Prompting and RAG Vs. Student Engagement and Comprehension in Educational Technology

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***Abstract*—Generative AI (GenAI) has emerged as a valuable tool in education technology, offering potential to enhance learning and teaching processes. While concerns like fraudulent practices, algorithmic bias, privacy issues, and overreliance on technology persist, GenAI's benefits are significant when used strategically. It is essential, however, to view GenAI as a supplementary aid for students and educators rather than a replacement for human-led teaching. Effective use of GenAI requires thoughtful implementation, including techniques like prompting and retrieval-augmented generation (RAG). Prompting involves formulating questions or tasks for the AI, while RAG enhances the AI's ability to retrieve relevant information based on its training. This study focuses on the relationship between GenAI and students, excluding educators' roles. A mixed-method survey evaluated students' interactions with GenAI-generated answers in two scenarios: one where they had prior topic knowledge and another where they did not. Five chatbots—ChatGPT, Gemini, Copilot, Perplexity AI, and Sana AI—were tested with varied prompts. Results showed that students benefit most when they are engaged and have foundational topic knowledge. These findings underscore the role of educators in fostering student engagement and guiding effective GenAI use. By prioritizing understanding, educators ensure GenAI enhances learning, reinforcing that AI should support, not replace, education.**

I. Introduction

The integration of generative AI into educational technology has rapidly evolved, with techniques such as prompting and retrieval-augmented generation (RAG) offering new pathways for fostering student engagement and comprehension. Prompting enables students to actively interact with AI by inputting tailored prompts, which allows for a personalized learning experience that encourages curiosity and enhances the learning process through iterative feedback [1]. Meanwhile, RAG combines retrieval systems with generative models to draw from vast, relevant knowledge bases in real-time, enriching comprehension by providing students with customized information relevant to their queries and educational needs [2].

As governments and educational bodies worldwide explore the potential of AI, guidelines emphasize the importance of ethical considerations and responsible use. The UK Department for Education, for instance, highlights that while generative AI can save educators time by handling repetitive tasks, it raises critical issues around data security, intellectual property, and content reliability [3]. Addressing these challenges requires educators not only to understand AI functionality but also to maintain a critical perspective on AI-generated content, guiding students in effectively using these tools while safeguarding academic integrity [1].

Beyond technical enhancements, recent studies underscore the impact of generative AI on cognitive engagement and active learning. Students, particularly those who might struggle with traditional methods, benefit from AI's adaptive feedback and contextual relevance, which together support a more interactive and immersive learning experience [4]. However, there is a growing recognition that while generative AI can amplify learning outcomes, its success hinges on the pedagogical frameworks that guide its use in classrooms [1][5].

This paper explores how prompting and RAG influence student engagement and comprehension within educational settings, highlighting their benefits and challenges. It further assesses the balance between technology-driven education and the need for a human-centered approach, proposing that a thoughtful integration of these tools could pave the way for more responsive, inclusive, and engaging educational experiences.

II. Literature Review

The integration of advanced technologies like generative AI, prompting strategies, and retrieval-augmented generation (RAG) is transforming the landscape of educational technology. A growing body of research highlights the potential for these technologies to significantly enhance student engagement and comprehension. Prompting techniques, where students interact with AI through tailored inputs, create an interactive learning environment that encourages active participation. These interactive methods foster deeper cognitive engagement, which is essential for improving comprehension, especially in diverse learning contexts [6][7].

Generative AI and RAG are central to the current evolution in personalized learning. By integrating AI with large-scale knowledge databases, RAG systems allow for dynamic content generation tailored to the learner's needs. This adaptive system has been found to improve comprehension by providing students with more contextually relevant information in real-time [8]. As these technologies become more integrated into educational settings, educators increasingly rely on them for both content delivery and interactive learning experiences, driving positive shifts in engagement levels [9].

However, the effective application of these technologies requires careful consideration of pedagogical frameworks. Researchers suggest that without a structured pedagogical approach, the impact of AI on student learning outcomes could be limited. For instance in 2023, the Department for Education, United Kingdom points out that while generative AI can streamline administrative tasks and enhance content delivery, its effectiveness in promoting student learning depends largely on the context in which it is deployed [3]. Similarly, scholars emphasize that the success of AI in education depends not only on the technology itself but also on how educators incorporate it into their teaching strategies [2].

