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Exploring Student Perceptions And Interactions With Chatgpt In Java Programming Learning

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Abstract

The integration of Artificial Intelligence (AI) tools like ChatGPT is transforming programming education by offering immediate assistance, debugging support, and simplifying complex concepts. This study explores students' experiences and perceptions of using ChatGPT for Java programming assignments in the Integrative Programming and Technologies course. It also examines how students formulate and adjust prompts to optimize ChatGPT's responses and assesses its impact on their understanding of key programming concepts. A qualitative approach using semi-structured interviews with nine participants was adopted, with data analysed through Interpretive Phenomenological Analysis (IPA). The findings show that ChatGPT significantly reduces task completion time, helping students' complete assignments more quickly. Students frequently relied on ChatGPT for coding tasks such as debugging and database integration, improving productivity and minimizing time spent on troubleshooting. However, some challenges arose when ChatGPT provided advanced responses beyond the students' current knowledge. ChatGPT also supported students in understanding complex and advance concepts in Java Programming. The study highlights the importance of clear and specific prompts to optimize ChatGPT's effectiveness. While students appreciated the tool's efficiency, concerns about over-reliance and its potential to hinder independent problem-solving were noted. The study concludes that, while ChatGPT is valuable for enhancing learning efficiency, educators must establish structured guidelines to ensure a balance between AI use and the development of critical thinking skills. This research contributes to the responsible use of AI tools in education, recommending their integration within traditional teaching frameworks to enhance student learning.

Keywords: *Artificial Intelligence(AI); ChatGPT; Java programming; Programming Education; Qualitative Research.*

I. INTRODUCTION

Artificial Intelligence (AI) has significantly transformed various industries, including education, by introducing advanced tools that enhance both learning and teaching practices. In Malaysia, AI is increasingly being integrated into the educational framework, particularly within Technical and Vocational Education and Training (TVET) and polytechnic institutions. This integration supports personalized and adaptive learning experiences, essential for preparing students for the modern workforce [1]. This shift reflects the government's commitment to embedding AI across educational sectors, as seen in recent initiatives to establish the nation's first AI-focused polytechnic and the development of guidelines for responsible ChatGPT usage in higher education [2][3]. However, challenges such as equitable access, digital literacy gaps, educator training, and ethical considerations remain prominent, as Malaysia seeks to make AI-driven education inclusive and culturally sensitive [4],[5].

One of the most influential AI technologies in education today is ChatGPT, a large language model developed by OpenAI. ChatGPT has demonstrated versatility across different educational domains, showing potential as both a teaching assistant for instructors and a virtual tutor for students [6]. It is designed to generate human-like responses, provide real-time answers to complex queries, and support a range of learning activities, making it particularly valuable in programming education [7]. In the context of Java programming, tools like ChatGPT offer personalized assistance by simplifying complex concepts, providing debugging guidance, and delivering immediate feedback [8]. These features could be transformative in Malaysia's polytechnic settings, where students often face

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challenges with core programming concepts. By integrating ChatGPT into Malaysia's educational landscape, institutions have the opportunity to improve learning accessibility and interactivity, though ongoing research and policy considerations are essential for addressing associated challenges [9].

Despite its benefits, there are growing concerns about students' over-reliance on AI tools like ChatGPT in programming courses. In classrooms, students have been observed depending heavily on ChatGPT to complete their coding assignments, with many tasks directly sourced from the platform. This raises concerns regarding the authenticity of their work and the depth of their understanding. Although ChatGPT is encouraged as a learning tool, its use is not sufficiently emphasized in the classroom, limiting its proper integration. Additionally, students sometimes lack knowledge about the appropriate prompts to use in order to generate correct code and fully understand the code they are learning. Research indicates that unclear or inadequate prompting can hinder the effectiveness of AI tools like ChatGPT, leading to incomplete or unsatisfactory outcomes in educational settings. For instance, studies suggest that when students use poorly structured prompts, the AI-generated responses may lack the necessary accuracy and context, impacting their ability to fully grasp the concepts being taught. This is particularly evident in programming education, where detailed and specific prompts are essential for generating relevant code and ensuring students develop a deeper understanding of programming principle [5], [6]. Furthermore, the absence of clear guidelines for using ChatGPT effectively in programming exacerbates the issue. This is especially true for Polytechnic students, as there are no specific findings or comprehensive guidelines available to assist educators in properly integrating the tool into their teaching.

