(self):
        circle = Circle(radius=2, color=BLUE)
        circle.set_stroke(width=2)
        axes = Axes(
            x_range=[-3, 3, 1],
            y_range=[-3, 3, 1],
            axis_config={"include_tip": True},
        )
        x_label = axes.get_x_axis_label("x")
        y_label = axes.get_y_axis_label("y")
        angles = [0, PI/6, PI/4, PI/3, PI/2, 2*PI/3, 3*PI/4, 5*PI/6, PI, 7*PI/6, 5*PI/4, 4*PI/3, 3*PI/2,
5*PI/3, 7*PI/4, 11*PI/6]
        angle_labels = ["0°", "30°", "45°", "60°", "90°", "120°", "135°", "150°", "180°", "210°",
"225°", "240°", "270°", "300°", "315°", "330°"]
        points = VGroup()
        labels = VGroup()
        for angle, label in zip(angles, angle_labels):
            point = circle.point_at_angle(angle)
            dot = Dot(point, color=RED)
            text = MathTex(label).scale(0.5).next_to(dot, np.sign(point), buff=0.3)
            points.add(dot)
            labels.add(text)
        lines = VGroup()
        for angle in angles:
            end_point = circle.point_at_angle(angle)
            line = Line(ORIGIN, end_point, color=GREEN, stroke_width=1)
            lines.add(line)
        self.play(Create(axes), Write(x_label), Write(y_label))
        self.play(Create(circle))
        self.play(Create(lines), Create(points), Write(labels))
        self.wait()

```

Table 1. The code snippet returned by ChatGPT after executing the command

After entering the command for ChatGPT to execute, the next step is to open Visual Studio Code (with Manim pre-installed) to proceed with further operations (Figure 3).

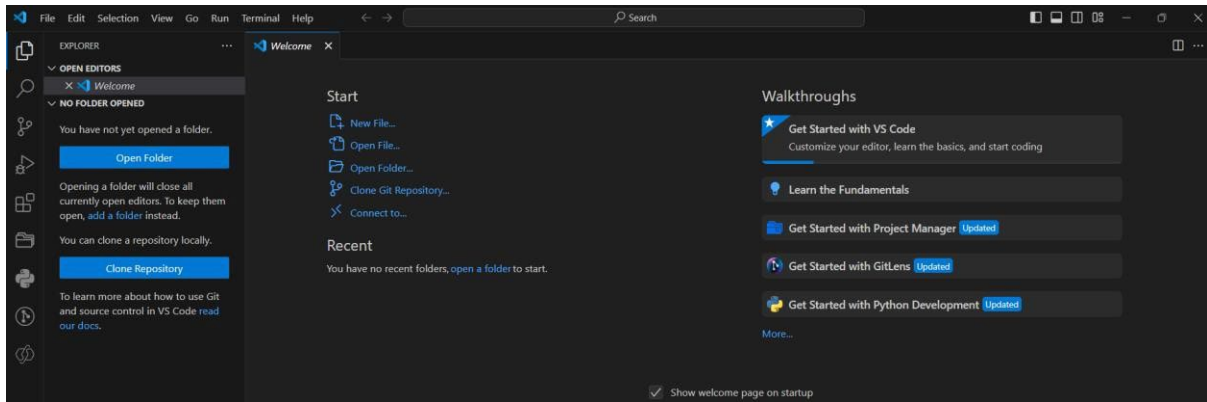


Figure 3. Illustration of the Visual Studio Code interface (with Manim pre-installed)

Next, create a new file in Visual Studio Code by selecting “File\New File” (Figure 4). Then, name the file (note: the file name should be the desired name followed by “.py”) (Figure 5). Next, choose the location where you want to save the file (Figure 6) and press Enter or click “Create File.” A new file will then be successfully created (Figure 7).

