

Unveiling the Impact of ChatGPT on Mathematical Dialogue and Engagement: A Thematic Case Study

Amena Hijazi

Lebanese University, Saida, Lebanon, amena.hijazi.1@st.ul.edu.lb

Résumé

Le programme libanais de mathématiques vise à développer les compétences en questionnement et le dialogue des élèves ; cette étude explore l'impact des assistants de dialogue IA, comme ChatGPT, sur ces compétences face à la diversité des personnalités et la taille des classes. L'importance de cette étude découle des perspectives offertes par le cas d'un élève de dixième année interagissant avec ChatGPT sur le produit scalaire. Deux questions sont posées: Comment un assistant de dialogue IA impacte-t-il la qualité des questions d'un élève de dixième année et approfondit-il les schémas de dialogue dans l'apprentissage du produit scalaire? De plus, ChatGPT aide-t-il cet élève à s'engager dans l'auto-apprentissage et à augmenter sa motivation? Une analyse thématique qualitative des dialogues a été menée pour découvrir les motifs et thèmes dans les questions posées, évaluer les interactions avec les concepts de produit scalaire et leur motivation. Des données supplémentaires ont été recueillies par l'observation des interactions, notant comment les réponses spécifiques influençaient leurs difficultés et leur compréhension, et par une entrevue pour examiner la perspective de l'élève sur l'expérience. Cette étude a révélé six thèmes: la précision et la pertinence contextuelle du contenu, la structuration stratégique des explications, les techniques pour soutenir l'apprentissage actif, l'évolution de la profondeur des enquêtes, l'élargissement du spectre de la quête de connaissances, et des signes de motivation et de curiosité accrues. Ces résultats suggèrent que ChatGPT peut améliorer le dialogue, des questions de base aux discussions conceptuelles et à la motivation, nécessitant ainsi des recherches sur les assistants IA pour enrichir les conversations éducatives.

Key words

Dialogue, ChatGPT, Questioning Skills, Student Engagement, Thematic Analysis

Abstract

The Lebanese mathematics curriculum aims to foster students' questioning skills and dialogue. Addressing challenges like varied student personalities and large class sizes, this study intends to explore how AI dialogue assistants like ChatGPT impact students' questioning and shift dialogue patterns. The importance of this study originates from the insights provided by the specific case of a tenth-grade student engaging with ChatGPT, specifically about scalar product. It poses two questions: how does an AI dialogue assistant like ChatGPT impact the quality of a 10th-grader student's questions and shift dialogue patterns toward deeper analysis in the context of learning scalar product? Additionally, does ChatGPT help this student engage in self-learning and increase motivation? A qualitative thematic analysis of the dialogue is conducted to uncover patterns and themes in the questions used to evaluate the student's interactions with scalar product concepts and their motivation. Additional data were gathered by observing the student's interactions, noting how specific responses impacted their struggles and understanding, and conducting an interview to examine the student's perspectives on the experience. This study unveiled six key themes: the precision and contextual relevance of mathematical content, the strategic structuring of explanations, techniques for sustaining active learning, the evolving depth of student inquiries, the sought spectrum of knowledge, and indicators of increased student motivation and curiosity. These findings suggest ChatGPT's potential to enhance dialogue, from basic inquiries to sophisticated conceptual discussions and motivation. Corroborated by observations and interviews, these outcomes advocate for further research into the expansive role of AI dialogue assistants in enriching educational conversations.

Key words

Dialogue, ChatGPT, Questioning Skills, Student Engagement, Thematic Analysis

مستخلص

يهدف منهج الرياضيات اللبناني إلى تعزيز مهارات التساؤل والحوار لدى الطلاب. لمواجهة التحديات مثل تنوع شخصيات الطلاب وكبير حجم الفصول، تنوي هذه الدراسة استكشاف كيف يؤثر مساعدو الحوار الذكاء الاصطناعي مثل ChatGPT على تساؤلات الطلاب وتغيير أنماط الحوار. تنبع أهمية هذه الدراسة من الرؤى المقدمة من خلال حالة محددة لطالب في

