Journal on Mathematics Education
Volume 15, No. 3, 2024, pp. 1027-1052

Investigating the use of ChatGPT to solve a GeoGebra based mathematics+computational thinking task in a geometry topic

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Received: 22 April 2024 | Revised: 13 July 2024 | Accepted: 5 August 2024 | Published Online: 25 September 2024

Abstract

ChatGPT is a chatbot with potential educational benefits, particularly in enhancing computational thinking (CT) proficiencies such as programming, debugging, and algorithmic thinking for students. Despite its promise, there is limited research on how ChatGPT can specifically support the integration of CT into mathematics education using tools like GeoGebra. The researchers implemented plugged-computational thinking in mathematics (Math+CT) lessons by means of the utilization of GeoGebra, an application that requires students to input commands in order to generate mathematical objects. The present investigation employed an educational design research (EDR) methodology in which the researchers incorporate ChatGPT into our Math+CT lessons to assist students in accomplishing the task. We purposely selected the participants who are mainly postgraduate students and collected data from the participants' conversation with ChatGPT and recorded their screens while interacting with ChatGPT and our Math+CT task. We analyzed the data through descriptive qualitative method on the participants' prompts, the final codes and the number of iterations. The researchers examined how ChatGPT could be utilized to assist the participants in writing GeoGebra commands in terms of its benefits and limitations. ChatGPT assisted most participants in completing the task successfully, with only a basic need for proficiency in GeoGebra commands, mathematics, and critical thinking. However, it revealed that participants did not yet utilize an affective prompt to ChatGPT. Furthermore, ChatGPT has the potential to be utilized for differentiated instruction due to the fact that its responses to individual users vary significantly based on the input prompts. Limited understanding of basic GeoGebra commands, and mathematical concepts could hinder the participants from training ChatGPT or prevent them from arguing with ChatGPT. This study enhances the existing literature by illustrating that ChatGPT can facilitate critical CT aspects, including programming and debugging, in a mathematics education context. This suggests that AI tools such as ChatGPT can contribute to the development of independent problem-solving skills, provide tailored support based on the needs of individual students, and enhance personalized learning experiences. Additional research involving students in school is required in order to gain a deeper understanding of the integration of ChatGPT into Math+CT lessons.

Keywords: ChatGPT, Computational Thinking, Educational Design Research, GeoGebra, Mathematics Education

How to Cite Yunianto, W., Lavicza, Z., Kastner-Hauler, O., & Houghton, T. (2024). Investigating the use of ChatGPT to solve a GeoGebra based mathematics+computational thinking task in a geometry topic. *Journal on Mathematics Education, 15*(3), 1027–1052. https://doi.org/10.22342/jme.v15i3.pp1027-1052

In the realm of education, Vygotsky's Zone of Proximal Development (1978) is a key framework for understanding how students learn. It emphasizes the role of social interaction and collaboration in facilitating learning. Learners can improve their performance more effectively by working under the supervision of an expert or communicating with a peer who has better performance, rather than working individually. With the advancement of technology, large language model (LLM) and artificial intelligence (AI) have emerged to assist students' learning process (Li et al., 2023; Plata et al., 2023). Chat Generative Pre-Trained Transformer (ChatGPT), an exemplify of LLM, might be considered an effective way of assisting students within the context of Vygotsky's Zone of Proximal Development, considering a growing public interest in ChatGPT since its introduction in 2022 by OpenAI (Sohail et al., 2023). In this study, our motivation is to examine ChatGPT as a personalized assistant to see whether it provides students with meaningful feedback and explains the content to improve their understanding.

There are several benefits of ChatGPT in education, such as improving students' performance in various domains, including examination accomplishments and creative writing (Baidoo-Anu & Owusu Ansah, 2023). On the other hand, some research (e.g., Cascella et al., 2023) has elaborated on the challenges of using ChatGPT in educational settings. Wardat et al. (2023) have investigated the potential and deficit of the utilisation of ChatGPT for teaching and learning mathematics but have not addressed the support of mathematical tools such as GeoGebra while learning mathematics with ChatGPT. Therefore, further research is necessary to explore the potential and limitations of integrating ChatGPT in education to facilitate effective teaching and learning mathematics with GeoGebra.

The benefits of generative artificial intelligence (AI) on engineering domains have been observed through its capacity to generate, document, and evaluate software programming codes (Plata et al., 2023). ChatGPT possesses the capability to generate programs or write codes in a variety of languages, including Python and Java. This capability is important in the development of computational thinking (CT) skills, as advocated by Wing (2006). Wing's work established CT components, including algorithmic design, programming, and debugging. According to Cotton et al. (2023), ChatGPT has been employed in computer science classes to facilitate the generation of computer programs. Furthermore, for students who utilised ChatGPT, supplementary evaluation methods, like oral presentations and interviews, have been incorporated to measure students' programming proficiency and mitigate instances of academic dishonesty. Nevertheless, the utilization of ChatGPT could encourage students to memorize the AI-generated programs or codes as a means of exam preparation, notwithstanding their limited proficiency in programming at their current state (Zdravkova et al., 2023). Although ChatGPT has drawbacks, it has demonstrated advantages by functioning as a virtual peer-to-peer, offering users immediate feedback and support (Dos Santos & Cury, 2023; Rudolph et al., 2023). According to Zawacki-Richter et al. (2019), the utilization of AI in education (AIEd) can be illustrated by the virtual peer-to-peer. In this project, the researchers employ this AIEd to facilitate student interaction with ChatGPT in order to accomplish our designed task.

The study conducted by Shabunina et al. (2023) examined the limitations, opportunities, and threats associated with the utilization of ChatGPT. It suggested that ChatGPT has the potential to aid students in acquiring proficiency in difficult tasks such as programming, public speaking, and academic writing. Furthermore, this tool also presents certain drawbacks, including reliance on technology, limited contextual understanding, plagiarism, deterioration of higher-order thinking abilities, disrupting academic honesty, and lowering the quality of teacher-student interactions (Baidoo-Anu & Owusu Ansah, 2023; Shabunina et al., 2023). Notwithstanding the controversy and risks surrounding the utilization of ChatGPT, it is imperative that the researchers maximize its capabilities and advantages. Shabunina et al. (2023) suggested employing suitable instructional techniques, human supervision, and a balanced approach to guarantee the efficient and responsible utilization of ChatGPT in education. In our scenario, users were allowed to engage in independent work using ChatGPT, while being prevented from copying the work of other participants.

Since its launch, ChatGPT has faced challenges from individuals to solve mathematical problems posted on the internet. ChatGPT poses deficiency in solving mathematical topics and might produce inaccurate results (Rane, 2023). However, Li et al. (2023) proved that ChatGPT could efficiently solve the Taiwanese mathematics examination covering various topics at the high school level with an accuracy rate of 90% (proficient). Moreover, limited research has been conducted on the application of artificial intelligence in mathematics classrooms. The AI tool Minerva has the capability to solve mathematical problems and can be useful for individuals who are not experts in mathematics (Castelvecchi, 2023). The study conducted by Ellis & Slade (2023) examined the application of ChatGPT in the field of data science and statistics. The researchers employed prompts to facilitate comprehension of certain statistical topics. It was found that ChatGPT has the potential to be utilized in the generation of statistical programming materials or as an educational tool for programming. Wardat et al. (2023) examined the application of ChatGPT in the mathematics classroom and found that it effectively enhanced learners' mathematical ability. Additionally, they discovered that ChatGPT can be used for teaching geometry. Nevertheless, the utilization of ChatGPT occasionally causes ineffective and inefficient solutions. Thus, it is essential to verify the outcomes (Wardat et al., 2023). The mathematical capabilities of ChatGPT were investigated by Frieder et al. (2023) revealing its ability to solve relatively simple problems, falling within the domain of undergraduate mathematics.

Based on the literature, ChatGPT can assist students in writing codes and solving mathematical problems. In relation to programs or generating codes, it connects to computational thinking (CT), which was initiated to let students explore programming while learning mathematics concepts (Papert, 1980). With the possibility of ChatGPT which could assist in writing programs, it may solve tasks and understand mathematical concepts. In our previous study, the researchers developed mathematics+CT lessons referring to the Shute et al. (2017) CT framework. Students were asked to input commands in GeoGebra for finding the area of a circle by approaching its area by the area of a regular polygon (Yunianto, Bautista, et al., 2023; Yunianto et al., 2024; Yunianto, Prodromou, et al., 2023). Learning CT and mathematics using GeoGebra can help students enhance CT aspects such as algorithmic thinking, programming, and debugging (van Borkulo et al., 2021; Yunianto, Bautista, et al., 2023; Yunianto, Prodromou, et al., 2023). However, those studies have not utilised ChatGPT, and this study attempts to innovate on the previous studies by utilising ChatGPT to enhance CT skills while learning mathematics.

In summary, ChatGPT shows both potential and limitations for using in the field of education, particularly in mathematics. Wollny et al. (2021) suggested exploring the potential of chatbots for assisting students. This study aims to investigate the potential of ChatGPT in assisting users to solve a Math+CT activity on GeoGebra. The findings might be crucial for further investigation into the application of ChatGPT in the context of mathematics education through GeoGebra. Four research questions have been addressed in this study: (1) How do participants communicate with ChatGPT during the Math+CT activity? (2) How does ChatGPT assist the participants? (3) What are the potential challenges encountered by participants when attempting to solve the Math+CT problems using ChatGPT? (4) What CT aspects are supported by interacting with ChatGPT while solving our Math+CT task?