The Malaysian Qualifications Agency (MQA) has recommended that higher education institutions develop clear guidelines for the use of generative AI in teaching, learning, research, and scholarly writing to help align AI usage with program learning outcomes [5]. Without structured guidance, students may misuse the tool, bypass foundational concepts, and develop gaps in their learning. Over-reliance on AI-generated answers, especially for students struggling with programming, could hinder the development of critical thinking and problem-solving skills [10],[11]. The long-term impact of such dependency on students' overall understanding and performance in programming remains a concern. Furthermore, Java programming courses, such as those in Integrative Programming and Technologies, present unique challenges in understanding complex concepts, particularly object-oriented languages like Java [12],[13]. Given these challenges, the role of AI tools like ChatGPT in helping students overcome learning barriers is becoming increasingly important.

This study aims to investigate students' perceptions of using ChatGPT for Java programming assignments within the Integrative Programming and Technologies course. It explores how students interact with ChatGPT, focusing on the effectiveness of prompt strategies in enhancing the tool's responses. Additionally, the study seeks to provide valuable insights for educational institutions on integrating AI tools like ChatGPT effectively, emphasizing balanced use to enhance learning outcomes, foster critical thinking, and support the development of independent problem-solving skills among students.

II. LITERATURE REVIEW

ChatGPT in Programming Education

ChatGPT, developed by OpenAI, has emerged as a transformative tool in programming education, particularly for tackling complex coding challenges. With its ability to generate human-like responses, ChatGPT assists students in debugging, coding, and understanding intricate programming concepts. This is particularly beneficial in subjects like Java programming, which is often challenging due to its syntax, object-oriented principles, and debugging intricacies [7],[8]. ChatGPT simplifies these challenges by breaking them into manageable steps, enabling students to learn independently and at their own pace, fostering a more inclusive learning environment [14],[15].

In Malaysia, the integration of ChatGPT is gaining traction, particularly in Technical and Vocational Education and Training (TVET) settings. Studies show that ChatGPT is particularly effective in providing real-time assistance, allowing students to focus on understanding foundational programming concepts rather than spending excessive time troubleshooting errors [16]. Additionally, ChatGPT has proven its competency in solving programming problems by offering structured and optimized solutions to complex challenges [17]. These features position ChatGPT as a promising tool for addressing programming difficulties in Malaysia's education system.

However, while ChatGPT has been praised for enhancing accessibility and personalizing the

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learning process, its adoption comes with challenges. Over-reliance on AI can hinder the development of critical thinking and problem-solving skills [18]. Furthermore, ethical concerns such as plagiarism and the passive use of AI-generated solutions must be addressed to ensure meaningful learning experiences [19]. Educators in Malaysia are encouraged to implement clear guidelines for using ChatGPT, integrating it as a supplementary resource rather than a replacement for foundational learning activities. This balanced approach can maximize ChatGPT's potential while fostering independent learning and preparing students for a tech-driven future [4].

Challenges in Java Programming

Java programming, as one of the most widely taught programming languages, is often perceived as challenging by students due to its complex syntax, object-oriented principles, and intricate debugging processes [13],[20]. These difficulties highlight the need for innovative tools and strategies to assist students in navigating these complexities. In this context, AI tools like ChatGPT have emerged as valuable resources, offering step-by-step assistance and simplifying the understanding of Java concepts [8],[21].