الصف العاشر يتفاعل مع ChatGPT خصوصًا حول الجداء القياسي (Scalar Product). تطرح الدراسة سؤالين: كيف يؤثر مساعد الحوار الذكاء الاصطناعي مثل ChatGPT على جودة أسئلة طالب في الصف العاشر وتغيير أنماط الحوار نحو تحليل أعمق في سياق تعلم الجداء القياسي؟ بالإضافة إلى ذلك، هل يساعد ChatGPT هذا الطالب على المشاركة في التعلم الذاتي وزيادة الدافعية؟ يتم إجراء تحليل موضوعي نوعي للحوار لكشف الأنماط والموضوعات في الأسئلة المستخدمة، ولتقييم تفاعلات الطالب مع مفاهيم الجداء القياسي وتقييم دافعيتهم. تم جمع بيانات إضافية من خلال مراقبة تفاعلات الطالب، وملاحظة كيف أثرت الاستجابات المحددة على صعوباتهم وفهمهم، ومقابلة لفحص وجهة نظر الطالب حول التجربة. كشفت هذه الدراسة عن ست موضوعات رئيسية: دقة وصلة المحتوى الرياضي بالسياق، البنية الاستراتيجية للشروحات، تقنيات لاستمرار التعلم النشط، تطور عمق استفسارات الطالب، توسع طيف مساعي المعرفة، وعلامات على زيادة دافعية الطالب وفضوله. تشير هذه النتائج إلى إمكانية ChatGPT في تعزيز الحوار من استفسارات أساسية إلى مناقشات مفاهيمية معقدة وتعزيز الدافعية. بتأكيد من الملاحظات والمقابلات، تدعو هذه النتائج إلى مزيد من البحث في الدور المتوسع لمساعد الحوار الذكاء الاصطناعي في إثراء المحادثات التعليمية.

الكلمات المفتاحية

الحوار، ChatGPT، مهارات طرح الأسئلة، تفاعل الطلاب، التحليل الموضوعي

1. Introduction

Employing dialogue for learning is the cornerstone of educational dialogue. According to Alexander (2017), meaning is co-created by participants through sequences of dialogue, thinking, and inquiry. In dialogic talk, both the teacher and students share ideas. Teaching students how to listen to others, express themselves, and formulate effective questions guarantees a smooth dialogic talk since students excel at articulating ideas and gaining insight into their thoughts and viewpoints to share ideas with others. However, even with the extensive research addressing dialogic teaching, the dominant pattern is monologic classrooms (García-Carrión et al., 2020; Tfaili, S., & Hijazi, A., 2024).

Conversational chatbots have gained popularity lately (Lin et al., 2023). ChatGPT is a large language model developed by OpenAI that interacts conversationally (OpenAI, 2022). Liu et al.

(2023) found that ChatGPT may effectively aid in several sectors, including education, but stressed that ethical issues should be considered. Based on Lo (2023), ChatGPT showed outstanding performance in critical and higher-order thinking; in addition, it can assist the learning of students as a self-learning tool. The dialogic nature of ChatGPT inspires an investigation into the feasibility of using ChatGPT as a supplementary tool in dialogue-based teaching.

İpek et al. (2023) conducted a systematic review showing that AI implementation in education has been activated. The review focused on research being published between December 2022 and February 15, 2023. The importance of the review arose from reviewing research that employed recognized scientific methods, explored different features of the application in educational contexts, and guided discussions across different scientific disciplines. İpek et al. (2023) excluded non-educational ChatGPT research as well as non-English and unindexed research in databases such as ERIC, Taylor & Francis Online, and Google Scholar. After employing the PRISMA staged process, they selected 40 studies revealing that ChatGPT is utilized in content creation, translation, assessment, and creating personalized learning environments. However, ChatGPT's disadvantages comprised incorrect answers and ethical issues such as privacy and cheating.

Thus, it is important to utilize ChatGPT wisely and harness its potential to improve education quality. Investigating optimal methods for integrating the discussions into the educational process, especially when utilizing a dialogic teaching approach, holds promise for significantly enhancing students' learning outcomes and fostering active engagement in dialogue.

Consistent with the presented study, Pavlova (2024) conducted a case study to foster student engagement in dialogic teaching by investigating a flipped dialogue model using ChatGPT. Pavlova (2024) acknowledged three key advantages, which are accessibility, reduced stress, and improved student research skills. She further emphasized that research and questioning skills are essential in real-life scenarios, therefore recommending the integration of ChatGPT with dialogic teaching.

Rethinking our educational goals and curriculum is essential nowadays. Further, embedding artificial intelligence into the educational process has become imperative and a reality. Research is increasingly demanded not only on the applications of AI but also on its impact on students' personalities, attitudes, and cognitive knowledge and development.

The current case study aims to explore in depth the learning process while chatting with ChatGPT in the context of learning mathematics, focusing on how students' questioning skills, engagement, and dialogue patterns evolved.