METHODS

Methodology

This study is part of a broader study into incorporating computational thinking (CT) in the discipline of mathematics education. Our objective is to contribute to develop of Math+CT lessons that incorporate mathematics software, specifically GeoGebra and spreadsheets. This paper focuses on the facilities of using ChatGPT in solving a problem as a part of Math+CT lessons utilizing GeoGebra. To enhance our comprehension of the functionalities of our design, the researchers employed an educational design research (EDR) approach as described by McKenney and Reeves (2018). The iterative process of the EDR could enhance our design. EDR facilitates the generation of practical products and/or local theories (Figure 1). This paper presents the fourth cycle, which draws upon the works of Yunianto, Bautista, et al. (2023) and Yunianto, Prodromou, et al. (2023) for the first and second cycles, respectively, by utilising ChatGPT on one of our Math+CT tasks. Due to page constraint, interested readers may access our previous studies to understand more about the development of our Math+CT lessons. In the interim, the third cycle is currently being submitted to the publisher of a scholarly journal. After careful consideration of prior cycles and the input received from the conference concerning "How if students cheated using ChatGPT?", the researchers have now proceeded to explore the potential of incorporating ChatGPT, an emerging technology in generative artificial intelligence (AI), into our design endeavours. The researchers inquired about ChatGPT's capability to generate commands for constructing objects in GeoGebra. Consequently, the researchers infer that ChatGPT possesses the capacity to be utilized in our instructional activities. Further investigation was conducted to pilot the task, which involved the utilization of ChatGPT with a selected group of colleagues.

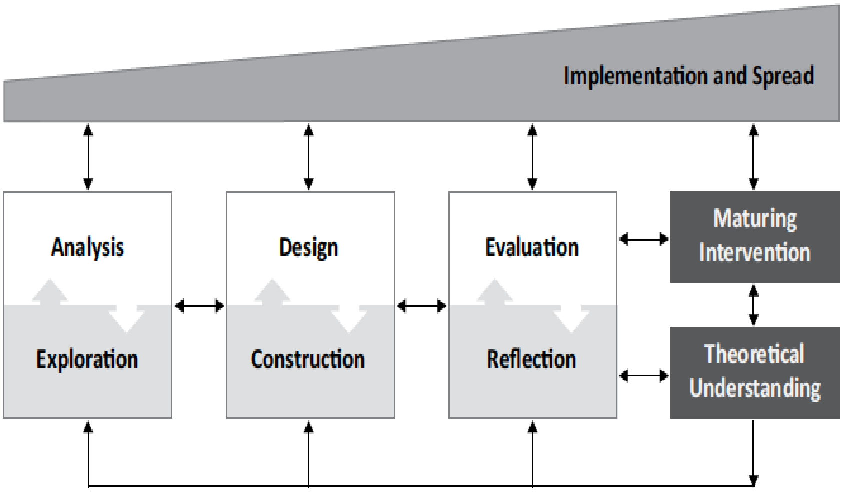

Figure 1. An educational design research approach (McKenney & Reeves, 2018, p.83)

Context

The researchers used one of our tasks from Math+CT lessons which the researchers have developed previously. The researchers refer to CT framework by Shute et al. (2017) consisting of six facets but this paper will explore on the two facets namely algorithms and debugging. The mathematics topic is related to the area of a circle and estimating pi. The researchers used the area of a regular polygon inscribed in a circle to approach its area. King (2013) called this as Archimedes's exhaustion method. Figure 2 shows the Math+CT task that our participants had to accomplish. They had to input codes (commands) into GeoGebra to construct the inscribed hexagon on a circle with a center at (0,0) and a radius of 4.

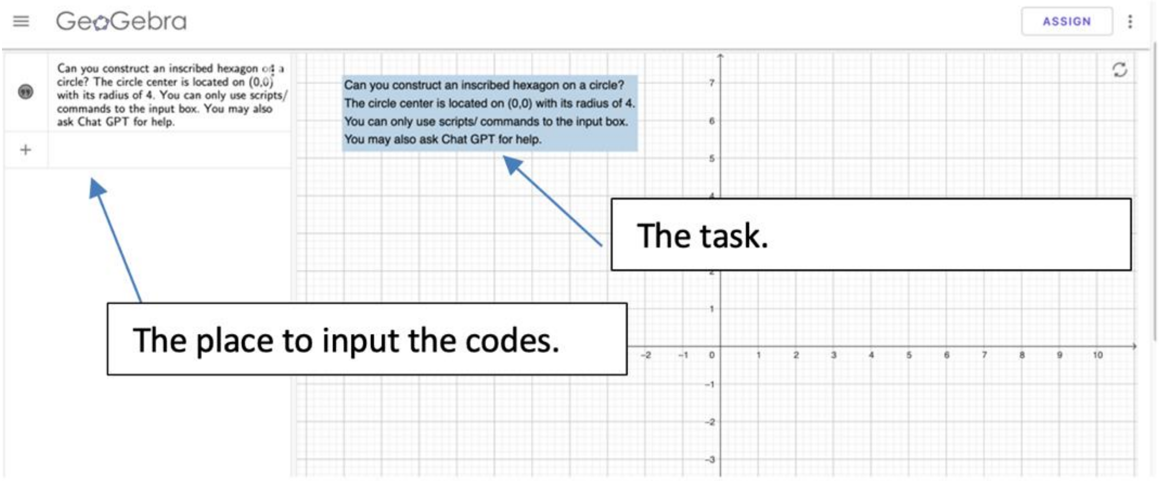

Figure 2. The Math+CT task for the participants

Participants and Data Collection

Our study aimed to investigate the success of human participants in utilizing ChatGPT for accomplishing integrated computational thinking and mathematics task, as well as the AI's capacity to provide successful GeoGebra commands or codes. We engaged five PhD students and visiting scholars studying STEAM education at a public university in Austria with diverse prior experiences to assess the implementation of ChatGPT-generated codes for constructing geometrical objects in GeoGebra. They have different experiences using GeoGebra and ChatGPT presented in Table 1.

Table 1. Participants' background

No	Gender	Occupation	Frequency of using ChatGPT	Frequency of using GeoGebra
P1	M	3D Artist	Seldom	Never
P2	F	Mathematics Teacher	Seldom	Often
P3	F	Mathematics Teacher	Always	Often
P4	F	Mathematics Teacher Trainer	Often	Seldom
P5	M	Mathematics Teacher Trainer	Often	Always

They were purposively contacted and selected to participate in this research. Purposive sampling is particularly suited for exploratory research, and it allows the researchers to aim the participants that might produce the most valuable data (Denscombe, 2010). Additionally, as we involved adult participants (older than 17-year-old), we have received their approval of their participations, and we ensured that no harms caused from their participations. In our publications, we would use pseudonym for their names and would not reveal their identities in accordance with privacy data protection. To provide more clarity, we implemented interventions by instructing participants to consistently follow task instructions and record their screen activities while interacting with ChatGPT. The investigation primarily examined the prompt usage, the final codes, the support of ChatGPT and the CT skill enhancement. Additionally, it assessed ChatGPT's capacity to generate accurate useful GeoGebra commands. By adopting a dual emphasis, we were able to methodically assess the participants' ability to effectively utilize ChatGPT and evaluate the AI's efficacy. This approach provided valuable insights into the dynamic relationship between human users and AI support.

The researchers sent the participants a link to a GeoGebra task (https://www.geogebra.org/m/r9uduymu) in one of our GeoGebra lessons and asked them to complete this task with the assistance of ChatGPT. The participants sent back their communication (prompts) with ChatGPT and video recordings of their processes. Five ChatGPT prompts, and three screen video recordings have been collected. The screen recording was not mandatory for the participants thus some participants recorded their screens and others did not, and this unstandardized procedure was to suit various comfort levels and technical ability. This procedural flexibility sought to reduce discomfort and technical difficulties while assuring inclusive participation. We recognized this variation and its potential influence, which we addressed through data triangulation (screen recordings, ChatGPT conversation, and examining the final codes), and uniform task instructions for all participants. We hope to maintain the validity and reliability of our findings by addressing this variation in a transparent manner. After completing the task, the researchers watched their screen videos and analysed the prompts they used. After completing the task, the researchers interviewed them to explore their thoughts on the usefulness of ChatGPT for solving it. Data would be available on this link (https://bit.ly/ChatGPTGeoGebra) if the readers are interested to read the participants' ChatGPT conversations and watch the screen videos.

Data Analysis

The researchers qualitatively analysed the prompts and the screen video recordings. We looked at the initial prompt entered into the chat how it generated the codes and compared them and this to address the first research question. Further, to answer the second research question, we presented the generated final codes and analysed how distinctive the codes from each other are. We could observe whether the codes and the sequences are different or not. If the codes and the sequence are different, we would code them 'yes'. Moreover, we would count how many iterations that the participants have been through to get their final codes from the ChatGPT conversation link they sent to us. To answer the third research question, the researchers watched the screen video recording to assess whether the final codes could construct the intended objects or not. We would triangulate the effectiveness of the final codes by inputting participants' final codes to GeoGebra and this is also to check the final codes of the participants who did not send their screen recording videos. If the final codes successfully work, we will code them 'yes' and the unsuccessful codes will be coded as 'no'. We also will identify which code that cause the unsuccessful construction by inputting the codes subsequently and observing its construction result. From this analysis, we will gain what challenges that the participants experienced to construct the intended objects in our Math+CT task. Lastly, to answer the fourth research question, we will watch the video screen recording and observe CT aspects by referring to CT framework by Shute et al. (2017). We could see how the participants inputted the codes into GeoGebra input box and how they refined the code by interacting with ChatGPT.

RESULTS AND DISCUSSION

In this part, the researchers would sequentially present how the prompt were inputted to GeoGebra, final codes generated by ChatGPT, the experiences of this ChatGPT in solving our GeoGebra-based Math+CT task and CT skills that have been supported by ChatGPT.

First Prompt

In order to answer the first research question, we investigated the participants' communication on their first prompt to ChatGPT as initial prompting plays important effect on how ChatGPT will be informed and be asked to perform a task. Therefore, in this part, we present the first prompt that the participants have inputted to ChatGPT whether their first prompts are effective or not by evaluating with an effective prompting suggested by Hardman (2023). Individuals exhibit varying approaches to initiating conversation, as observed in this case when the participants initiated the prompt to ChatGPT. Figure 3 represents the initial prompt provided by Participant 1 (P1).