One major concern is the potential over-reliance on AI tools, which may inhibit the development of critical thinking and problem-solving skills essential for programming [18]. The tendency of students to rely on ChatGPT-generated solutions without fully understanding the underlying concepts also raises ethical concerns, such as plagiarism and academic dishonesty [22]. These issues underscore the importance of integrating AI as a supplementary resource rather than a replacement for foundational learning. Research highlights the need for educators to actively monitor AI usage to ensure students remain engaged in the problem-solving process, which is vital for building long-term programming skills [21].

Despite these challenges, studies have shown that AI tools like ChatGPT can help overcome learning barriers in programming education. By breaking down complex concepts into simpler, manageable components, ChatGPT makes programming more accessible and interactive for learners [7],[14]. Furthermore, the ability of ChatGPT to offer immediate feedback and personalized assistance has been shown to increase engagement and confidence among students [8],[21]. This is particularly valuable for students struggling with Java's intricacies, as it fosters a deeper understanding of the material and supports students in independently navigating programming tasks. However, to maximize these benefits, educators must guide students in using AI responsibly, ensuring that it complements rather than replaces traditional teaching and learning methods [4],[23].

Advantages and Disadvantages of ChatGPT

AI tools like ChatGPT have brought significant benefits to programming education by offering instant feedback and personalized guidance. This helps students resolve errors quickly, navigate coding challenges, and understand complex concepts better. These features are particularly useful in programming subjects, fostering independent learning and boosting student confidence [10],[23]. Additionally, ChatGPT adapts to the diverse needs of learners, making programming education more accessible and efficient [12],[24].

However, over-reliance on AI tools poses challenges. It can limit students' critical thinking and problem-solving skills, essential for programming success [18]. Ethical concerns like plagiarism and misuse of AI-generated content also arise when students fail to fully understand the solutions provided [22],[25]. These risks emphasize the need for educators to guide students in using ChatGPT responsibly as a supportive tool, rather than a substitute for active learning.

While many students appreciate ChatGPT's ability to enhance their learning experience, some remain cautious about its outputs. Misalignment with course objectives or reliance on AI can undermine student confidence in their abilities [26],[27]. Educators must promote a balanced approach to integrating AI tools, encouraging students to critically engage with AI-generated solutions while developing independent problem-solving skills [28],[29].

Prompt Design in Programming

Prompt design plays a crucial role in enhancing ChatGPT's effectiveness for programming tasks. Studies show that carefully crafted prompts significantly improve ChatGPT's performance, especially in coding education. Sun et al. [30] emphasize that prompt-based learning can boost critical thinking skills and improve programming outcomes, calling for further research on the long-term impact of prompts. Liu et al. [31] and Liu et al. [32] found that specific, context-rich prompts improve code generation accuracy, highlighting the importance of optimizing prompt structure for better

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AI results. Additionally, Mnguni et al. [33] advocate for the use of code-to-code prompts, which outperform text-to-code prompts by offering clearer guidance, leading to more accurate and efficient code generation. These findings collectively stress the need for teaching students "prompt literacy" to maximize ChatGPT's potential in programming education.

III. RESEARCH METHODOLOGY

Study Design

This study employs a qualitative approach, specifically using Interpretive Phenomenological Analysis (IPA) to analyze the data collected. IPA is particularly suited for capturing participants' lived experiences and gaining insights into their perceptions and interpretations of phenomena [29]. By using IPA, this research aims to uncover rich, nuanced responses from participants regarding their experiences and interactions with ChatGPT in their Java programming studies. The qualitative approach was selected as it allows for an in-depth understanding of student experiences and perspectives, offering a comprehensive view of the role ChatGPT plays in their educational journey.

Participant Selection and Consent

Participants were selected using purposive sampling, focusing on students who had used ChatGPT in class to complete Java programming assignments. This approach ensured the data collected was relevant to the research question, which sought to understand students' experiences and perceptions of using ChatGPT in learning Java. Among the 14 students who participated in the task session, only 9 were selected for the interviews. This selection was based on the quality of their ChatGPT-generated responses to ensure the interviews provided data that aligned with the study's objectives.