On the other hand, the ethical implications of AI in education are under scrutiny. Concerns about data privacy, bias in AI algorithms, and the potential for over-reliance on AI tools have led to growing calls for comprehensive guidelines. The House of Lords Library (2024) outlines these risks, noting that while AI can support educators by alleviating some of their workload, it is crucial that these systems are transparent and equitable to avoid reinforcing educational inequalities [1]. Ethical considerations extend beyond just fairness and privacy; they also encompass the intellectual integrity of AI-generated content, which might mislead students if not monitored appropriately [10].

Moreover, the role of RAG in fostering engagement remains a key area of study. By combining generative models with retrieval mechanisms, RAG ensures that the information provided to students is not only accurate but contextually aligned with their learning trajectory. Several studies demonstrate that RAG systems are especially effective in subjects requiring detailed content understanding, such as science and history, where real-time, contextual information can significantly enhance comprehension [11][12].

Lastly, the role of human oversight in AI-assisted education remains vital. The literature consistently stresses that while AI tools like RAG can support and enhance learning, human guidance is indispensable. Educators must interpret and adapt AI-generated content to ensure its educational value, particularly in complex or sensitive subject areas [13]. As such, the interplay between AI technologies and traditional pedagogical methods continues to shape the future of education.

III. Methodology

The methodology employed a mixed-method survey to explore how students interact with GenAI tools. Quantitative data measured students' ability to assess AI responses based on their prior topic knowledge, while qualitative data captured personal insights into their experiences. By testing responses from five chatbots across varied question levels, the study evaluated the influence of topic familiarity on students' effective use of GenAI, providing both measurable performance metrics and detailed perceptions.

TABLE I: Survey structure used for the study.

Prompts	Popular GenAI Tools				
	ChatGPT	Gemini	Copilot	Perplexity AI	Sana AI
Promp-1	*	*	*	*	*
Promp-2	*	*	*	*	*
Promp-3	*	*	*	*	*
Promp-4	*	*	*	*	*
Promp-5	*	*	*	*	*

A. Survey Structure

The survey structure was designed to examine students' interactions with generative AI tools across topics where they had prior knowledge (course-related) and where they lacked familiarity (non-course topics). This design allowed researchers to assess whether students' understanding influenced their ability to evaluate and utilize GenAI outputs. Five distinct GenAI tools—ChatGPT, Gemini, Copilot, Perplexity AI, and Sana AI—were utilized for consistency checks. For each tool, students were presented with five progressively complex prompts (Prompt-1 through Prompt-5) for each topic, allowing the study to analyze the following:

- Consistency Across Tools: By using five different GenAI tools, the survey could assess if responses displayed repeatable patterns or variations, particularly across known versus unknown topics.
- Impact of Knowledge: The use of both familiar and unfamiliar topics enabled researchers to measure how students' knowledge affected their interaction and assessment of GenAI outputs across prompts.

This structure provided a comprehensive overview of how topic familiarity and tool choice influenced students' engagement with generative AI, thus providing insights into GenAI's repeatability and utility in diverse learning scenarios. The tabulated form of the survey structure is shown in Table I.

B. Question Complexity

To evaluate the effectiveness and comprehension potential of GenAI responses, the study implemented five distinct prompts for each GenAI tool. Each prompt varied in structure and phrasing to test different question complexities and assess which style of inquiry most effectively enhanced student understanding. The prompts, labeled Prompt-1 through Prompt-5 (shown in Table I), employed diverse wording, question types, and levels of specificity, allowing the study to determine:

- Prompt Effectiveness: By altering the way questions were framed, the survey aimed to see which prompt type provided responses that students found most helpful.
- Comprehension Support: Each prompt's response was analyzed for clarity and educational value, helping to iden-

tify the most effective approaches in prompting GenAI for educational purposes.

This approach allowed for an in-depth exploration of how varied prompt styles influence the usability and quality of GenAI responses for student learning.

C. Tool Comparison

The study conducted a comparative analysis of five generative AI chatbots—ChatGPT, Gemini, Copilot, Perplexity AI, and Sana AI—to assess their effectiveness in supporting student engagement and comprehension. Each chatbot was tested with the same set of prompts across two distinct topics (one familiar and one unfamiliar to students). This comparison aimed to identify:

- Response Consistency: Whether each tool produced reliable, repeatable responses across topics and prompt styles.
- Educational Value: Evaluation of the clarity, accuracy, and relevance of each tool's responses, helping determine which AI best supports learning needs.
- Tool-Specific Strengths and Weaknesses: Analysis of each chatbot's ability to handle varied question complexities, providing insights into which tools are most adaptable to different learning contexts.