Figure 3. Participant 1 first prompt

P1 initiated the conversation with ChatGPT by greeting it with 'Hi' and expressing his intention to utilize the GeoGebra. He did not provide any instructions regarding ChatGPT's expertise in utilizing GeoGebra commands. Subsequently, he requested ChatGPT to create a hexagonal shape on a circle using scripts (Figure 4).

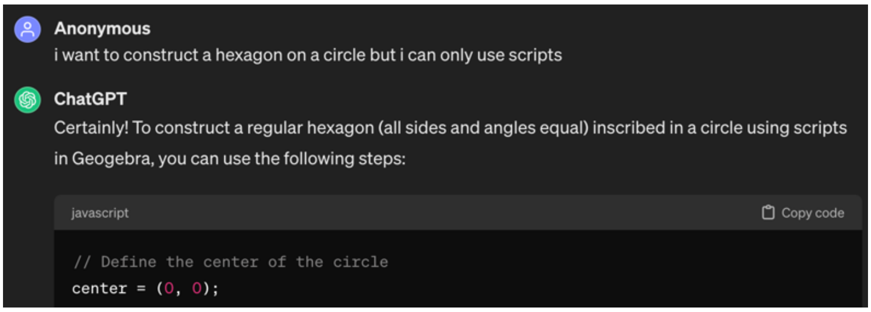

Figure 4. How ChatGPT responded to the use of script to construct the objects

Conversely, Participant 2 (P2) approached the task in a distinct manner. He directly requested assistance from ChatGPT (Figure 5) but did not explicitly instruct it to assume the role of a GeoGebra expert. The ChatGPT promptly answered and provided codes for this problem. The codes in P1 and P2 exhibit variances. In P1, the initial value was 'center=(0,0)', but in P2, it was 'C=Circle[(0,0),r]'. Based on the codes created by P1 and P2, it seems that ChatGPT would produce different responses depending on the instructions.

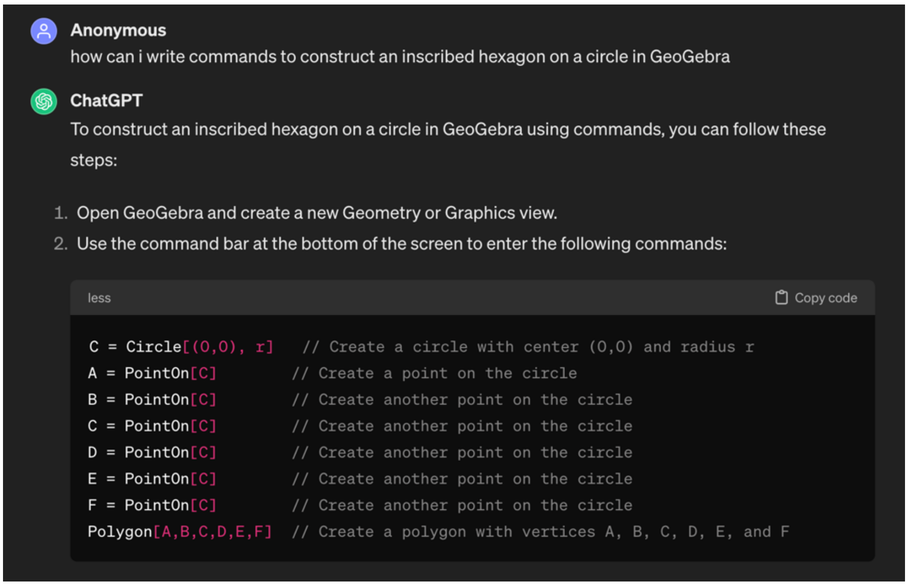

Figure 5. Participant 2 first prompt

In order to verify the validity of this assumption, the researchers proceeded with the remaining initial prompts and generated codes. Participants 3 (P3) utilized ChatGPT Pro, a subscription-based platform, to request commands on how to generate a circle with a center located at a coordinate (0,0) and a radius of 4. Figure 6 illustrates that ChatGPT presented different codes for constructing a circle, namely 'Circle[(0,0),4]', which bear a resemblance to the codes of P2's 'C=Circle[(0,0,r]', with the substitution of "r" with a numerical value.

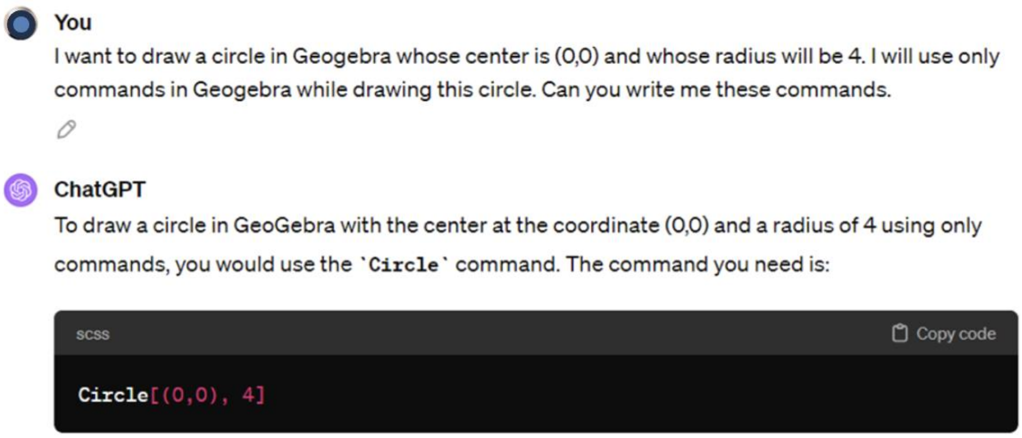

Figure 6. Participant 3 first prompt

In contrast, Participant 4 (P4) has a mathematics education background similar to that of Participant 2 (P2) and basic knowledge of using GeoGebra. P4 directly requested ChatGPT to assist her in constructing the objects without explicitly asking it to be a GeoGebra expert. Figure 7 illustrates that the codes produced by ChatGPT differ from those of P1, P2, and P3. The variable 'var radius=4' and other variables are present in P4's codes.

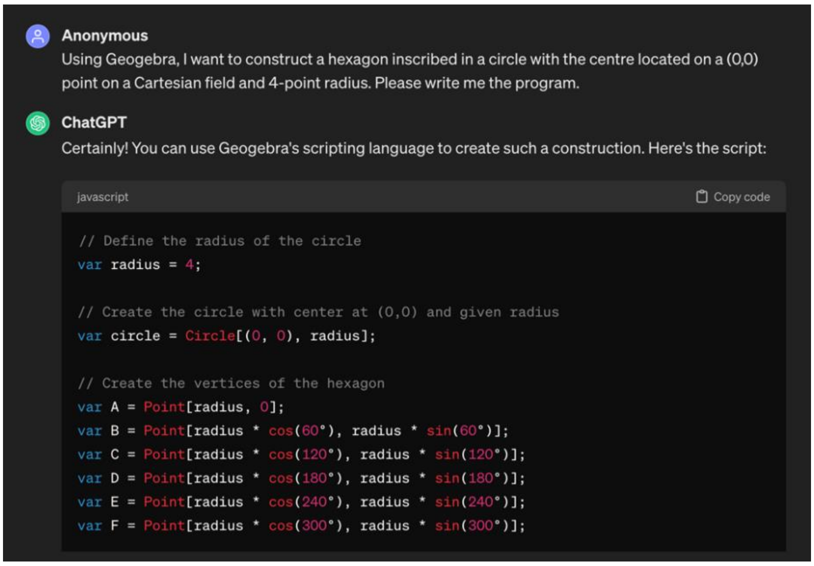

Figure 7. Participant 4 first prompt

Participant 5 (P5) has significant experience as a mathematics teacher trainer and demonstrates expertise in GeoGebra. He may have prior knowledge of constructing the requested objects using GeoGebra. The researchers encouraged him to pretend to lack knowledge about the construction of the hexagon inside a circle instead of seeking assistance from ChatGPT. Figure 8 displays the initial prompt that he entered into ChatGPT.

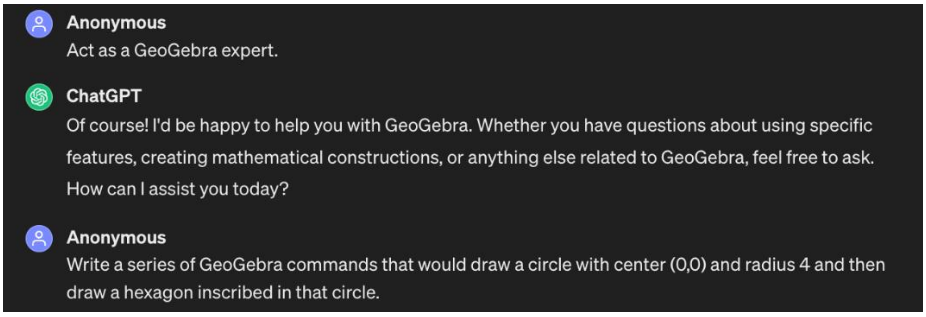

Figure 8. Participant 5 first prompt

Interestingly, P5 instructed the ChatGPT to possess expertise in GeoGebra and requested that it provides him with a sequence of GeoGebra commands for constructing the desired objects. The commands differ from prior participants due to the specified point A as A=(0,0). In the subsequent section, the researchers look deeper into the functioning of codes generated by ChatGPT.