Before the interviews, each participant signed a consent form, confirming their understanding of the study's purpose and agreeing to participate. Confidentiality was prioritized, with appropriate measures in place to protect the participants' personal information and ensure their privacy throughout the research process.

Data Collection Procedure

The data collection process was conducted in several phases to gather comprehensive insights into students' experiences with ChatGPT in their Java programming assignments. First, participants were given a designated period during class time to complete a set of practice questions based on Chapters 1 to 4 of the course material. These questions were the same set that had been previously assigned to the students for completion without using ChatGPT. During this session, students were instructed to complete the tasks exclusively using ChatGPT. Upon completing the tasks, students submitted their responses via a Google Drive link, and the submission times were recorded based on the timestamp provided by Google Drive.

After the task completion, the researcher conducted semi-structured, face-to-face interviews with each participant. The interviews, which lasted between 20 and 40 minutes, allowed participants ample time to reflect on and discuss their experiences using ChatGPT. The interview guide included five main topics: Experience and Activity-Based Questions, Understanding and Learning Questions, Prompt Strategy Questions, Advantages and Disadvantages Questions, and Overall Perspective and Suggestions Questions. These structured areas of inquiry allowed the researcher to capture a wide range of insights while also giving participants the flexibility to elaborate on their thoughts.

IV. RESULT AND DISCUSSION

The analysis of student experiences with ChatGPT in Java programming assignments, conducted through interviews after completing tasks with and without ChatGPT, provides valuable insights into its influence on learning outcomes and students' perceptions. Key themes emerged based on interview topics: Experience and Activity-Based Responses, Understanding and Learning, Prompt Strategies, Advantages and Disadvantages, and Overall Perspectives and Suggestions.

Comparing Task Completion Time

The analysis of the time taken by students to complete assignments with and without using ChatGPT reveals a significant difference in efficiency. As shown in the chart in Figure 1, the average time spent on assignments was notably shorter when students used ChatGPT. On average, students completed their tasks in approximately 52 minutes when using ChatGPT, compared to approximately 121 minutes when completing the same tasks without ChatGPT. The time measured includes both the time spent on inputting answers into the answer sheet and completing the tasks themselves.

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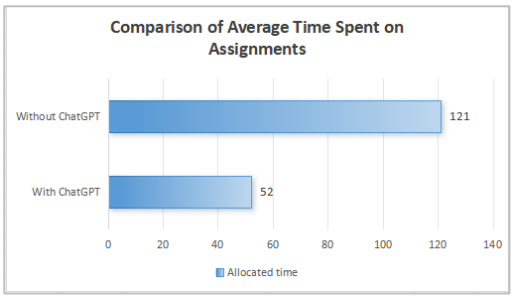

Figure 1: Comparison of Average Time Spent on Assignments

The results demonstrate that ChatGPT has a significant impact on task completion time, helping students' complete assignments more quickly. However, the variation in time taken by different students indicates that ChatGPT's effectiveness may depend on individual usage. This highlights the importance of providing proper guidance to ensure that students use AI tools in a way that complements their learning. Factors such as students' prior experience with programming, their familiarity with AI tools, and their ability to formulate effective prompts all play a role in determining how ChatGPT can be leveraged for maximum benefit [1][20]. While ChatGPT has demonstrated potential in increasing productivity and saving time, educators must ensure that it is used as a tool to enhance learning without fostering over-reliance on the technology [10].

Experience and Activity-Based Responses

The analysis of students experiences shows that ChatGPT is frequently relied upon for coding-related tasks such as debugging, database integration, and interface design. Many students noted that ChatGPT significantly reduced the time required to complete assignments. One student explained, "*Instead of wasting hours fixing syntax errors, ChatGPT identified them immediately*". Another shared, "*It saved a lot of time I would have spent searching online or looking through forums*." This aligns with findings by Castro et al. [27], who reported that ChatGPT enhances productivity by providing quick and accessible solutions for coding challenges. A third participant added, "*I could focus more on understanding the logic behind the code because ChatGPT helped resolve minor issues quickly*." These responses highlight how ChatGPT streamlines the coding process, allowing students to allocate more time to higher-order learning tasks. Similarly, Kadir et al. [7] emphasize that ChatGPT's debugging capabilities enable students to focus on understanding coding logic rather than being hindered by minor syntax errors.