1.1. Theoretical Background

1.1.1. Dialogic Teaching

This study intends to assess ChatGPT's potential as a teaching aid for dialogues. It supports Alexander's (2020) approach of "dialogic stance", which means prioritizing our relationships in classrooms and recognizing that education is an exchange between people. According to Alexander (2020), "Dialogic teaching harnesses the power of talk to engage interest, stimulate thinking, advance understanding, expand ideas, and build and evaluate arguments, empowering students for lifelong learning and democratic engagement."

Alexander (2020) identifies six principles that aid in conducting classroom talk and gauging how far the talk was dialogic. These principles are Collective, Supportive, Reciprocal, Deliberative, Cumulative, and Purposeful. Alexander (2020) explains the principles as follows:

- Collective: Students and teachers are keen and prepared to tackle tasks together.
- Supportive: Students have the liberty to share opinions without risk.
- Reciprocal: Students are active learners who ask questions and listen to each other.
- Deliberative: Students value discussions and reach outcomes through thoughtful examination, analysis, and debate.
- Cumulative: Students acquire understanding through ongoing and collaborative contributions.
- Purposeful: The talk should target specific learning goals.

Alexander's (2020) approach is used in this study to explore to what extent the conversation with ChatGPT was dialogic and how it contributed to improving creating questions and self-learning skills. The study aims to address the following two questions:

- How does an AI dialogue assistant like ChatGPT impact the quality of a 10th-grader student's questions and shift dialogue patterns toward deeper analysis in the context of learning scalar product?
- Does ChatGPT help this student engage in self-learning and increase motivation?

2. Methodology

The qualitative research methodology was employed to gain insight into the impact of using ChatGPT as a dialogic opponent while studying mathematics on students' questioning, motivation, and dialogic patterns. The central focus of this study was the integration of ChatGPT with a dialogic approach. To explore this, a case study research design was utilized. According to Leedy and Ormrod (2015), a case study is "A type of qualitative research in which in-depth data are gathered relative to a single individual, program, or event for the purpose of learning more about an unknown or poorly understood situation." The importance of a case study originates from the in-depth analysis, and it is most useful for supplying preliminary support for one or more hypotheses regarding the phenomenon being investigated (Leedy and Ormrod, 2015).

2.1. Participants

The focus of the research is a single student, identified only by the pseudonym "Rana" to protect their identity. Rana, a fifteen-year-old girl, is presently enrolled at a private school in Lebanon's tenth grade.

The case is a "typical case" which is also known as a representative case that is suitable for exploratory study (Seawright & Gerring, 2008). She was selected due to her status as an average student in mathematics, her previous experience using ChatGPT for essay writing, and her interest in participating in the research. Rana was informed of her role in the research and how the data would be used, and then approval from both Rana and her parents was obtained verbally.

Rana is a native Arabic speaker, but the language of instruction is English, and her below-average English proficiency sometimes hinders her from expressing herself even when she understands the mathematical concept. She has exclusively attended private schools, and the Lebanese official math book titled "Building-up Mathematics" serves as her primary resource. Technology integration in her classrooms has been limited to PowerPoint presentations and videos via LCD screens. To ensure ethical standards, all personal identifiers have been removed or altered, and any sensitive information has been handled with the utmost confidentiality.

2.2. Data Collection

2.2.1. Customized GPT

The researcher used a customized GPT. Customized GPTs are “custom versions of ChatGPT that you can create for a specific purpose” (OpenAI, 2023). No coding skills were required; just enough to provide instructions and information for the intended task. To ensure decent performance, the researcher tested a customized GPT, adding necessary instructions and ultimately producing the GPT named “Math Dialogue Coach”, which is described as “Enhances students' understanding in scalar products using both geometrical and analytical views”. The final version of the instructions emphasized promoting student-led dialogues and open-ended discussions, using a wide range of question types based on Bloom's taxonomy to deepen students' understanding of mathematical concepts. The instructions encompassed guiding students through critical thinking processes, such as problem-solving, linking ideas, and applying mathematics to the real world. The customized GPT was directed to span from introductory to increasingly challenging problems, precisely aligned with the curriculum's geometrical and analytical approaches. Interactions with students were described as clear, encouraging, and mathematically precise. The GPT prompted to incorporation of simple language, emojis for engagement, and accurate use of vector symbols. The conversation should target comprehensive knowledge areas—factual, conceptual, procedural, and metacognitive—while ensuring personalization to address individual misconceptions and maintain mathematics as an engaging and relevant subject. Lebanese learning outcomes mentioned by CRDP were provided. It is worth noting that the learning outcomes were copied from the detailed Lebanese math curriculum.