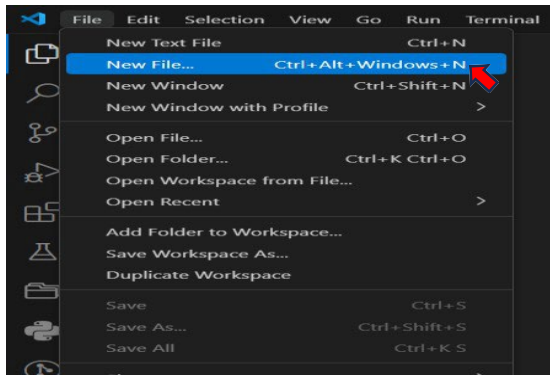


Figure 4. Illustration of how to create a new file in Visual Studio Code

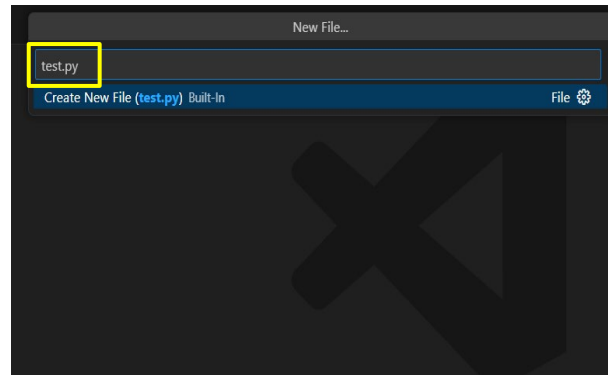


Figure 5. Illustration of how to name a file in Visual Studio Code

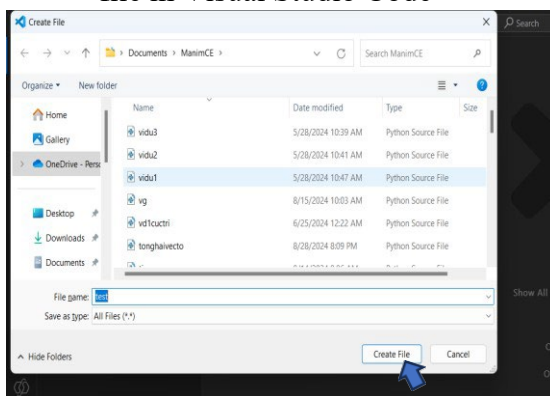


Figure 6. Illustration of the file save location in Visual Studio Code

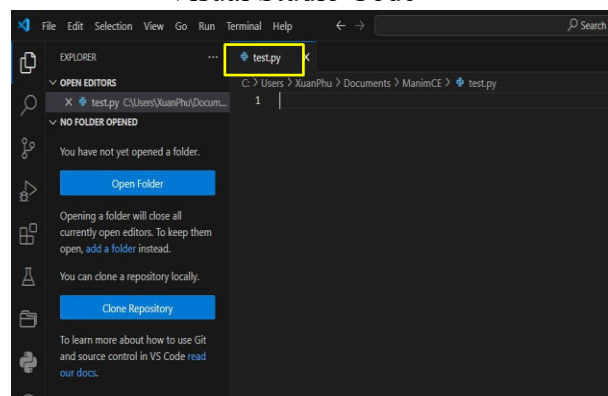


Figure 7. Illustration of a fully created file in Visual Studio Code

After creating a new file in Visual Studio Code, return to ChatGPT to copy the generated code by clicking on “Copy Code”. Once copied, the label will change to “Copied” (Figure 8). After copying, go back to Visual Studio Code and paste the code into the newly created file (Figure 9).