However, students faced challenges when ChatGPT produced outputs that were too advanced or beyond the scope of what they had learned in class. One participant shared, "*The code it generated sometimes included concepts we hadn't learned, making it hard to apply*." Another noted, "*Sometimes the answers were beyond what we covered in class, so I wasn't sure how to apply them.*" This highlights a concern raised by Silva et al. [18], who caution that AI-generated solutions may sometimes be overly complex, necessitating iterative refinement and educator guidance to ensure alignment with the students' academic levels.

Understanding and Learning

The analysis reveals that ChatGPT provided significant support to students in understanding Java programming concepts such as AWT, Swing, Event Handling, and Database integration. Many students expressed that ChatGPT offered clear explanations, enabling them to grasp challenging topics more effectively. For instance, one student remarked, "*It breaks down complex concepts into simpler terms, which helps me get a quick grasp of topics I struggle with*." These observations are consistent with findings by Deriba et al. [8], who highlighted ChatGPT's ability to simplify complex programming topics, making them more accessible to learners. However, some students noted that ChatGPT's responses could be overly technical or advanced, leading to confusion. As one participant explained, "*Sometimes the answers were beyond what we covered in class, so I wasn't sure how to apply them.*" These instances necessitated iterative queries and adjustments to ensure the generated code aligned with their assignments. For example, one student shared that they had to "*…ask ChatGPT to simplify the coding to match what we learned in class.*"

Students generally found ChatGPT accurate in generating basic code solutions, such as creating user interfaces or debugging syntax errors. It was particularly helpful for database connectivity tasks, where several participants highlighted its ability to save time by providing precise step-by-step instructions. As one participant explained, "*ChatGPT really helped with database connection problems by providing clear steps to fix the issue.*" This aligns with Hartley et al. [23], who emphasized the value of AI tools in providing structured and timely guidance for technical tasks. Nevertheless, the need to verify and refine ChatGPT's outputs encouraged students to critically engage with the tool. One participant mentioned, "*Even when I use ChatGPT, I still have to fix parts of the code, and that helps me understand it better.*"

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Overall, ChatGPT positively impacted students' conceptual understanding, particularly for practical applications like database integration and event handling. However, its effectiveness was limited when the tool introduced advanced techniques beyond students' current knowledge. This highlights the importance of guided use, where educators could provide structured support to ensure students leverage ChatGPT effectively while developing their coding and problem-solving skills independently.

Advantages and Disadvantages

The analysis reveals that students find ChatGPT highly useful for completing assignments quickly. Many describe it as a "*...lifesaver during tight deadlines*" due to its ability to provide instant and accessible solutions. One student mentioned, "*ChatGPT helps us learn new things, such as coding in different languages*." Another student noted, "*It helps us with basic coding and makes it easier to understand complex topics because it explains step by step how the code works.*" Students also appreciated how ChatGPT reduced frustration by identifying and resolving errors more efficiently than traditional trial-and-error methods. As one student put it, "*ChatGPT is useful for repetitive tasks and for troubleshooting errors. It saves time and ensures fewer mistakes in our work.*" Additionally, some students found that ChatGPT provided quick solutions, making it easier to complete assignments faster. One student shared, "*ChatGPT provides quick solutions and suggestions, making it easier to complete assignments faster.*" These advantages align with Hartley et al. [23], who highlighted the time-saving benefits of ChatGPT and its positive impact on reducing students' stress during assignments.