All five participants have different ways of initiating communication with ChatGPT, and the responses were varied. It connects to the benefit of ChatGPT to acts as a virtual peer-to-peer in providing users with instant feedback and assistance as shown by Dos Santos and Cury (2023). The users' abilities and styles to communicate to ChatGPT might influence how ChatGPT respond to them. This different assistantship and or responses by ChatGPT connects to meeting what students aim for or their intention. To some extent, ChatGPT could be a mean of providing differentiated instruction as it is used for personalized learning (Dos Santos & Cury, 2023). The idea of differentiated instruction pioneered by Tomlinson (1999) aims to adjust teaching and learning to providing opportunities for students to make sense of their ideas in the classroom. There are five dimensions in doing differentiated instruction namely content, instructional strategies, the classroom, products, and teacher (Reis & Renzulli, 2018). A teacher can differentiate instructional strategies, the learning environment, products, content, or themselves (Reis & Renzulli, 2018) to meet the individual needs and preferences of students and support their mathematical understanding during teaching and learning practices. Initiating a prompt to ChatGPT could vary among users, even though they are working on the same task. It facilitates differentiated instruction (Li et al., 2023) in education. This variation could be due to differences in instructional strategies and approaches to accomplishing the task. Integrating ChatGPT in education could provide personalised feedback and interactive learning experiences, assisting learners' understanding and creating an opportunity to develop a personalised/ individualised learning path for each learner.

In the context of utilizing ChatGPT, to obtain useful feedback in ChatGPT, users must provide an efficient prompt that includes the following elements by Hardman (2023) who introduced a comprehensive list of seven essential elements for crafting prompts for ChatGPT. These elements include (1) a well-defined role for the AI, (2) the demographics and Zone of Proximal Development (ZPD) of the learners, (3) domain expertise, (4) a title and topic, (5) an example, (6) a clearly articulated task, and (7) a clearly defined output. None of the participants have all seven functional keys to prompt ChatGPT in our study (see in Figure 3, Figure 5, Figure 6, Figure 7, and Figure 8). Only P5 expressed the need for ChatGPT to become an expert in GeoGebra, as indicated in Figure 8. Consequently, our participants had not yet employed a method to provide prompts for ChatGPT, resulting in suboptimal results that could potentially cause confusion or errors.

Different Generated Codes

To answer the second research question regarding how ChatGPT assists the participants, we analysed the generated codes to see how ChatGPT provided codes whether directly produce successful codes or not and whether or not codes differ from each participant. The prompts and communication methods used with ChatGPT have an impact on both the responses and the generated codes. Figure 9 displays the final codes of P1.

```
// Define the center of the circle
center = (2, 3);

// Define the radius of the circle
radius = 5;

// Create the circle
circle = Circle(center, radius);

// Create points on the circle to form the hexagon
pointA = (center[1] + radius * cos(0), center[2] + radius * sin(0));
pointB = (center[1] + radius * cos(60), center[2] + radius * sin(60));
pointC = (center[1] + radius * cos(120), center[2] + radius * sin(120));
pointD = (center[1] + radius * cos(180), center[2] + radius * sin(180));
pointE = (center[1] + radius * cos(240), center[2] + radius * sin(240));
pointF = (center[1] + radius * cos(300), center[2] + radius * sin(300));

// Create lines to form the hexagon
lineAB = Line(pointA, pointB);
lineBC = Line(pointB, pointC);
lineCD = Line(pointC, pointD);
lineDE = Line(pointD, pointE);
lineEF = Line(pointE, pointF);
lineFA = Line(pointF, pointA);

// Display the circle, points, and lines
Show(circle);
Show(lineAB);
Show(lineBC);
Show(lineCD);
Show(lineDE);
Show(lineEF);
Show(lineFA);
```

Figure 9. Participant 1 final codes

In contrast, P2 generated distinct final codes. Figure 10 illustrates the sequential generation of codes to construct different components of the requested objects.

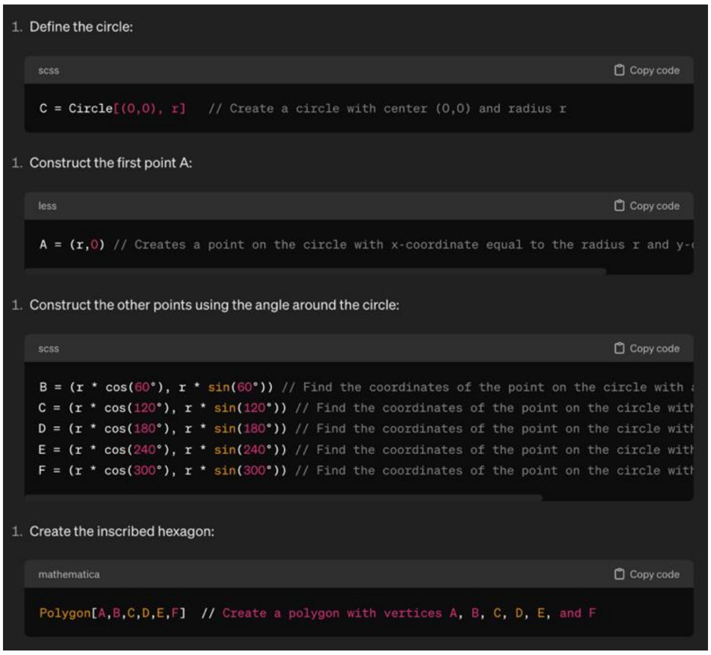

Figure 10. Participant 2 final codes

Given the constraints of limited pages, the researchers have provided a summary of whether the final codes differ from those of all five participants. Table 2 displays the data pertaining to the final codes assigned to the participants, as well as the number of iterations they underwent in order to obtain their final codes. The number of iterations showcased the codes have been through some processes to achieve codes that could work to construct the intended objects.

Table 2. Final codes from five participants

No	Different final codes	How many iterations
P1	Yes	18
P2	Yes	5
P3	Yes	2
P4	Yes	4
P5	Yes	5

Even though they received different final codes, it does not mean that all the codes could successfully construct the requested objects when inputted on GeoGebra. ChatGPT could generate GeoGebra commands but some of them are different from its standard commands such as the use of square brackets instead of round brackets. Therefore, the users should check and adjust the codes in order to use the commands successfully. Moreover, if some of them work, this reflects that the solution to construct the requested objects is not trivial. This connects to the open-ended questions as described by Silver (1995) that it allows different methods of solutions. The task that the researchers designed could be solved with different codes as long as they could successfully construct the objects (Yunianto, Prodromou, et al., 2023). Therefore, ChatGPT could support the users to generate codes with different number of iterations due to unsuccessful first codes to construct the intended objects and need to undergo revisions until result in final codes. ChatGPT could generate different final codes depending on how the users interacted with it and the different final codes might work to construct the intended objects. Additionally, the differentiated instruction by Tomlinson (1999) permits students to approach the task with their methods. However, the researchers should note that the different methods should belong to acceptable correct answers. The researchers will investigate further this on the next part whether the generated codes by ChatGPT worked or not.

The Effectiveness of Final Codes and Perception on ChatGPT

To address the third research question related to the potential challenges encountered by participants when attempting to solve the Math+CT problems using ChatGPT, we investigated the participants' final codes whether they worked successfully or not and what caused the codes did not work. Additionally, we analysed the usefulness of ChatGPT after experiencing successful and unsuccessful construction with their final codes. The prompts and communication methods used with ChatGPT have an impact on both the responses and the generated codes. Figure 8 displays the final codes of P1. By inputting these codes into GeoGebra (Figure 11), the researchers shall demonstrate the process.

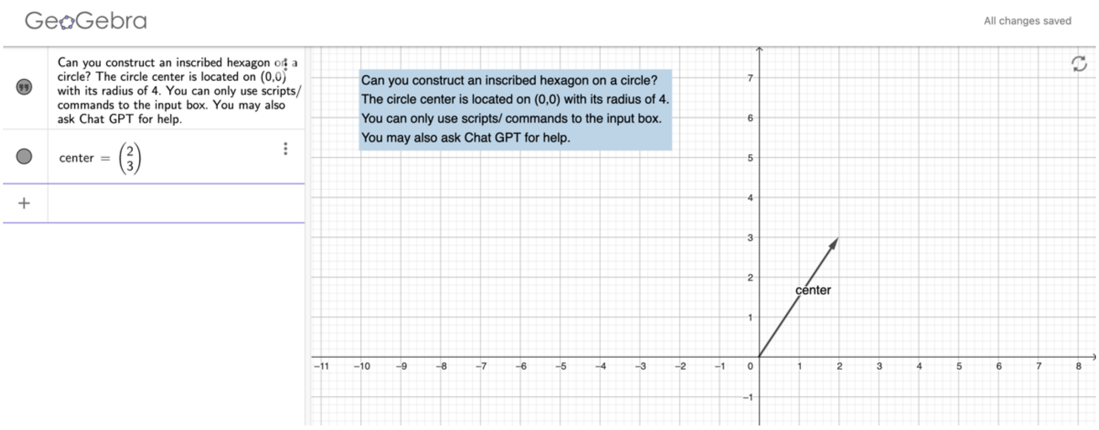

Figure 11. Participant 1 first code from final codes inputted on GeoGebra

The researchers tried to input the P1's final codes. The initial command "center=(2,3)" was typed into GeoGebra, resulting in the generation of a vector rather than the desired center point of a circle. However, when the researchers typed the command "Center=(2,3)" with a capital C, it succeeded in creating a center at the location (2,3), as seen in Figure 12.