2.2.2. Data Collection Types

Data were gathered from Rana through three forms of data collection methods: a document of the conversation with customized GPT, an observation of her while chatting with ChatGPT, and a semi-structured interview at the end. Chatting with ChatGPT was carried out at the student's home. This is done to employ the desired setting for implementing such an approach and to provide a comfortable place for the student.

Observation notes were taken while the student interacted with ChatGPT, focusing on the student's engagement, question formulation, and problem-solving strategies. During this phase, the researcher's role was to primarily answer general questions about ChatGPT utilization and push the student to use ChatGPT to answer all her questions. The researcher spent more time in the role of an observer.

A semi-structured interview was conducted to delve deeper into the student's attitudes toward the ChatGPT experience, focusing on perceived benefits, challenges encountered, and the impact on their learning processes. Additional inquiries assessed the student's engagement levels, preferences for future use, and suggestions for enhancing the ChatGPT learning experience. Instead of recording, detailed notes were taken during the interview to capture the student's responses.

2.2.3. Data Collection Procedure

First, Rana was informed of the goal of integrating ChatGPT into the learning process. Permission was obtained from both her and her parents. A concise overview of the customized GPT system was provided, emphasizing its role in facilitating conversational interactions. She was encouraged to converse with ChatGPT using the question-and-answer format. To structure the experience, pre-prepared topics were provided as guidelines for discussion with ChatGPT. These topics included defining scalar product, understanding main scalar product properties, exploring its geometrical interpretation, and solving problems ranging from basic applications to higher-order analyses, mirroring the complexity levels found in the official book. Additionally, real-life applications of scalar product were included in the discussions. Throughout the conversation with ChatGPT, the researcher documented insights that would help answer the research questions. It was a two-hour conversation, punctuated by a 15-minute break, during which the student explored all designated topics.

Following these interactions, the conversations were exported to be used for thematic analysis. To supplement this qualitative research, an interview was conducted via phone on a separate day to explore the student's perception of utilizing ChatGPT in learning.

The use of three ways of data collection – observation of interactions, thematic analysis of transcripts, and semi-structured interviews - serves to triangulate the data, enhancing both validity and reliability. Further, the rich description was employed to strengthen the validity of the research outcomes. According to Creswell (2014), triangulating different data sources of information and using a rich and thick description of the settings are forms to ensure the validity of qualitative research. Additionally, documenting as many of the steps of the procedures as possible is employed as it helps in determining reliability (Yin, 2009, as cited in Creswell, 2014).

2.3. Data Analysis

MAXQDA software (version 24.2.0) was employed to generate codes, add notes, and perform thematic analysis for the document. The document involved 84 paragraphs, each corresponding to one opponent (student or ChatGPT), and 1634 words. After becoming familiar with the data, initial codes were created inductively. Through several iterations of coding attempts, 20 codes were identified, leading to six themes.

3. Results

3.1. Conversation Document

The document served as a valuable data source, highlighting several teaching and learning aspects since it presented a diverse collection of questions from the student in addition to detailed explanations from ChatGPT. The selection of topics provided to student for discussion with ChatGPT positively impacted the learning process. ChatGPT responses are found to be supportive, informative, and engaging. However, dialogue could at times become cyclical and unproductive, especially if a student is unsure what questions to ask and receives repeated replies from ChatGPT. Guiding students in formulating questions that elicit the most enlightening answers aids in facing circular discussions and leads to more successful use of ChatGPT. This will improve their learning experience and stimulate their curiosity. Through thematic analysis of the document, six key themes were identified, enhancing the understanding of the interaction dynamics:

3.1.1. Precision and Relevance in Mathematical Content

The explanations entailed correct mathematics and were exhaustive with examples. They were tailored to the student's age, aligned with predefined learning outcomes, and employed concise definitions. Nevertheless, certain repetitions were noted; in these instances, rephrasing could enhance comprehension instead of mere repetition.

An example showing a concise definition is the one provided for the question “What is dot product? (Document (1), Pos. 3)” which was “The dot product, also known as the scalar product, is a mathematical operation that takes two vectors and returns a single number (scalar). It's defined for two vectors, let's say u and v , as the product of their magnitudes (lengths) and the cosine of the angle (θ) between them. Mathematically, it's expressed as:

$$u \cdot v = |u| |v| \cos(\theta) \text{ (Document (1), Pos. 5-6)}.”$$

3.1.2. Explanation Flow

The explanation started by clearly defining the topic or term the student asked about. Then, it broke these definitions down into easier points and explained each one in detail. Next, it made the topic more interesting by showing the importance of the topic and its application. Often, GPT ended the explanation by summarizing the main points and suggesting topics for exploration, making sure the suggestion was easy to follow and a good next step. This flow is clearly illustrated in the following response shown in Table 1.