However, students also raised concerns about over-reliance on ChatGPT, which they felt could limit their ability to develop independent problem-solving skills. One student admitted, "*I sometimes rely too much on it and feel like I'm not truly learning to solve problems on my own.*" This reflects insights from Chukwuere [26], who warned that excessive dependence on AI tools like ChatGPT might hinder the development of critical thinking and self-reliance in learning processes. Students pointed out that ChatGPT sometimes provides advanced solutions which are not suitable for beginners, with one student mentioning, "*ChatGPT sometimes provides advanced solutions which are not suitable for beginners.*" Another concern was that some of the code generated by ChatGPT required adjustments, especially for more complex tasks. As one student noted, "*Some code generated by ChatGPT requires adjustments, especially for complex tasks like database integration.*" There were also concerns about the specificity of prompts, with a student commenting, "*If the prompt is not specific enough, ChatGPT may give incorrect or irrelevant answers.*"

Students emphasized the importance of critically evaluating ChatGPT's outputs to ensure alignment with course requirements and avoid potential misunderstandings. As one student mentioned, "*ChatGPT cannot replace understanding the core concepts. Over-reliance on it may hinder independent learning*." They also noted that for specific tasks, ChatGPT's solutions might not always meet their needs, and sometimes they would have to refine the results themselves. A student shared, "*For specific tasks, ChatGPT's solutions may not always be what we need, and sometimes we have to refine the results ourselves*." These concerns align with the findings of Silva et al. [18] and Selvanathan and Narayanan [10], who recommended the integration of AI tools into educational frameworks to ensure they complement rather than replace foundational learning. Structured guidance from educators is essential to help students use ChatGPT effectively while fostering independent learning.

Prompt Strategies

The analysis of student prompts highlights the critical role of clear and specific instructions when using ChatGPT for Java programming assignments. Students consistently reported that detailed prompts resulted in more accurate and useful outputs. As one student noted, "*If I just type 'help with database error,' the response is too generic. But when I specify the exact problem, like a 'connection issue in SQL, I get more useful advice*." Furthermore, students emphasized the need for step-by-step guidance in their queries, with one stating, "*I asked for step-by-step guidance, giving simple and basic coding requests to ChatGPT*". When asking for specific tasks, such as centering a button, students had to be precise, with one participant explaining, "*When I needed specific tasks like centering a button, I told ChatGPT to give me the code for that specifically*". Additionally, students adjusted their prompts to ensure clarity, as one remarked, "*I had to ask for simple, basic coding and request explanations with each prompt for clarity*". For more tailored answers, students refined their queries to meet their learning level, with another participant saying, "*When I needed to adjust something, I had to refine my prompts for more specific answers*". These insights underscore the necessity of precise, clear

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prompts to optimize the effectiveness of ChatGPT in programming tasks.

From the prompts analyzed, students used two main strategies. Firstly, students often copied full assignment questions, including detailed descriptions of components such as labels, text fields, and database requirements, into ChatGPT. They iteratively refined the generated outputs, requesting adjustments to align with their desired outcomes. **Figure 2** illustrates an example of a prompt where a complete question is provided to ChatGPT, detailing specific requirements for creating a Java Swing-based registration form and integrating database functionalities. Based on the analysis, students employing this strategy were generally used by students with learning difficulties and less focused during class sessions. This method appeared to be a shortcut for completing tasks without fully understanding the underlying concepts.

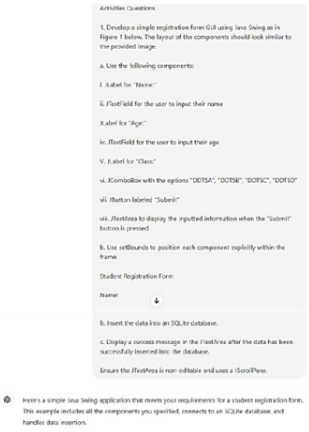

Figure 2 Prompt example - Copying full assignment questions

Students employed a visual-based approach by capturing screenshots or photos of the assignment interface and uploading them to ChatGPT or other generative AI tools to generate the required code. This approach enabled students to first replicate the visual layout of the interface before progressively incorporating functionalities or database integration. By dividing the tasks into smaller, manageable components, students ensured the generated code aligned with their specific requirements. **Figures 3** and **4** illustrate this method, beginning with interface design in **Figure 3** and progressing to database integration in **Figure 4**. This strategy was particularly effective for students who remained focused during class and had a clear understanding of all the topics they had learned.