Figure 8. Illustration of successfully copying code on ChatGPT

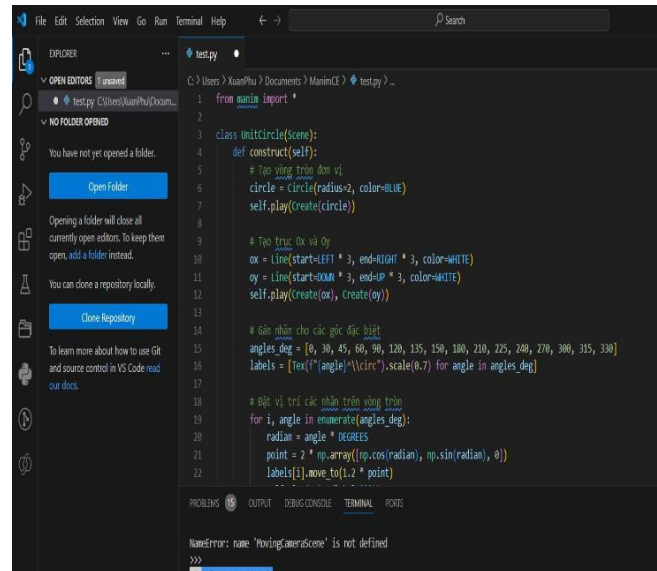


Figure 9. Illustration of code pasted into Visual Studio Code

```
from manim import * class
UnitCircle(Scene):
    def construct(self):
        circle = Circle(radius=2, color=BLUE)
        circle.set_stroke(width=2)
        axes = Axes(
            x_range=[-3, 3, 1],
            y_range=[-3, 3, 1], axis_config={"include_tip":
            True},
        )
        x_label = axes.get_x_axis_label("x")
        y_label = axes.get_y_axis_label("y")
        angles = [
            0, PI/6, PI/4, PI/3, PI/2, 2*PI/3, 3*PI/4, 5*PI/6,
            PI, 7*PI/6, 5*PI/4, 4*PI/3, 3*PI/2, 5*PI/3, 7*PI/4, 11*PI/6
        ]
        angle_labels = [
            "0°", "30°", "45°", "60°", "90°", "120°", "135°", "150°",
            "180°", "210°", "225°", "240°", "270°", "300°", "315°", "330°"
        ]
        points = VGroup() labels
        = VGroup()
        for angle, label in zip(angles, angle_labels): point =
        circle.point_at_angle(angle)
        dot = Dot(point, color=RED)
        text = MathTex(label).scale(0.5).next_to(dot, np.sign(point), buff=0.3) points.add(dot)
        labels.add(text)
```

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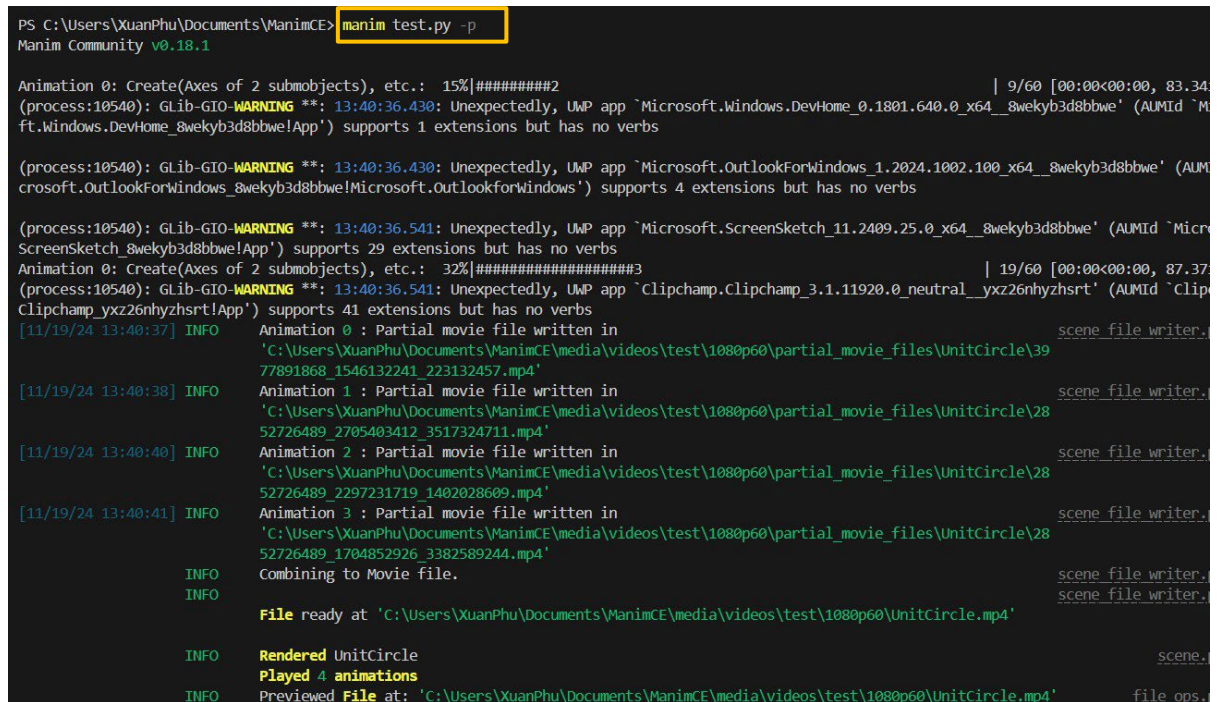
```

lines = VGroup()
for angle in angles:
    end_point = circle.point_at_angle(angle)
    line = Line(ORIGIN, end_point, color=GREEN, stroke_width=1)
    lines.add(line)
self.play(Create(axes), Write(x_label), Write(y_label))
self.play(Create(circle))
self.play(Create(lines), Create(points), Write(labels))
self.wait()

```

Table 2. The code generated by ChatGPT has been copied into Manim

Next, run the code in Visual Studio Code by pressing “F5” or “Ctrl + F5”. Then, enter the command **manim <filename>.py -p**, for example, **manim test.py -p**. If there are no errors, all commands will execute successfully (Figure 11). Finally, the output will be rendered as a video (Figure 11).