Table 1. Example of the Explanation Flow Theme in Document (1), Pos. 20-29

Explanation Components	Example
Definition of the term	By "magnitude information," I'm referring to how the dot product can give us insights into the lengths of the vectors involved and how much one vector projects onto the other.
Breaking out the ideas	<p>Let's break this down a bit more:</p> <ol style="list-style-type: none"> 1. Magnitude of Vectors: The magnitude (or length) of a vector \mathbf{u}, denoted as \mathbf{u}, is a measure of its size. It's calculated (for a 2D vector $\mathbf{u} = (u_1, u_2)$) by the formula $\mathbf{u} = \sqrt{u_1^2 + u_2^2}$. 2. Projection of One Vector onto Another: The dot product, $\mathbf{u} \cdot \mathbf{v} = \mathbf{u} \mathbf{v} \cos(\theta)$, measures how much of one vector lies in the direction of the other. Consider the projection: <ul style="list-style-type: none"> • Projecting vector \mathbf{u} onto vector \mathbf{v} reveals that the dot product provides the length of this projection, adjusted for the angle between them. 3. Interpreting the Dot Product: <ul style="list-style-type: none"> • A larger positive value indicates a significant alignment of one vector with the direction of the other, meaning they are pointing in the same general direction. • A negative value means the vectors are pointing in opposite directions relative to each other. • A value of zero indicates that the vectors are perpendicular, meaning the projection of one vector onto the other is zero—there's no component of one vector lying in the direction of the other.
Conclusion	In simpler terms, the magnitude information provided by the dot product helps us understand how vectors interact with each other in terms of direction and size. It's like asking, "How much of vector \mathbf{u} is going in the same direction as vector \mathbf{v} ?"
Further exploration inquiry	Would you like to see this concept applied in an example?

3.1.3. Active Learning Engagement Techniques

Various strategies were employed to maintain student engagement, such as highlighting the topic's significance: "This formula is particularly useful for computations and applications in physics, engineering, and mathematics. (Document (1), Pos. 15)", encouraging exploration, and suggesting

subsequent topics for discussion: “Would you like to explore some properties or examples of the dot product? (Document (1), Pos. 16)”. Revisiting and linking ideas proved effective in re-engaging student, offering deeper insights into previously discussed topics. Consider the following example showing revisiting ideas:

Example Revisited

From the previous example, $u = (3, 4)$ and $v = (1, 2)$, and we found $u \cdot v = 11$. The magnitude of v was $|v| = \sqrt{5}$.

$$|\text{proj}_v \mathbf{u}| = \frac{11}{\sqrt{5}}$$

The magnitude of the projection of u onto v is:

This value tells us how much of vector u lies in the direction of vector v , in terms of length. It's a direct measure of the component of u that contributes to v 's direction. (Document (1), Pos. 63-67)”.

3.1.4. Depth and Form of Student’s Inquiry

Informed by the researcher to favor questions, the student's inquiries varied between questions and commands, predominantly utilizing "what" and "how". The conversation revealed a deepening of inquiry over time, with questions progressively focusing on finer details essential for understanding the scalar product. Figure 1 shows this evolution of queries from basic initial understandings to more advanced applications.

Figure 1. Progression of the Posed Questions

Progression of Posed Questions

what is dot product ? (Document (1), Pos. 3)	what do you mean by magnitude information? (Document (1), Pos. 18)	how do we know (how much one vector projects onto the other in terms of magnitude)? (Document (1), Pos. 53)	give me an example from real life about projection ? (Document (1), Pos. 71-72)
This is a basic question because it asks for a definition of a fundamental concept in vector mathematics.	This question is also basic as it seeks clarification of a fundamental term, "magnitude".	This advanced question requires understanding vector projection calculations, building on dot product and magnitude concepts.	This advanced question applies vector projection to real-world scenarios, demonstrating contextual understanding.

3.1.5. Sought Knowledge Spectrum

Beginning with a factual inquiry ("What is the dot scalar product?"), the dialogue evolved to encompass conceptual questions and real-life applications. I believe that learning does not linearly progress from factual to metacognitive knowledge; instead, it adapts, targeting different knowledge forms as needed. Hence, the diversity of knowledge types explored during the dialogue indicated a fruitful and engaging exchange.