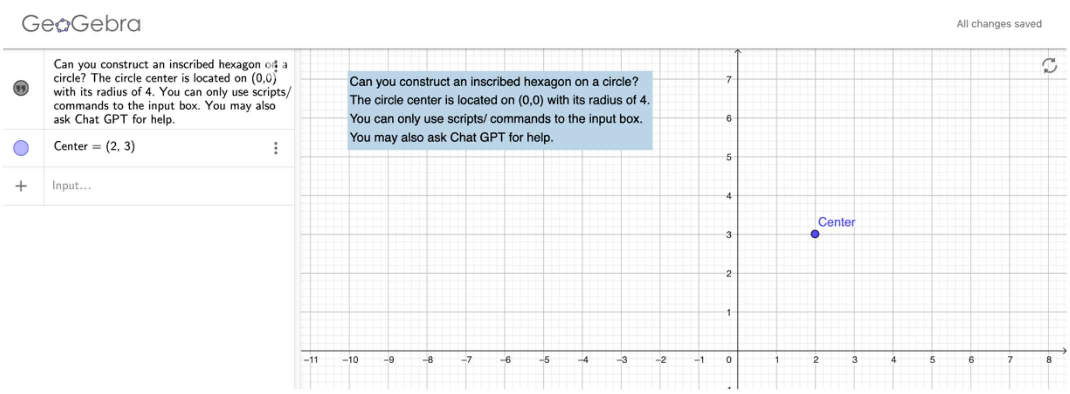

Figure 12. Replacing small c to capital C on the code

During the initial phase of the interaction, there was an instance where P1 omitted several commands or codes and proceeded directly to the "circle=Circle(point,number of radius)" code, which closely resembled the code from ChatGPT "circle=Circle(center,radius)" by substituting its respective variables (Figure 13). Based on the video recording of the P1 screen, it is evident that the omission of some codes does not hinder the production of the circle. For this case, to create a circle, users can create a point first as the center of the circle, O=(0,0) and later use this point in the circle command as Circle(O,radius). Therefore, omitting the point O will work to circle command as it can be Circle(point, number of radius) like Circle((0,0),5) to create a circle with (0,0) as its center and 5 as its radius.

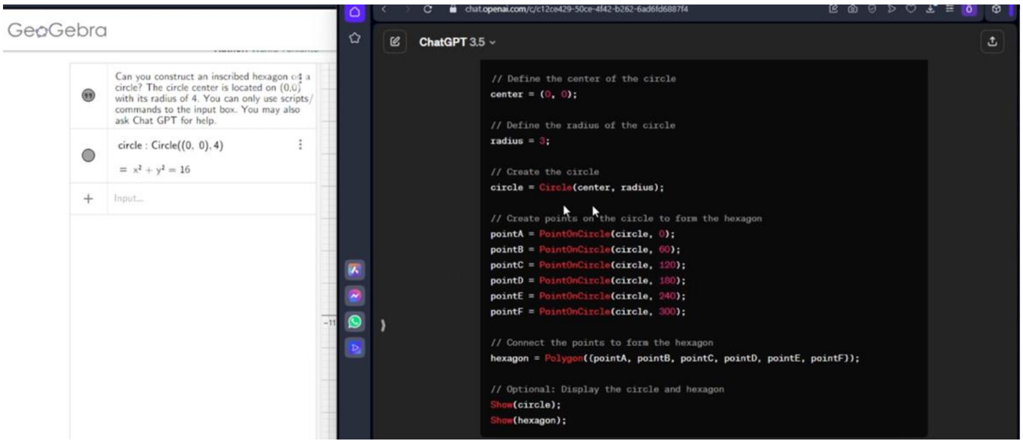

Figure 13. Participant 1 skipped the first-two codes

Interestingly, P1 did not directly execute the subsequent code from ChatGPT when inputting the command "Point". GeoGebra offers recommended instructions for creating points, but the "PointonCircle" command is inaccessible. Hence, P1 posed a crucial inquiry to ChatGPT over the existence of the 'pointoncircle' (Figure 14). Nevertheless, ChatGPT presented the same codes, and P1 entered the code, but it was still unsuccessful. P1 raised a concern regarding ChatGPT, stating that the code 'pointA=PointOnCircle(circle,0)' does not exist.

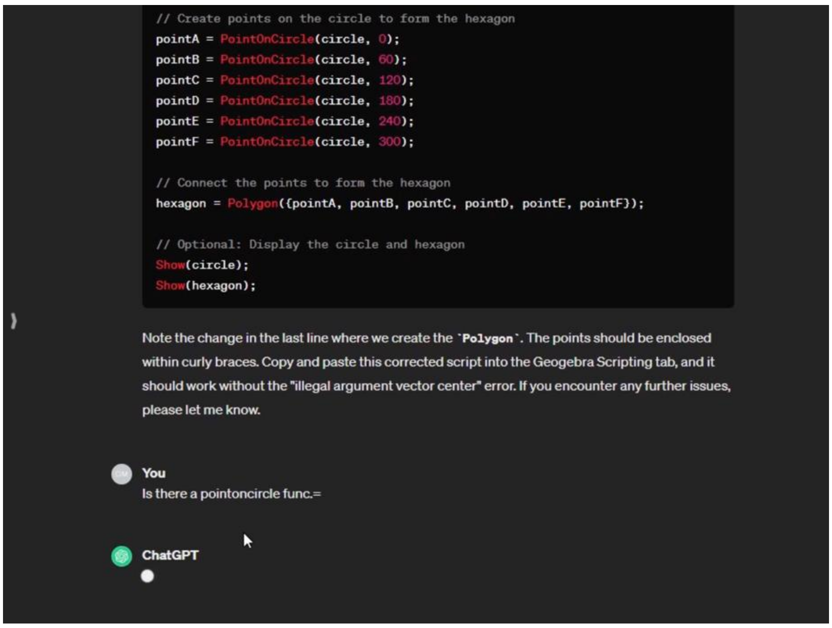

Figure 14. Participant 1 discussed with ChatGPT on the point commands

After several iterations, ChatGPT generated codes, but they were unsuccessful. P1 then informed GPT that she was stuck at the polygon function because GeoGebra failed to identify all the point codes she entered. This resulted in the generation of vectors instead of points (Figure 15). Therefore, the Polygon command cannot be applied as it relies on points. Due to a lack of awareness regarding the distinction between vectors and points, P1 was unable to engage in argumentation or train ChatGPT using this knowledge. Despite undergoing another iteration, the codes remained inoperable.

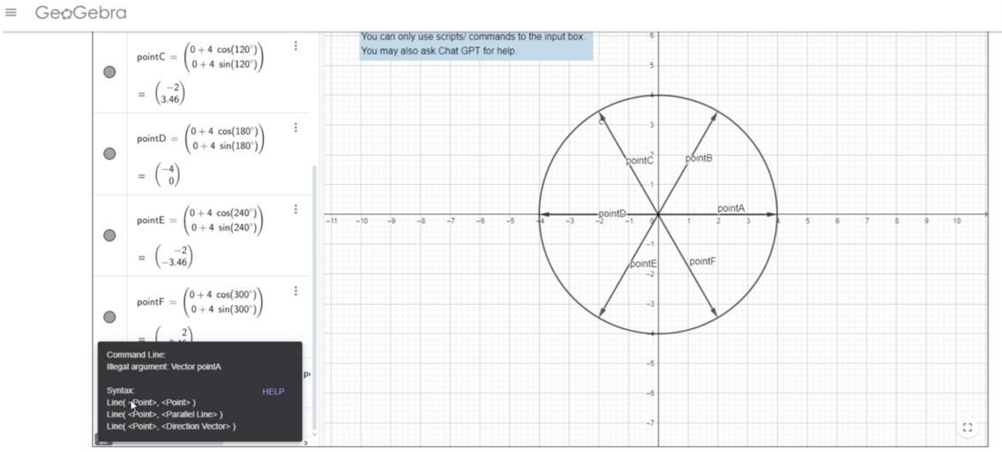

Figure 15. Participant 1 struggled with his last code

In this study, the researchers present other codes derived from P2 (Figure 16) and elucidate their functionality through the P2's screen video recording. The first three codes were successful; however, the fourth code was failed due to the variable name being identical to the first code. Hence, the transformation "C=Circle[(0,0, r]" was substituted with the expression "C=(r *cos(120°), r *sin(120°))". As a result, the circle C failed to exist when it was transformed into a point.

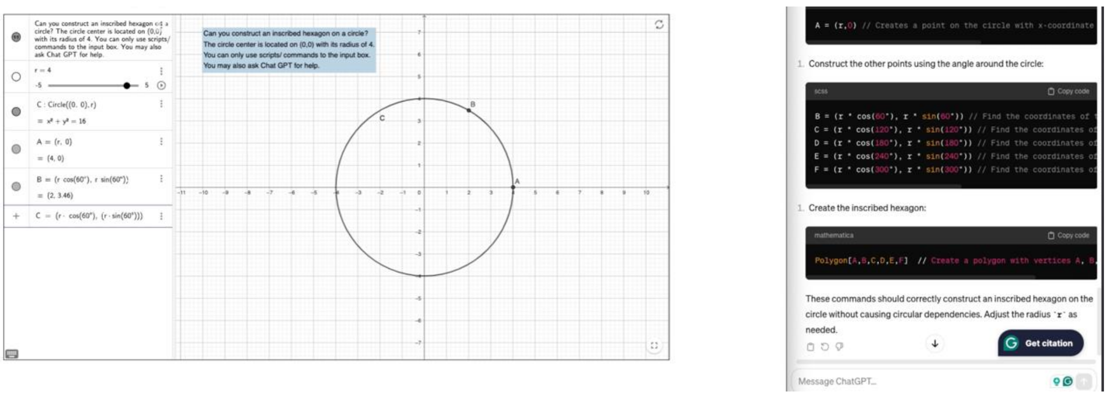

Figure 16. Two objects with the same name C

If the researchers continue to follow the codes, the resulting objects will solely consist of a hexagon, as depicted in Figure 17. If the C variable is not used twice, these scripts will function properly. She informed to ChatGPT that her circle had disappeared on GeoGebra.