```

PS C:\Users\XuanPhu\Documents\ManimCE> manim test.py -p
Manim Community v0.18.1

Animation 0: Create(Axes of 2 submobjects), etc.: 15%|#####2 | 9/60 [00:00<00:00, 83.34
(process:10540): GLib-GIO-WARNING **: 13:40:36.430: Unexpectedly, UMP app `Microsoft.Windows.DevHome_0.1801.640.0_x64_8wekyb3d8bbwe' (AUMid `M
ft.Windows.DevHome_8wekyb3d8bbwe!App`) supports 1 extensions but has no verbs

(process:10540): GLib-GIO-WARNING **: 13:40:36.430: Unexpectedly, UMP app `Microsoft.OutlookForWindows_1.2024.1002.100_x64_8wekyb3d8bbwe' (AUM
crosoft.OutlookForWindows_8wekyb3d8bbwe!Microsoft.Outlookforwindows`) supports 4 extensions but has no verbs

(process:10540): GLib-GIO-WARNING **: 13:40:36.541: Unexpectedly, UMP app `Microsoft.ScreensSketch_11.2409.25.0_x64_8wekyb3d8bbwe' (AUMid `Micro
ScreensSketch_8wekyb3d8bbwe!App`) supports 29 extensions but has no verbs
Animation 0: Create(Axes of 2 submobjects), etc.: 32%|#####3 | 19/60 [00:00<00:00, 87.37
(process:10540): GLib-GIO-WARNING **: 13:40:36.541: Unexpectedly, UMP app `Clipchamp.Clipchamp_3.1.11920.0_neutral_yxz26nhyzhsrt' (AUMid `Clip
Clipchamp_yxz26nhyzhsrt!App`) supports 41 extensions but has no verbs
[11/19/24 13:40:37] INFO Animation 0 : Partial movie file written in scene file writer.
'C:\Users\XuanPhu\Documents\ManimCE\media\videos\test\1080p60\partial_movie_files\UnitCircle\39
77891868_1546132241_223132457.mp4'
[11/19/24 13:40:38] INFO Animation 1 : Partial movie file written in scene file writer.
'C:\Users\XuanPhu\Documents\ManimCE\media\videos\test\1080p60\partial_movie_files\UnitCircle\28
52726489_2705403412_3517324711.mp4'
[11/19/24 13:40:40] INFO Animation 2 : Partial movie file written in scene file writer.
'C:\Users\XuanPhu\Documents\ManimCE\media\videos\test\1080p60\partial_movie_files\UnitCircle\28
52726489_2297231719_1402028609.mp4'
[11/19/24 13:40:41] INFO Animation 3 : Partial movie file written in scene file writer.
'C:\Users\XuanPhu\Documents\ManimCE\media\videos\test\1080p60\partial_movie_files\UnitCircle\28
52726489_1704852926_3382589244.mp4'
INFO Combining to Movie file. scene file writer.
INFO scene file writer.
INFO File ready at 'C:\Users\XuanPhu\Documents\ManimCE\media\videos\test\1080p60\UnitCircle.mp4'
INFO Rendered UnitCircle scene.
INFO Played 4 animations
INFO Previewed File at: 'C:\Users\XuanPhu\Documents\ManimCE\media\videos\test\1080p60\UnitCircle.mp4' file ops.