The results from this analysis offered a nuanced understanding of each GenAI tool's potential to enhance educational outcomes.

IV. Results & Analysis

Data for the study's analysis were collected through a structured questionnaire distributed via Microsoft Forms. This questionnaire gathered quantitative data on students' ability to assess and engage with responses from various GenAI tools, as well as qualitative feedback on their experiences and perceived utility of the AI responses. Analysis focused on identifying patterns in student performance, particularly in relation to prior knowledge of the topic and the effectiveness of different prompt types, while comparing the consistency and educational value across the five chatbots tested.

Table II presents the structure of the proposed survey, which was used to gather both qualitative and quantitative data for this study. The survey was designed with two distinct topics to examine response patterns: Robotics and Quantum Computing. These topics were selected for their contrasting familiarity within the target audience, as outlined in Section-X.

The Robotics topic, commonly part of computer, electrical, and electronics engineering curricula, was familiar to most survey participants, who were either students or professionals in these fields. In contrast, Quantum Computing is an advanced, specialized topic typically outside standard engineering curricula, making it less familiar to participants. This distinction was intended to explore how familiarity with a subject might influence the nature of responses.

In Table II, the data has been consolidated to represent both topics in a single summarized format due to the similarity in response types across the two subjects. This summarization enabled a unified analysis of the response styles elicited by both topics. The responses collected from the survey have been categorized into two primary types:

- Overly General or Abstract Responses: These responses provided broad, high-level explanations without addressing specific details. They lacked step-by-step guidance, making it challenging for students to follow or grasp the concepts being explained. Such responses often fail to engage with the specific context of the question, resulting in a less personalized learning experience for the student.
- Human-like or Cognitive Responses: In contrast, cognitive responses demonstrated an awareness of the questioner's understanding level. This type of response sought to gauge the questioner's background and adjust the explanation accordingly. By providing detailed, step-by-step explanations, cognitive responses aimed to make complex concepts more accessible, thereby facilitating deeper understanding. This response type mirrored a human-like instructional approach, breaking down information in a way that is tailored to the learner's needs.

The analysis reveals that while responses across both topics exhibited these two primary patterns, the cognitive responses were particularly beneficial for understanding complex subjects, like Quantum Computing, where layered explanations are essential. This categorization provides insight into the effectiveness of response types in educational contexts, highlighting the potential for enhancing AI-driven instructional methods to mimic human-like cognitive approaches.

The doughnut chart of Figure 1 shows that the majority of survey participants had some familiarity with Robotics, with 58% identifying as novices, 25% as intermediate, and 17% as totally unaware of the topic. This distribution suggests that while Robotics is part of many engineering curricula, most students only have a basic understanding, with only a quarter possessing intermediate knowledge and a small portion being completely unfamiliar. Consequently, most participants may find general prompts more accessible, but they might struggle with technical or advanced content. This implies that when using AI to support learning in Robotics, foundational explanations may be necessary to engage the predominantly novice audience effectively.

Figure 2 illustrates survey results showing students' responses to various prompts on the topic of Robotics across five different Generative AI (GenAI) platforms: ChatGPT, Gemini, Copilot, Perplexity AI, and Sana AI. The observed trend across all five Generative AI (GenAI) platforms—where students engaged most consistently with Prompt 5—suggests that certain types of prompts resonate better with students, particularly on familiar topics like Robotics, which is part of their core curriculum. This alignment highlights an essential aspect of using GenAI in educational settings: the design and framing of prompts play a critical role in how effectively students engage with AI-generated responses.

Since Robotics is part of the students' academic background, they may feel more confident in evaluating and interacting with GenAI responses related to it. This familiarity

TABLE II: Qualitative summary of survey structure and response types received from popular GenAI platforms.