3.1.6. Indicators of Increased Student Motivation and Curiosity

Several instances indicated a growing interest in the topic, as seen through the student's proactive questions, requests for examples, applications, and clarifications on previously discussed terms. For instance, when ChatGPT suggested "Would you like to explore some properties or examples of the dot product? (Document (1), Pos. 16)", the student asked "what do you mean by magnitude information? (Document (1), Pos. 18)". In addition, an inquiry into real-life examples is conducted to further understand dot product and its relationship with magnitude information.

3.2. Observation

At the beginning of the session, the student was hesitant about her questions and frequently looked to the observer for comfort. Thus, the observer advised her to be confident in her questions. She

also encountered minor language barriers and difficulties with mathematical notations, but these did not significantly hinder her learning. Moreover, the observer suggested using online translators or ChatGPT for clarifications on language and terminology.

Before the study, the student was skilled at performing scalar product calculations; however, she lacked conceptual understanding and real-life applications. During her interactions with ChatGPT, this gap began to close, especially with explanations of projections. Then, to ensure the student grasped the concept, the observer asked about the best method that would help her understand the concept. The student suggested a real-life example; thus, she prompted a further discussion with ChatGPT about real-life applications. Notably, she attempted to sketch sunlight projections, actively deducing the concepts herself. Lastly, the student independently solved scalar product problems, depending on her prior knowledge, without needing ChatGPT's help.

3.3. Interview

Initially, the student was skeptical about how ChatGPT could help. Eventually, she found it extremely valuable, especially the real-life examples provided, like the shadow example. She described using ChatGPT as insightful and engaging. No major difficulties were faced while using ChatGPT because of the friendly user interface and simple language. However, she mentioned only the disadvantage, which is the lack of visual aids like images that could improve the learning process, despite finding explanations and examples helpful. Additionally, she found it more suitable for learning than conventional methods of learning because of its non-judgmental approach and the ability to ask unlimited questions. In addition, she valued its availability at any time and quick responses, which differed significantly from usual educational settings. The student stated that she would recommend using ChatGPT to her peers because of its effectiveness in transforming her learning experience. Finally, ChatGPT's suggestions on the following topics encouraged her to explore and engage with the study material.

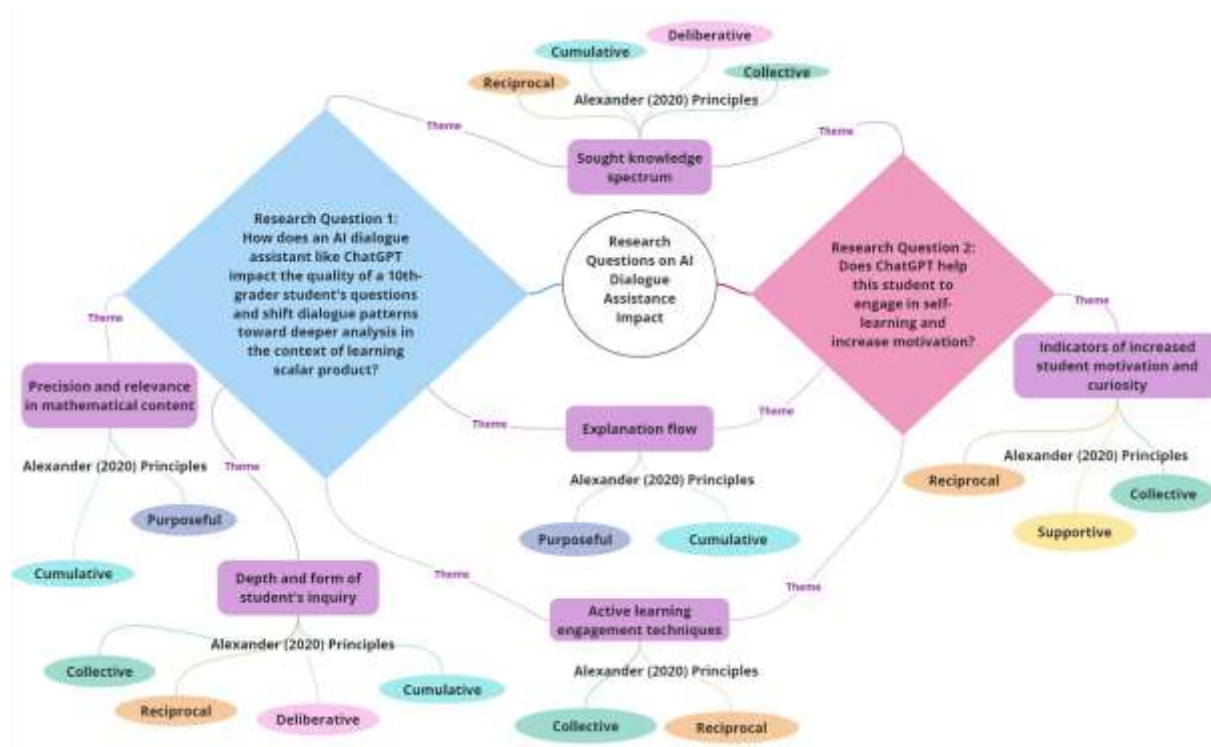
4. Discussion

Results show that ChatGPT effectively engages student in mathematical dialogues, improving their questioning skills, conceptual understanding, and self-learning abilities. Although these