```

Figure 10. Illustration of the command to run the code and the process of executing the code to generate a video

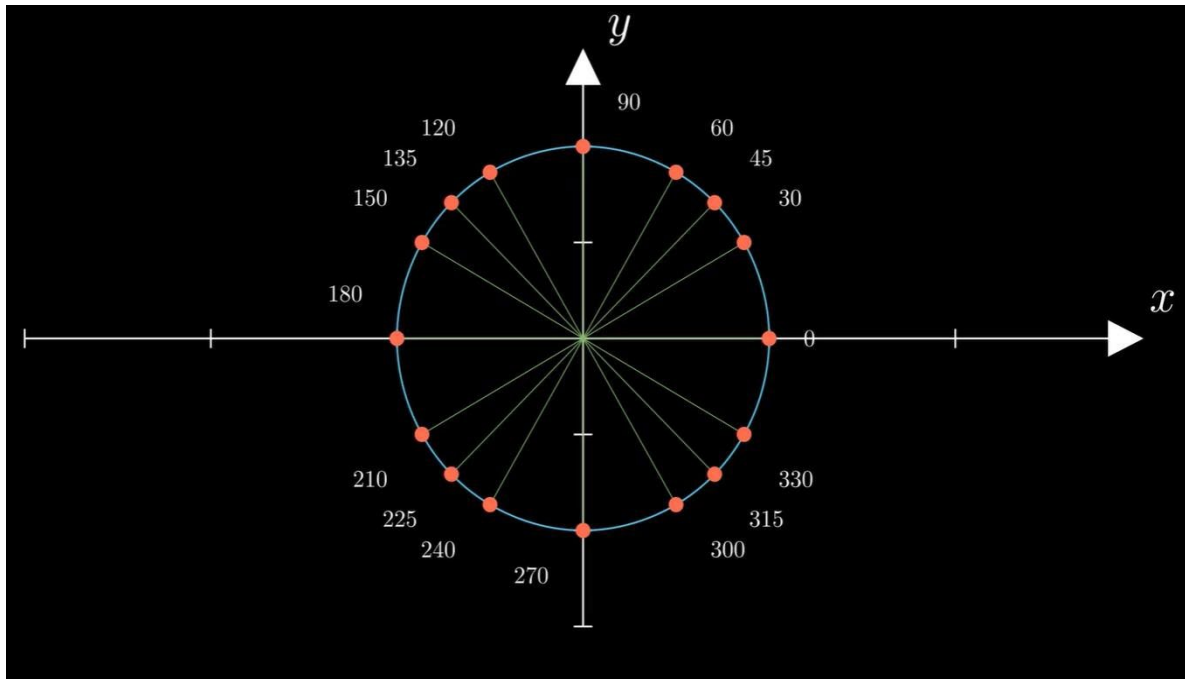


Figure 11. Illustration of the output produced by Manim (an open-source Python library)

Step 3: Adjust the visual content generated by AI tools. If the adjustments are satisfactory, save and use the output; if not, return to Step 2 for further modifications.

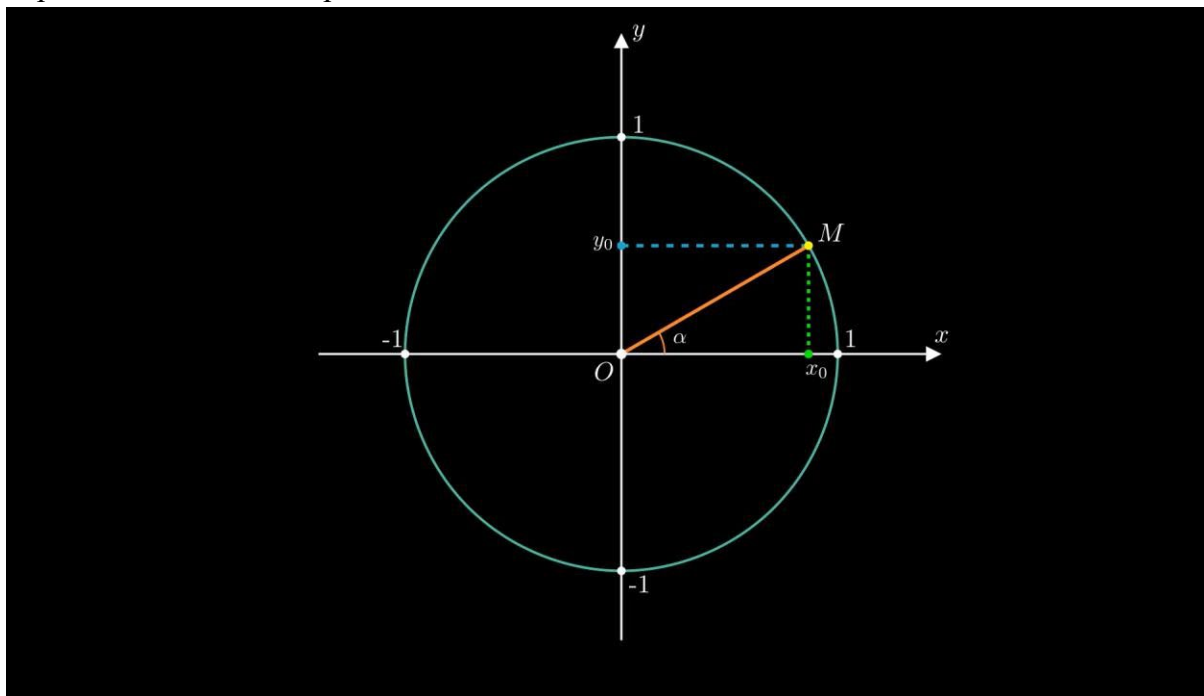


Figure 12. The product has been adjusted for suitability

2.4. Some visual aids designed through artificial intelligence

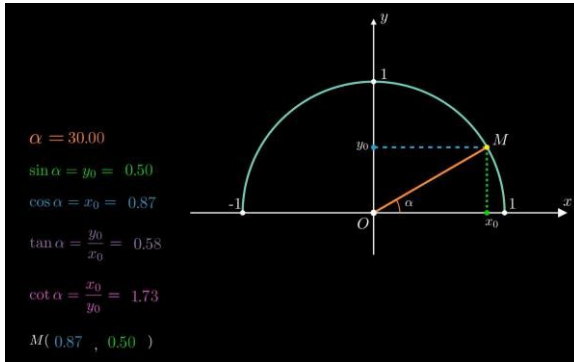


Figure 13. Description of trigonometric values from 0 degrees to 180 degrees using AI

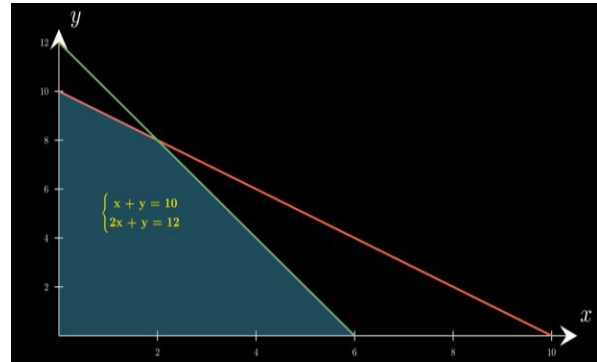


Figure 14. Description of the solution region of a system of linear inequalities in two variables using AI

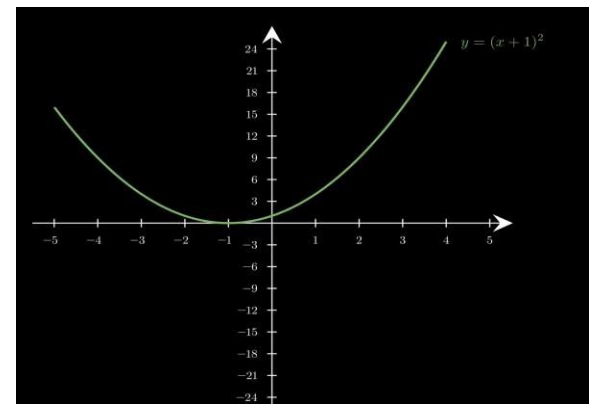
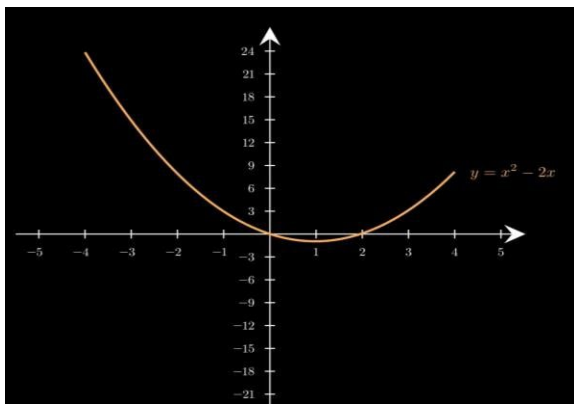