Prompts	Responses from Popular GenAI Tools				
	ChatGPT	**Gemini**	**Copilot**	**Perplexity AI**	**Sana AI**
Prompt-1: **What is X?**	Overly General or Abstract Response	Overly General or Abstract Response	Overly General or Abstract Response	Overly General or Abstract Response	Overly General or Abstract Response
Prompt-2: **I want to learn about X. Can you teach me?**	Overly General or Abstract Response	Overly General or Abstract Response	Overly General or Abstract Response	Overly General or Abstract Response	Overly General or Abstract Response
Prompt-3: **How can I get started with X as a beginner?**	Overly General or Abstract Response	Overly General or Abstract Response	Overly General or Abstract Response	Overly General or Abstract Response	Overly General or Abstract Response
Prompt-4: **What are the basics I should know before building X?**	Overly General or Abstract Response	Overly General or Abstract Response	Overly General or Abstract Response	Overly General or Abstract Response	Overly General or Abstract Response
Prompt-5: **Can we have a conversation about X to help me understand it better? You can start the discussion.**	Human Like or Cognitive Response	Human Like or Cognitive Response	Human Like or Cognitive Response	Human Like or Cognitive Response	Human Like or Cognitive Response

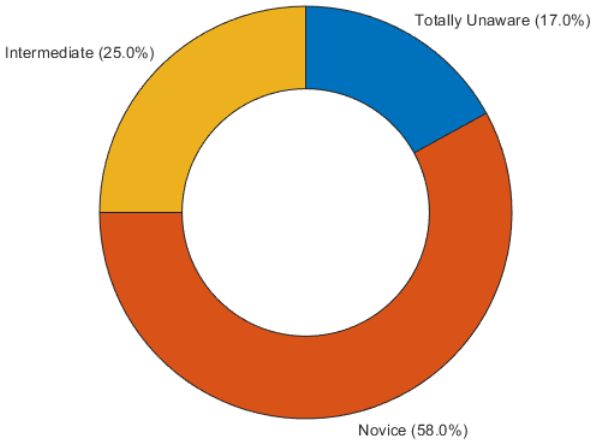


Fig. 1: Overall knowledge level of students who attended the proposed qualitative survey on the topic of Robotics, commonly part of computer, electrical, and electronics engineering curricula, was familiar to most survey participants.

likely enables them to discern useful information, critically assess the AI's responses, and leverage them in a meaningful way. When students are already comfortable with a subject, they're more likely to critically engage with AI outputs, asking follow-up questions or clarifying points as needed, which can deepen their learning experience.

Moreover, the varied response patterns across prompts and AI platforms reveal the nuanced ways in which students' existing knowledge impacts their interaction with AI. In scenarios where students lack foundational knowledge, they may struggle to interact productively with GenAI, often taking AI responses at face value without the ability to gauge accuracy or relevance. This study suggests that familiarity with the subject matter allows students to use GenAI as a tool for exploring nuances and expanding their understanding rather than as a crutch for basic knowledge acquisition. In other words, GenAI becomes a supplement to human learning rather than a replacement, enhancing critical thinking and reinforcing established knowledge.

The differential engagement across prompts also implies that educators should carefully design prompts that not only align with the students' current curriculum but also challenge them to think critically. Educators can thus strategically use GenAI to bridge gaps in understanding, scaffold complex concepts, and encourage inquiry, especially in areas where students have a foundational understanding. The survey findings underscore that GenAI is most effective when students are equipped with prior knowledge, as it allows them to maximize the tool's potential by analyzing, synthesizing, and reflecting on AI responses.

This has practical implications for integrating AI into academic programs. For instance, instructors can focus on structuring AI prompts that are contextually relevant and gradually increase in complexity, helping students progressively deepen their understanding of the material. Additionally, educators can encourage students to reflect on the quality of AI-generated responses, fostering a critical approach to using AI in learning. This can help students build skills in evaluating information—a crucial competency in an era where AI-generated content is increasingly prevalent.

Finally, the findings reinforce the idea that while GenAI can serve as a powerful educational tool, it requires thoughtful integration to be effective. Educators have a key role in guiding students on how to use GenAI constructively. By setting clear learning objectives, designing meaningful prompts, and ensuring that AI use complements rather than replaces traditional learning, educators can help students engage with AI in a way that genuinely enhances their educational experience. This study suggests that GenAI's true potential lies in its ability to act as a partner in learning, augmenting student engagement,

comprehension, and critical thinking when applied within a framework that builds on their existing knowledge and curiosity.