findings are not meant for broad generalization due to the qualitative nature of this study, they provide insights into the potential of AI-generated dialogues in educational settings.

Figure 2 is a thematic map highlighting how each theme contributes to addressing the research questions and connects to Alexander's (2020) principles.

Figure 2. Thematic Map of Themes Addressing Research Questions and Connecting to Alexander's (2020) Principles



Providing precise and relevant content paves the way for the students to deepen the analysis and address the students' questions accurately, thereby making the conversation more dialogic. This facilitation of continuous and progressive learning in mathematical content aligns with the Cumulative principle. It also helps students focus on precise aspects of the scalar product, ensuring their questions target specific learning goals, consistent with the Purposeful principle. Furthermore, the explanation flow enhances students' ability to follow and engage with the material, thus improving the quality of their questions and promoting continuous learning and self-study, also relating to the Cumulative and Purposeful principles.

The enhancement in the student's inquiry forms and depth clearly shows an improvement in their questioning skills and deepening dialogic patterns. This is evident in the Cumulative principle, where students acquire understanding through several inquiries and collaboration, and in the Collective principle, where students are keen to understand mathematical concepts. Moreover, students value discussions and reach outcomes through thoughtful examination, analysis, and debate, implying the Deliberative principle. Students actively asking questions highlights the Reciprocal principle. Similarly, the "sought knowledge spectrum" theme demonstrates the Cumulative, Collective, Deliberative, and Reciprocal principles, showing increased student engagement and motivation, and fostering self-learning as students choose topics they do not understand.

The approved active learning engagement techniques involve methods that encourage students to ask better questions, engage more deeply, and promote self-learning and sustained engagement. Observations show that students interact better when these techniques are used, relating to the Collective and Reciprocal principles, as students interact with ChatGPT by asking questions and receiving feedback, mirroring active listening and participation, and promoting collective problem-solving.

Finally, the theme indicating increased motivation and curiosity shows ChatGPT's role in improving student engagement, supporting the Reciprocal, Collective, and Supportive principles, as students feel free to ask questions, as also evidenced in the interviews.

Therefore, the analysis revealed that the dialogue with ChatGPT aligns with the six principles outlined by Alexander (2020) since students are accountable for learning; otherwise, the dialogue cannot be held alone. ChatGPT facilitated this process by using supportive language that encourages students to ask questions. The students were not passive; they actively selected questions that enhanced their understanding. Debates and discussions were central to their learning process. The learning was cumulative, where the discussions deepened progressively the student's understanding of the scalar product, ensuring a purposeful dialogue that was strategically focused on this mathematical concept.

Importantly, the results suggest that ChatGPT not only increases student motivation but also encourages a shift in dialogue patterns toward more in-depth analysis, though the student's role

remains crucial. This is consistent with the findings of Pavlova (2024) who found that when used in a flipped classroom setting, ChatGPT facilitated deeper engagement. According to Rane (2023), ChatGPT revolutionizes mathematics education by fostering interactive learning, enhancing conceptual clarity, and promoting adaptive techniques. These advancements support our findings that ChatGPT shifts dialogue patterns and improves questioning skills, as students engage more deeply with mathematical concepts and receive personalized support. The current study advocates for viewing AI assistants as dialogic partners rather than authoritative knowledge providers, consistent with the findings of Tang et al. (2024). As a dialogue partner, AI encourages students to refine their questions to achieve better results, provides them time to reflect on the answers, and helps verify knowledge. This shift is crucial for educators, who should reconsider the evolving shape of education and how to effectively integrate AI tools. Considerable effort is needed to guide students in using ChatGPT, leading conversations, and considering the ethical implications of its use.