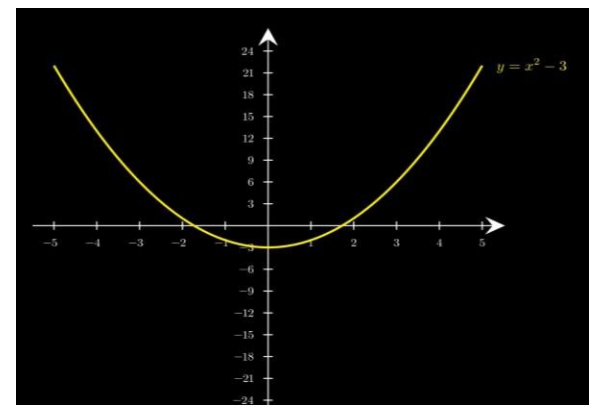
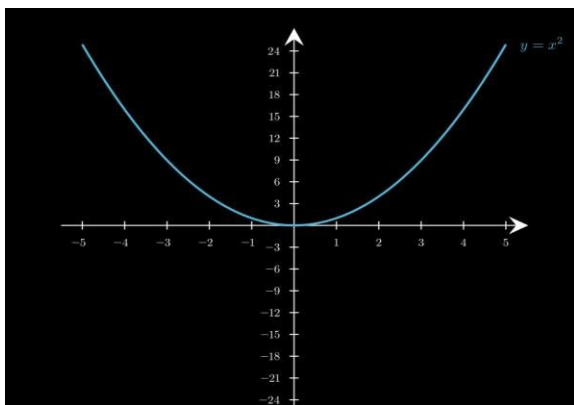


Figure 15. Description of some types of quadratic function graphs using AI

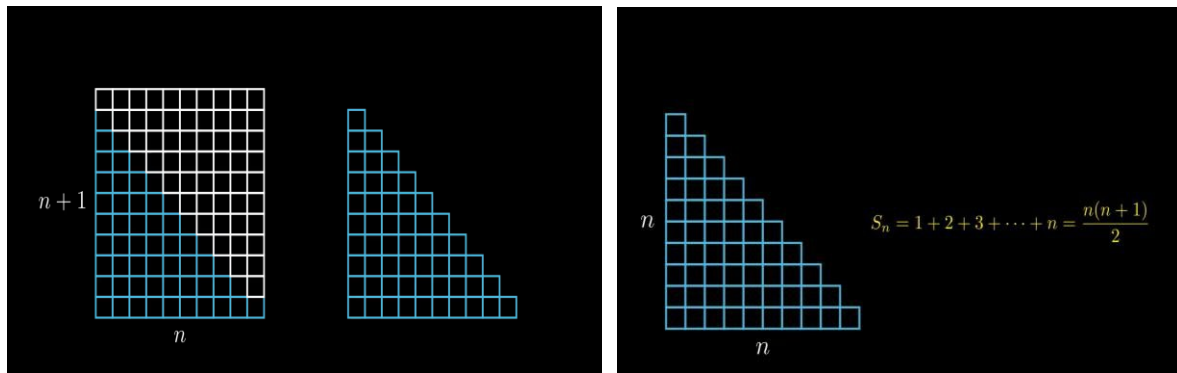


Figure 16. Description of the sum of n consecutive natural numbers using AI

3. Conclusion

The application of visual teaching aids is an instructional method that captures learners' attention, stimulates creativity and exploration, and facilitates the acquisition of new knowledge. This demonstrates the crucial role of visual aids in mathematics education in particular and the education system in general. However, it is essential to design detailed and clear visuals to maximize knowledge accessibility. Additionally, selecting appropriate audio elements is necessary to enhance learners' concentration. Most importantly, to ensure that the designed visual aids meet the desired educational objectives, they should be evaluated by instructors and reviewed through learner feedback after each lesson.

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The article highlights the outstanding advantages of AI in personalizing the learning process for each student, from creating tailored learning pathways to providing exercises and tests flexibly adjusted to individual progress. Additionally, AI plays a crucial role in automating various administrative and management tasks in schools, freeing up teachers' time to focus on guiding and supporting students. Clearly, AI is not merely a supporting tool but also a companion in the learning process, empowering students to take greater ownership of their knowledge exploration and skill development. In the near future, we can anticipate more innovative AI applications in education, such as intelligent student-support chatbots, highly personalized online learning platforms, and even educational robots capable of interacting with students.

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