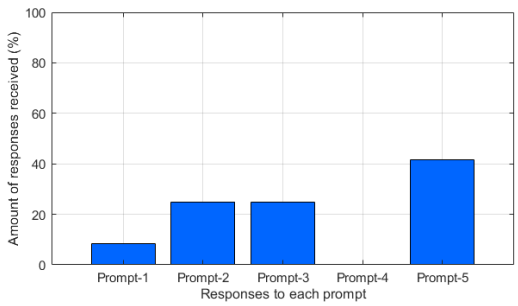
The doughnut chart Figure 3 highlights that Quantum Computing was a largely unfamiliar topic for the survey participants, with two-thirds totally unaware of the subject and only a small percentage (8.3%) having intermediate knowledge. This distribution suggests that most participants would struggle to engage with complex prompts or AI-generated responses related to Quantum Computing. For effective learning with AI on this topic, students would likely benefit from introductory or foundational content, as the majority lack the background knowledge required to interpret more advanced information. This underscores the importance of tailoring AI prompts and responses to accommodate students' knowledge levels, particularly when dealing with specialized or advanced subjects outside their standard curriculum.

Figure 4 presents survey results capturing students' responses to various prompts on the topic of Quantum Computing across five Generative AI (GenAI) platforms: ChatGPT, Gemini, Copilot, Perplexity AI, and Sana AI. The data reveals a clear trend: students were more likely to respond to certain prompts, particularly Prompt 5, across all AI platforms, even when faced with an advanced topic like Quantum Computing that falls outside their typical curriculum. This pattern suggests that students could only engage effectively with prompts that were either structured in a straightforward manner or crafted to minimize the need for specialized background knowledge. When prompts were too complex or highly technical, student engagement dropped significantly, indicating that prior knowledge plays a crucial role in students' ability to interact meaningfully with GenAI systems.

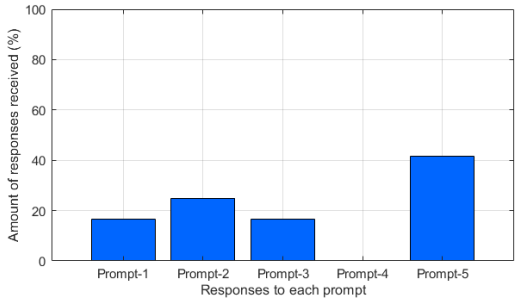
The lower engagement across prompts, compared to the Robotics topic, highlights the challenges students face when using GenAI on unfamiliar subjects. Without foundational knowledge, students may struggle to interpret AI-generated responses accurately or may be unable to determine the relevance or accuracy of information provided. This reflects the importance of context and prior learning in leveraging GenAI effectively, as students appear to benefit from GenAI tools only when the subject matter is accessible and within their range of understanding.

This trend underscores the need for careful prompt design, especially in educational settings where GenAI is used to introduce students to advanced topics. Educators and instructional designers can use these insights to structure prompts that scaffold learning, guiding students through complex concepts in more digestible steps. For instance, prompts could start with general explanations before diving into more advanced aspects, enabling students to build foundational knowledge progressively.

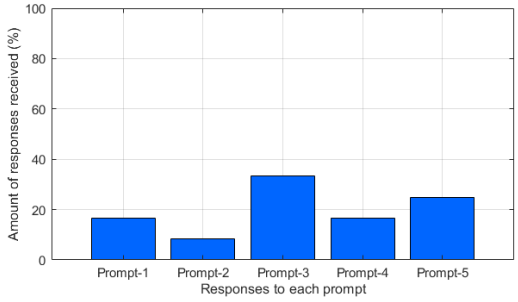
Furthermore, this survey highlights that GenAI, while useful, has limitations when students lack the subject background. Educators play an essential role in bridging these gaps by providing context, simplifying complex ideas, or offering preliminary instruction before students engage with AI. This



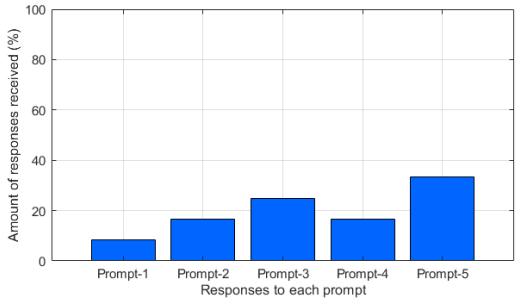
(a) Robotics ChatGPT



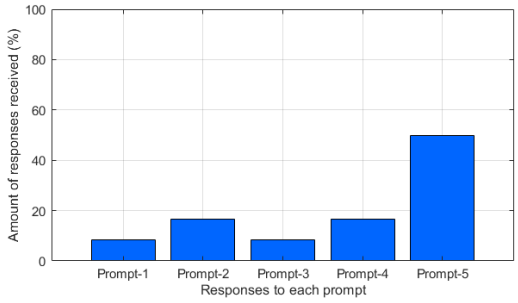
(b) Robotics Gemini



(c) Robotics Copilot



(d) Robotics Perplexity AI



(e) Robotics San AI

Fig. 2: The overall preferred prompt and response type from students who participated in the qualitative survey on Robotics—a topic commonly included in computer, electrical, and electronics engineering curricula—was familiar to most survey participants.