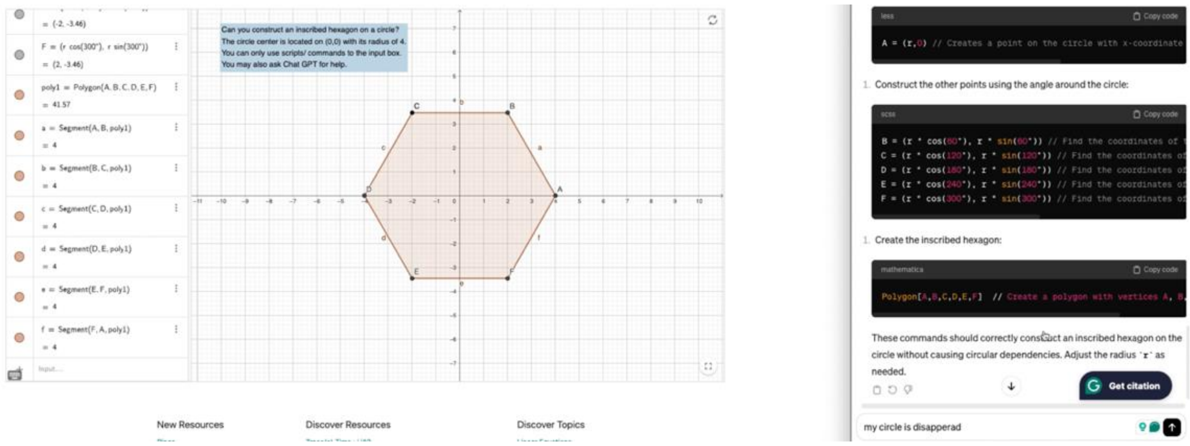

Figure 17. Disappearing circle due to the same name variable

The functionality of the codes can be ensured by employing an alternative variable name for the circle. By adjusting the value of r using the slider to 4, the requested objects can be constructed. The successful construction of the objects in P2's final coding might have been achieved by renaming the double variables, as depicted in Figure 18.

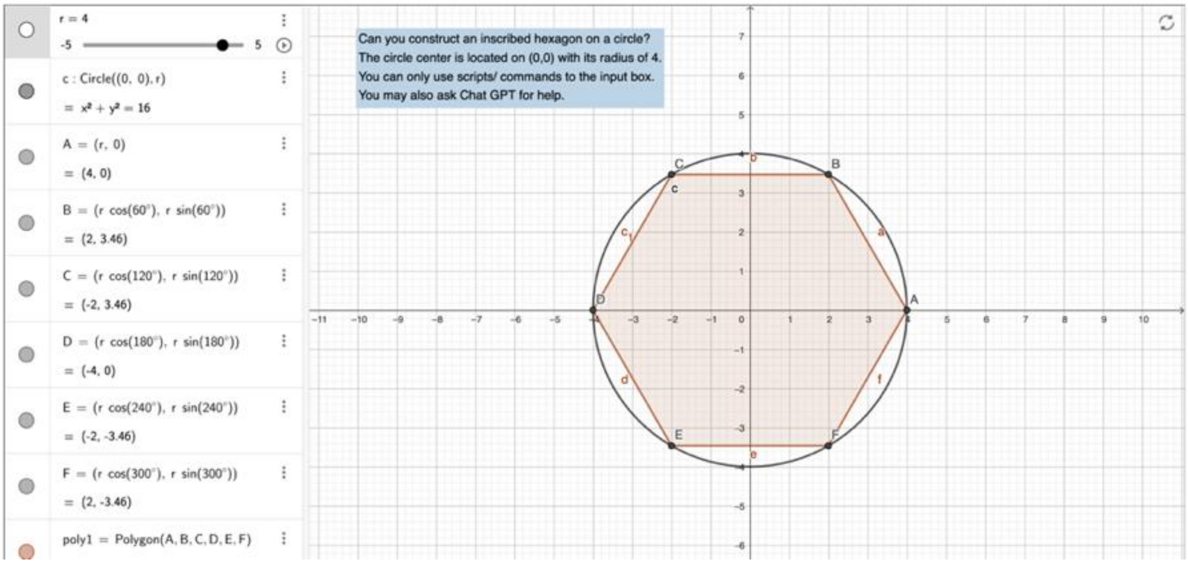

Figure 18. Participant 2 results without two same variables

In fact, P4 final codes did not work to construct the requested objects (Figure 19). According to Figure 19, an error occurs when the third instruction "A=Point(radius,0)" is entered. The command "Point" is utilized to generate a point on an object, a point with a vector, or a list of points. GeoGebra users have the option to input "A=(radius,0)" instead of "A=Point(radius,0)" in order to construct a single point. Hence, the utilization of "Point" is identified as the underlying cause of error in P4's codes.

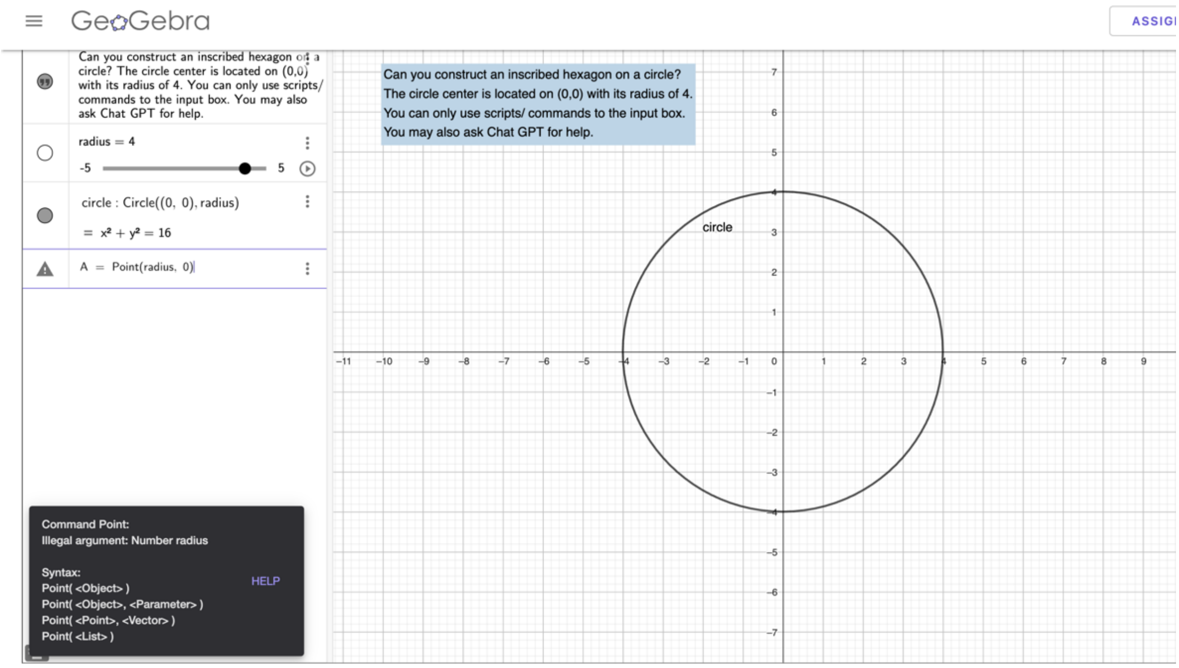

Figure 19. Participant 4 first prompt

Interestingly, P4 sent the result of her inputs to GeoGebra, which resulted in a successful construct. In her input, it appears that she omitted the "Point" part from the "A=Point(Radius,0)" command, instead using "A=(radius,0)". The construction of the successful construction of P4 is depicted in Figure 20.

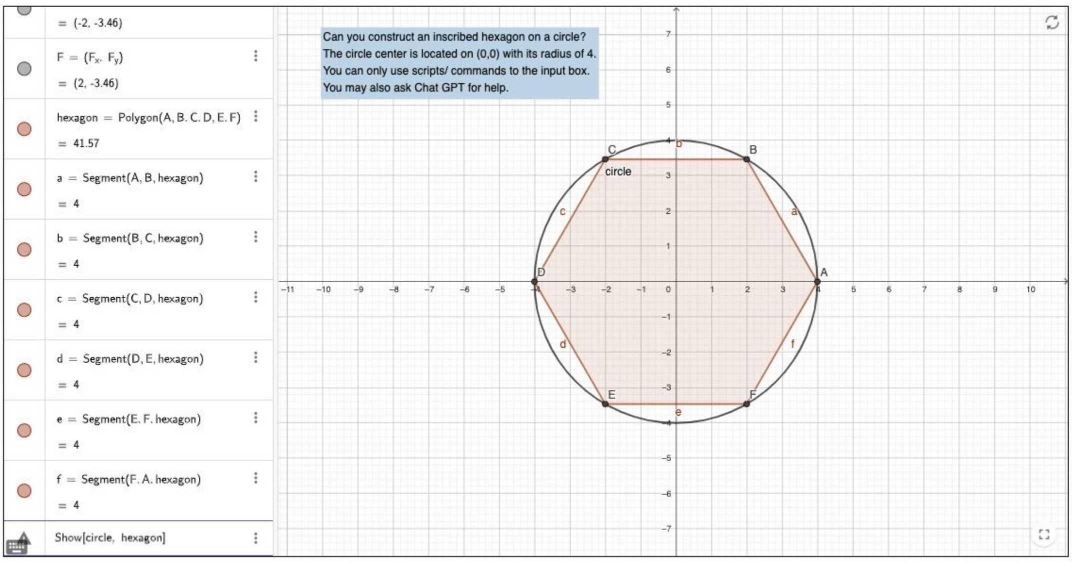

Figure 20. Participant 4 successful construction not following ChatGPT codes

The researchers will examine further codes from P5 (Figure 21) to determine their effectiveness. Given P5's exceptional proficiency in GeoGebra, he seems to find it less difficult to engage in arguments with ChatGPT on the created codes. Before arriving at these final codes, P5 has undergone training of ChatGPT in order to modify the code. P5 understands GeoGebra commands and how they are written and when ChatGPT provided him with an incorrect or unavailable code, P5 could instantly notice it and request ChatGPT to revise it. For instance, ChatGPT provided P5 with a GeoGebra command: RegularPolygon(P,Q,n) but this is an incorrect command and not available. The following is the prompt he inputted: “There is no "RegularPolygon" command. The syntax for constructing a regular polygon is Polygon (P, Q, n) where PQ is one of the sides of the polygon and 'n' is the number of sides. Please revise the code above”.