5. Conclusion

This study addressed the challenges of fostering students' questioning skills and dialogue. By exploring the integration of ChatGPT as a dialogic partner in mathematics education, the research aimed to understand its impact on students' questioning, motivation, and dialogic patterns, specifically focusing on a tenth-grade student's engagement with the scalar product concept. The study unveiled six key themes, demonstrating that ChatGPT can effectively engage students, promoting deeper understanding and active learning through structured, interactive dialogues. The findings align with Alexander's six dialogic teaching principles but also underscore the need for educators to guide AI-assisted learning effectively.

The study's focus on a single case for a short period may limit the generalizability of the findings. Additionally, the specific mathematical context might not capture the AI's potential across other subjects or educational levels. However, the primary aim of this case study is to obtain insight into the usefulness of employing GPT in dialogic teaching. Therefore, future research should explore a broader range of subjects, educational contexts, and personalities to validate and expand upon these findings. Longitudinal studies could provide deeper insights into the long-term impacts of AI-assisted learning on student outcomes in addition to emotional and social implications.

Moreover, examining the ethical implications and developing best practices for AI integration in education will be crucial for maximizing its benefits while mitigating potential risks. As technology evolves, it remains crucial for educators to adapt and innovate, ensuring that AI tools like ChatGPT are utilized to their fullest potential to create engaging, effective, and ethical learning environments.

References

- Alexander, R. (2020). A dialogic teaching companion. <https://doi.org/10.4324/9781351040143>
- Creswell, J. W. (2014). Research design: Qualitative, quantitative, and mixed methods approaches. SAGE.
- García-Carrión, R., López de Aguilera, G., Padrós, M., & Ramis-Salas, M. (2020). Implications for social impact of dialogic teaching and learning. *Frontiers in Psychology*, 11. <https://doi.org/10.3389/fpsyg.2020.00140>
- İpek, Z. H., Gözüm, A. İ. C., Papadakis, S., & Kallogiannakis, M. (2023). Educational applications of the CHATGPT AI System: A systematic review research. *Educational Process: International Journal*, 12(3). <https://doi.org/10.22521/edupij.2023.123.2>
- Leedy, P. D., & Ormrod, J. E. (2015). Practical research: Planning and design (eBook). Pearson Higher Ed.
- Lin, C., Huang, A. Y., & Yang, S. J. (2023). A review of AI-driven conversational chatbots implementation methodologies and challenges (1999–2022). *Sustainability*, 15(5), 4012. <https://doi.org/10.3390/su15054012>
- Liu, Y., Han, T., Ma, S., Zhang, J., Yang, Y., Tian, J., He, H., Li, A., He, M., Liu, Z., Wu, Z., Zhao, L., Zhu, D., Li, X., Qiang, N., Shen, D., Liu, T., & Ge, B. (2023). Summary of chatgpt-related research and perspective towards the future of large language models. *Meta-Radiology*, 1(2), 100017. <https://doi.org/10.1016/j.metrad.2023.100017>
- Lo, C. K. (2023). What is the impact of CHATGPT on education? A rapid review of the literature. *Education Sciences*, 13(4), 410. <https://doi.org/10.3390/educsci13040410>
- OpenAI. (2022, November). Introducing ChatGPT. Retrieved February 18, 2024, from <https://openai.com/blog/chatgpt>
- OpenAI. (2023, November 6). Introducing GPTs. Retrieved March 3, 2024, from

<https://openai.com/blog/introducing-gpts>

Pavlova, N. (2024). Flipped dialogic learning method with ChatGPT: A case study. *International Electronic Journal of Mathematics Education*, 19(1), em0764.

<https://doi.org/10.29333/iejme/14025>

Rane, N. (2023). Enhancing mathematical capabilities through ChatGPT and similar generative artificial intelligence: Roles and challenges in solving mathematical problems. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.4603237>

Seawright, J., & Gerring, J. (2008). Case selection techniques in case study research. *Political Research Quarterly*, 61(2), 294–308. <https://doi.org/10.1177/1065912907313077>

Tang, K., Cooper, G., Rappa, N., Cooper, M., Sims, C., & Nonis, K. (2024). A dialogic approach to transform teaching, learning & assessment with generative AI in secondary education. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.4722537>

Tfaili, S., & Hijazi, A. (2024). Exploring the impact of teachers' discourse on students' mathematical language while writing a formal proof about congruent triangles. *Communication & Development*, (37), 181-207.

https://www.arabaacs.com/uploads/2/8/4/0/28402165/%D8%A7%D9%84%D8%A7%D8%AA%D8%B5%D8%A7%D9%84%D9%88%D8%A7%D9%84%D8%AA%D9%86%D9%85%D9%8A%D8%A9%D8%A3%D8%AC%D9%86%D8%A8%D9%8A_-_37_3_.pdf