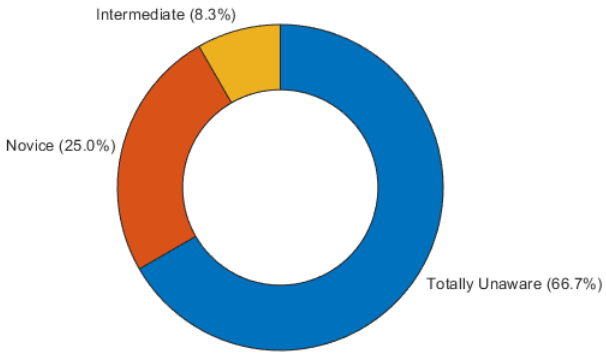


Fig. 3: Overall knowledge level of students who attended the proposed qualitative survey on the topic of Quantum Coumputing, commonly not part of computer, electrical, and electronics engineering curricula, was not familiar to most survey participants.

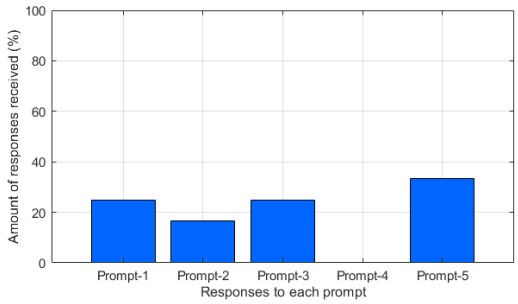
approach ensures that AI is used as a supportive learning tool, helping students gradually familiarize themselves with advanced topics rather than overwhelming them with unfamiliar information.

In conclusion, these findings suggest that for GenAI to be most effective, especially in challenging areas like Quantum Computing, educators must carefully consider prompt complexity and the students' existing knowledge base. By doing so, they can maximize student engagement and facilitate more meaningful interactions with AI, supporting an incremental learning process that aligns with the students' educational level and cognitive readiness.

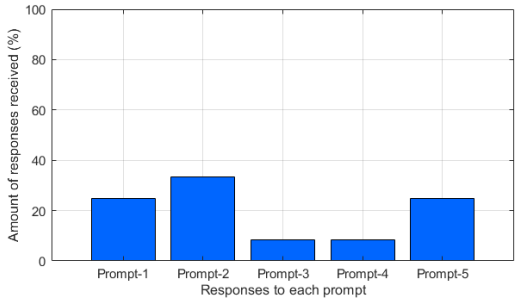
V. Discussion

The integration of Generative AI (GenAI) in education has generated both enthusiasm and concern. While GenAI tools such as ChatGPT, Gemini, Copilot, Perplexity AI, and Sana AI present significant opportunities for enhancing student learning, their educational value ultimately depends on both students' and educators' roles. This study underscores the importance of responsible GenAI use by examining its effects on student engagement and comprehension across familiar and unfamiliar topics.

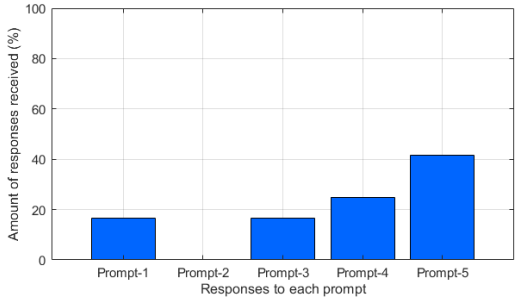
The primary goal of this research was to identify effective ways to incorporate GenAI in students' learning journeys. However, despite the availability of advanced GenAI tools, a gap remains between students' access to these tools and the quality of work they produce. Many educators remain hesitant or even restrict the use of GenAI in academic settings due to concerns about misuse, academic integrity, and dependency. However, with GenAI technology now widely accessible, it is increasingly challenging to restrict its use, particularly as it has become integrated into students' routines.