After inputting the codes generated by P5, the final construction depicted in Figure 21 demonstrates the effective execution of the codes to create a hexagon on a circle with a center located at coordinates (0,0) and a radius of 4.

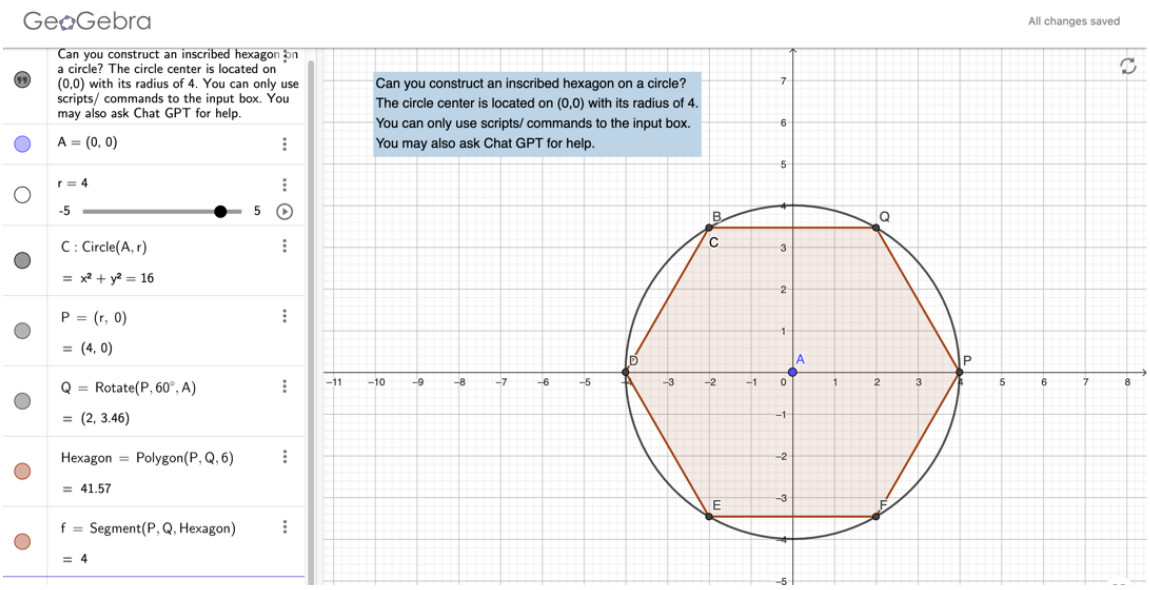

Figure 21. P5’s final codes successfully constructed the requested objects

A personal discussion with P5 aimed to discover the codes he would employ in the absence of ChatGPT. Table 3 presents a comparison between the Chat GPT codes and the codes that do not utilize Chat GPT. In the absence of Chat GPT, the codes of P5 are capable of constructing the inscribed hexagon within a circle. The codes of P5, in the absence of ChatGPT, are capable of constructing the inscribed hexagon within a circle. The P5's codes, in the absence of ChatGPT, are concise, consisting of only 5 lines. This depicts the parsimony principles when the simplest (lesser codes) is preferable if it can construct the same objects. However, the researchers need to note that having lesser codes might eliminate mathematical concepts contained on the code. For instance, in a longer code, it contained sinus and cosines, but in Table 3, both mathematical concepts are missing.

Table 3. Codes with and without ChatGPT support

Line	ChatGPT codes	Line	P5 Codes without ChatGPT
1	A=(0,0)	1	A=(0,0)
2	r=4	2	B=(4,0)
3	C=Circle[A,r]	3	Circle(A,B)
4	P=(r,0)	4	C=Rotate(B,60deg,A)
5	Q=Rotate[P,60deg,A]	5	Polygon(B,C,6)
6	Polygon[P,Q,6]		

To provide a complete summary of the final codes produced by the five participants, the researchers have created a table that presents the results of their respective codes (Table 4). It should be noted that not all codes were successful in generating the intended objects.

Table 4. Final codes' results

No	# of codes	Work or not	Cause
P1	15	No	ChatGPT suggested a code creating a vector instead of a point on a circle for the 'center' command.
P2	8	No	The variable was used twice in ChatGPT, resulting in overlapping and the construction was not created.
P3	2	Yes	-
P4	4	No	ChatGPT suggested an invalid command for creating a point in GeoGebra.
P5	5	Yes	-

Some of the final codes produced by ChatGPT were unable to effectively construct the requested objects. It should be noted that ChatGPT was trained from diverse resources, and this could lead to produce incorrect codes due to unreliable sources. Therefore, ChatGPT training with reliable resources could increase its learning and results to generate GeoGebra commands. The participants' failure to construct objects can be attributed to a deficiency in basic understanding of GeoGebra commands, the utilization of duplicate variables, and poor understanding of mathematical representation. Having proficiency in basic GeoGebra commands can assist users in engaging in arguments with ChatGPT and effectively training it. Baidoo-Anu and Owusu Ansah (2023) highlighted the limitations of ChatGPT, including its restricted understanding and the presence of bias in its training data. The ChatGPT may have undergone training on GeoGebra using a limited number of resources available in their archive. Consequently, this resulted in the utilization of flawed codes or the substitution of round brackets with square brackets, which occasionally gave rise to errors. The ChatGPT was trained by some participants in this study, resulting in its ability to generate accurate codes. The responses or generated codes of ChatGPT are influenced by the training process employed, as demonstrated in the study conducted by Baidoo-Anu and Owusu Ansah (2023). As ChatGPT was trained from a large publicly data and could produce bias results such in our case incorrect GeoGebra commands, the users should be aware on using this tool and crosscheck the result before fully trusting it. Having basic skill on GeoGebra could be useful to train ChatGPT to learn correct GeoGebra commands and the users can enhance their understanding by training ChatGPT. Based on this experience, it is evident that ChatGPT can be beneficial for both teachers and students who have a basic understanding of GeoGebra commands and mathematics and are able to provide critical responses to ChatGPT.

The researchers collected data from the participants about their experiences in using ChatGPT to solve out Math+CT task. Table 5 presents their perspectives on using ChatGPT. Participants familiar with GeoGebra have positive thoughts about using ChatGPT. On the contrary, P1 had used GeoGebra for the first time, and he found the responses of ChatGPT were not useful. The positive tendency toward ChatGPT could be different if the tasks are more complex or recent. It is worth noting that ChatGPT is currently only able to assist users with basic skills.

Table 5. Participants' experiences with ChatGPT

No	Usefulness of ChatGPT
P1	Strongly disagree
P2	Agree
P3	Strongly agree
P4	Strongly agree
P5	Agree

Further investigation with different tasks should be carried out if the positive opinion about ChatGPT remains still. Most participants responded positively to the used of ChatGPT to solve the assigned Math+CT task requiring them to program GeoGebra. Based on this, there is a possibility that school students will also get the same benefits as our participants. ChatGPT can currently be considered an assisted system. Students can improve their understanding by interacting with ChatGPT, provided they have a fundamental knowledge of the content. The support to generate codes is relevant to Ellis & Slade (2023) who have shown that ChatGPT could assist students to learn and understand programming, in our case to program GeoGebra objects. However, further investigations are needed for school students utilizing ChatGPT for our Math+CT task.

Supporting Computational Thinking

To address the fourth research question, we investigated what computational thinking (CT) facets that have been supported by ChatGPT by using the CT framework by Shute et al. (2017). The researchers observed that ChatGPT generated codes (GeoGebra commands) which need to be inputted on GeoGebra to construct the inscribed polygon in a circle. The participants had to type in or copy-paste the code one by one on the GeoGebra's input box. P1 who previously never use GeoGebra could learn how the GeoGebra commands work as they would create mathematical objects or representations. In this case, ChatGPT can support the CT aspect 'algorithms' by Shute et al. (2017) which includes algorithm design to create a series of ordered steps to solve a problem. However, P1's lacking the basic understanding of GeoGebra commands constrained him to execute the proper commands. Despite this problem, P1 learned the way how to program on GeoGebra. This is relevant to the study by Ellis and Slade (2023) who have shown that ChatGPT could assist students to learn and understand programming. Nevertheless, the generated codes will not automatically work when being inputted. Within this constraint, the researchers witnessed P1 did not fully prescribe the generated codes and skipped first two codes but able to construct a circle with its center (0,0) and radius of 4. It seems that P1 possessed the ability to shorten the code after seeing the recommendation commands from GeoGebra while typing in the circle command. Figure 22 depicts the suggestions from GeoGebra how to construct a circle by using "Circle(Point, Radius Number)". He pressed the refresh button on the GeoGebra and started over. P1 skipped the first two codes and followed the suggested command and successfully constructed a circle with its center is located on (0,0) and its radius is 4 (Figure 23).

Another CT aspect, debugging, seems to be more prevalent in this study. Shute et al. (2017) described it as detecting and identifying errors, and then fixing the errors, when a solution does not work as it should. As generated codes from ChatGPT did not always work to construct the requested objects, the participants tried to find what were the problems and to fix it. The researchers witnessed from the participants' conversations with GeoGebra related to the code that did not work or did not exist. The case of with "PointonCircle" command that did not work has led P1 to inquiry if this command exist. At the end, P1 did not successfully fix the PointonCircle command but used another command. This command also did not work as it created a vector. Nevertheless, P1 has attempted to fix the error from the generated codes. Another case is P5 who has fixed the wrong command generated by ChatGPT, which was "RegularPolygon" command. He trained ChatGPT to use "Polygon" command without "Regular". The new generated code used "Polygon" command and successfully created the Hexagon.