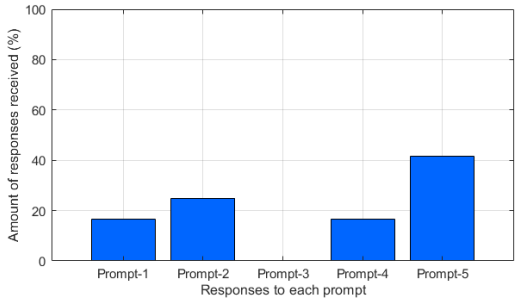
(a) Quantum Computing ChatGPT



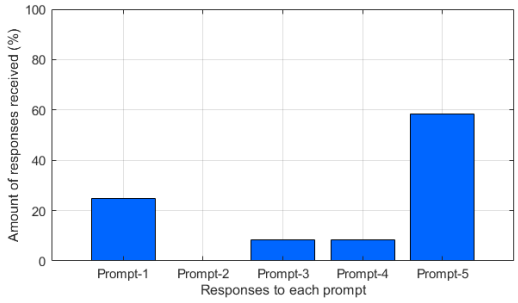
(b) Quantum Computing Gemini



(c) Quantum Computing Copilot



(d) Quantum Computing Perplexity AI



(e) Quantum Computing Sana AI

Fig. 4: The overall preferred prompt and response type from students who participated in the qualitative survey on Quantum Computing—a topic commonly not included in computer, electrical, and electronics engineering curricula—was not familiar to most survey participants.

One of the key findings of this study is the importance of appropriate prompting in maximizing the educational value of GenAI responses. Effective prompting reflects a student's willingness to engage deeply with the material, which, in turn, allows GenAI to generate more human-like or cognitive responses. When students are intentional with their prompts, GenAI can assess the level of understanding required and adjust the complexity of its responses accordingly, much like a human teacher would. This study found that when students were familiar with a topic, such as robotics, they were more likely to choose well-structured prompts, resulting in responses that closely resembled those a teacher might provide—layered, clear, and appropriately detailed.

In contrast, when dealing with a less familiar topic like quantum computing, some students tended to choose simpler, overly general prompts. This approach often led to descriptive or abstract responses from GenAI, which, while easier to understand initially, did not provide an effective entry point for deeper learning. Such responses lacked the foundational context or step-by-step explanations that would support students in building a strong understanding of the subject. Thus, this study emphasizes the need for careful prompt selection, particularly for unfamiliar topics, to ensure that GenAI serves as a productive educational tool rather than a superficial information source.

This research highlights a critical insight: for GenAI to be effective in education, it must be combined with students' foundational understanding of the topic and an instructional framework that fosters analytical thinking and engagement. While prompting techniques and Retrieval-Augmented Generation (RAG) enhance the GenAI response quality, they alone cannot bridge the gap if students lack the necessary knowledge base or approach to learning.

The Cognitive AI Framework offers a valuable tool for integrating GenAI in education. Though not the primary focus here, its five stages—Explore, Engage, Examine, Formulate, and Reflect—provide a structured approach to support cognitive engagement with AI. For instance, students familiar with topics tended to Explore and Engage, while those less familiar often shifted to Examine and Reflect, critically assessing AI outputs but in a more observational role due to limited background knowledge.

Future studies could explicitly use the Cognitive AI Framework to track students' progression through these stages when interacting with GenAI examining the effectiveness of the prompting techniques and Retrieval-Augmented Generation (RAG) in enhancing the GenAI response quality. Research could assess how specific prompts support each stage, fostering exploration, critical analysis, and reflection, especially in unfamiliar subjects. Adaptive prompts tailored to the framework could encourage students to advance through cognitive stages, maximizing AI's role as a tool for exploration and growth.

The framework can also inform AI tool design in education, helping developers and educators create prompts and feedback that align with each cognitive stage, supporting structured and personalized learning, particularly where foundational knowledge is essential.

VI. Conclusion

In conclusion, GenAI holds potential as an educational tool, but its success depends on a balanced approach where students' prior knowledge and engagement strategies are prioritized. Educators play a vital role in guiding students to build the cognitive foundation required to interact meaningfully with GenAI. The study suggests that effective GenAI integration in educational environments requires a focus on these essential pillars of learning: prior knowledge, a structured approach to problem-solving, and engagement. As GenAI tools become increasingly sophisticated, their value will be maximized when students are equipped with the critical thinking skills needed to approach complex subjects with curiosity and discernment, ultimately fostering a more enriched learning experience.

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