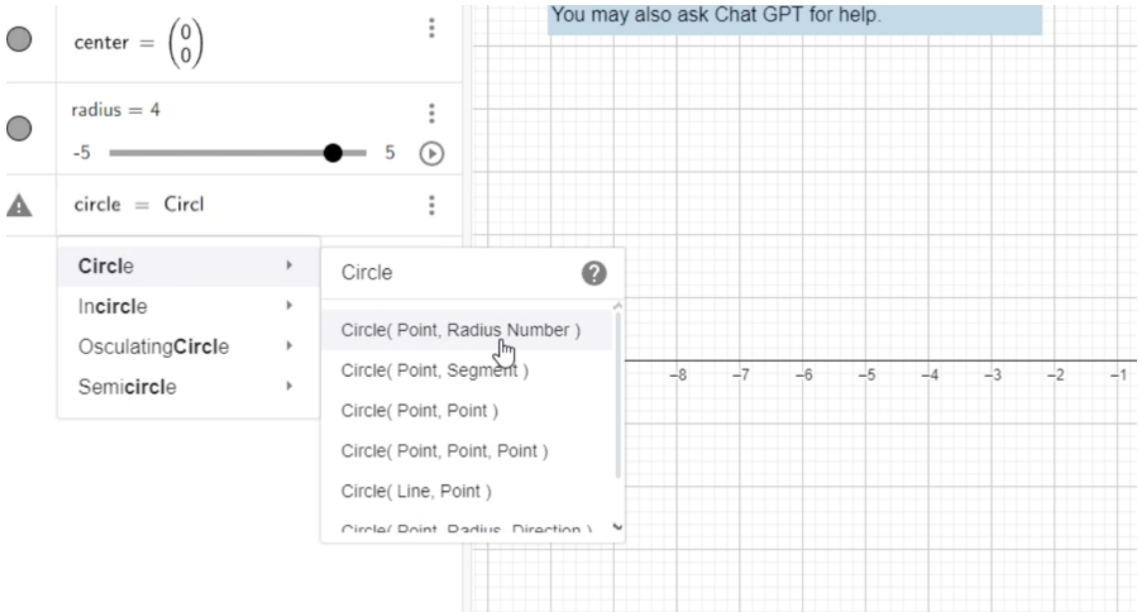

Figure 22. P1 understanding to program in GeoGebra

Unlike in our previous studies, Yunianto, Bautista, et al. (2023), and Yunianto, Prodromou, et al. (2023), where students learned and developed their computational thinking skill through the hints and half-baked artefacts proposed by Kynigos (2007), in this current study participants learned what GeoGebra commands and how they worked by the assistantship of ChatGPT. We did not yet compare or analyse which one is more productive, but it seems both scenarios have supported students' CT skills. Additionally, our results align with previous research that show how AI can enhance learning outcomes in the classroom (Baidoo-Anu & Owusu Ansah, 2023). Studies indicate that artificial intelligence (AI) technologies can enhance students' performance in a number of subjects, including mathematics (Li et al., 2023; Plata et al., 2023). Our study, however, expands on this understanding by focusing on the computational thinking skill in GeoGebra-based mathematics lessons. In contrast to earlier research, we offer empirical proof of ChatGPT's ability to support important CT skills like debugging and programming in a mathematical context.

ChatGPT has provided a room for learning to program GeoGebra with its limited functionality of the generated codes. However, this deficit has promoted debugging skill to our participants. In the future, it could be that ChatGPT would be updated and trained with more reliable resources producing correct GeoGebra commands, but this might limit the potential for the users to enhance debugging and train ChatGPT. Furthermore, our investigation validates the difficulties highlighted by Cascella et al. (2023) pertaining to the utilisation of ChatGPT in educational settings. The challenges encountered by participants in utilizing efficient prompts and comprehending basic GeoGebra commands suggest that mere integration of AI capabilities is insufficient. To achieve successful implementation, it is necessary to specifically address these obstacles by providing support. In the meantime, mathematics teachers still can utilise ChatGPT for assisting students to develop CT skills, especially debugging and programming in GeoGebra environment, and prepare students with proper ways to prompt ChatGPT. In summary, this has shown another potential of ChatGPT used in educational settings by allowing students to interact with AI to develop CT skills while learning mathematics.

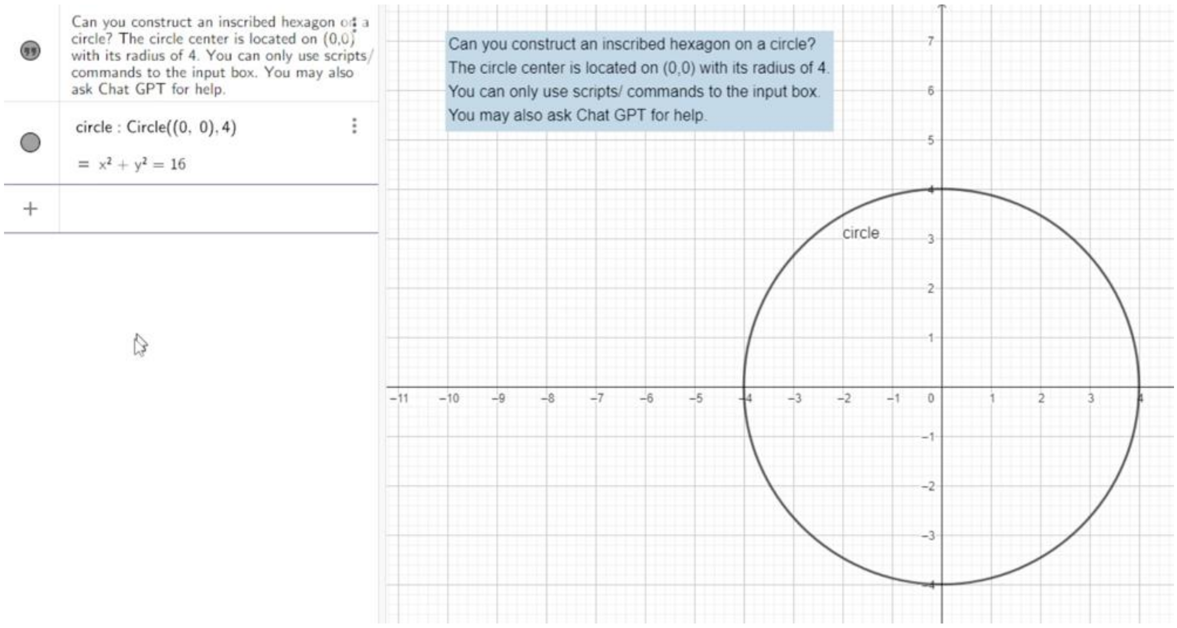

Figure 23. P1 followed the GeoGebra’s command suggestion

CONCLUSION

The findings of our study indicate that it is crucial to prompt ChatGPT to produce correct codes, and participants have not yet utilized efficient prompts. The participants may have difficulty generating correct codes due to a deficiency in prompting abilities. Therefore, it is imperative to equip participants with the required abilities to engage in prompting for our forthcoming investigation. ChatGPT generated different codes based on the prompts and training, and not all of them were compatible with GeoGebra. One notable advantage of ChatGPT is its ability to offer users diverse responses, serving as a form of differentiated instruction. The solution to our Math+CT task can be accomplished through several codes, as demonstrated by the successful diverse codes provided by ChatGPT.

Therefore, this study contributes to the current literature by presenting empirical information regarding the practical benefits and limitations of utilizing ChatGPT in Math+CT lessons. While prior research has emphasized the overall educational advantages of artificial intelligence (AI) technologies, our study especially concentrates on their utilisation in the field of mathematics education, particularly with the use of GeoGebra. This distinctive viewpoint assists in bridging the knowledge gap about how AI might facilitate the incorporation of computational thinking into mathematics, offering useful insights for educators and researchers.

Several implications for teaching practice are related to the findings of this study. Initially, the integration of ChatGPT into Math+CT lessons can enhance the accessibility and engagement of students with complex concepts. ChatGPT enables educators to offer students immediate, personalized feedback, thereby assisting them in overcoming learning challenges and fostering self-assurance. Secondly, the study suggests the necessity of providing training to both educators and students on the effective use of

AI tools. Professional development should be provided to educators to assist students in the development of effective prompts and the critical evaluation of AI-generated responses.

ChatGPT demonstrated its ability to support participants' computational thinking (CT) skills, specifically in the areas of programming and debugging. The participants in our study had favourable encounters with ChatGPT in assisting them with our Math+CT task. However, it is important to note that the study has limitations due to the small sample size, and therefore, the results may not be generalizable to larger populations. Future studies should use bigger and more diverse sample sizes to validate these results and explore the impact of ChatGPT on a wider range of students. Additionally, exploring the different mathematics topics could provide more understanding on how ChatGPT could benefit students in learning mathematics. Moreover, researchers could also compare the results of the Math+CT lessons without ChatGPT and Math+CT lessons with ChatGPT.

Acknowledgments

The researchers would like to thank to my colleague, Selen Galiç, who has provided a proofreading to the manuscript. Additionally, this publication is funded by the Johannes Kepler University Open Access Publishing Fund and the federal state Upper Austria.

Declarations

Author Contribution	:	WY: Conceptualization, Writing - Original Draft, Editing and Visualization. ZL: Validation and Supervision Writing - Review & Editing. OK-H & TH: Review & Editing Substantial contributions in writing the manuscript and revising the manuscripts.
Funding Statement	:	No funding
Conflict of Interest	:	The authors declare no conflict of interest.
Additional Information	:	All information is available for this paper.

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