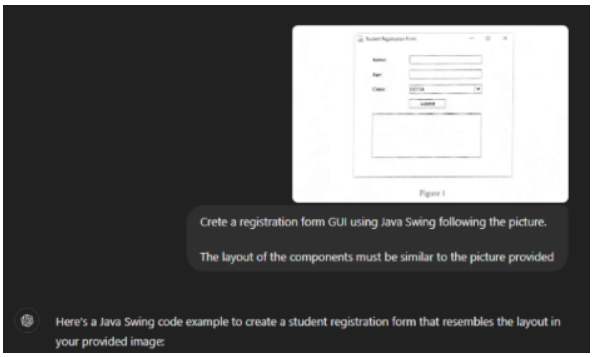

Figure 3 Prompt example - Visual-based prompts

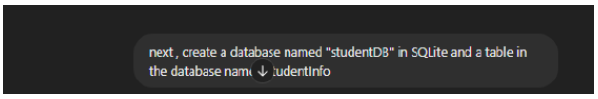

Figure 4 Database creation prompt

Java programming is widely used and integral to computer science education, enabling ChatGPT to generate code, including GUI-focused courses. However, students often rely on overly simplistic or vague prompts, which can hinder ChatGPT's ability to provide accurate solutions. Sun et al. [30] emphasize that unclear prompts may lead to incomplete or inaccurate responses. Liu et al. [31] highlight the need for specific, context-rich prompts to improve the quality of code generation, particularly for complex tasks like GUI programming. Mnguni et al. [33] also stress the importance of detailed prompts to ensure ChatGPT's output aligns with students' expectations and reduces the need for repeated corrections. Furthermore, Liu et al. [32] note that precise prompting significantly enhances ChatGPT's ability to generate relevant code, especially for advanced programming concepts.

Overall Perspectives and Suggestions

Most of the students responded positively to the effectiveness of ChatGPT, particularly in enhancing productivity and comprehension, especially for tasks like debugging and learning new coding concepts. One student remarked, "*ChatGPT makes it easier to understand complex topics because it explains step by step how the code works*." However, they emphasized the importance of balanced usage, highlighting that while ChatGPT is helpful, it should complement traditional learning rather than replace it. Another participant suggested, "L*ecturers should create guidelines to help us understand when and how to use ChatGPT appropriately.*" Many participants highlighted that ChatGPT is particularly beneficial for repetitive or foundational tasks, such as writing code templates or troubleshooting errors.

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However, they stressed the need for assignments that require critical thinking and independent problem-solving to balance AI assistance. One student shared, "*ChatGPT is useful to start assignments, but lecturers should focus on tasks that make us think critically, especially in exams*." This reflects a consensus that AI tools should aid skill development without fostering dependency. Several students also emphasized that ChatGPT should not be used as a replacement for engagement with core learning concepts. As one student mentioned, "*I think it's useful, but it should be used for support, not as a shortcut to doing the work*."

The findings suggest that educators need to integrate ChatGPT into their teaching strategies responsibly. Structured guidelines and activities that blend AI usage with traditional teaching can enhance learning efficiency while preserving academic integrity. For instance, ChatGPT can be incorporated into collaborative coding exercises where students critically evaluate AI-generated outputs [1][4]. These measures can ensure students leverage ChatGPT as a complementary tool while maintaining focus on core programming skills and ethical considerations, aligning its use with broader pedagogical goals [11].

V. CONCLUSION

This study highlights the transformative role of ChatGPT in Java programming education, particularly within courses like Integrative Programming and Technologies. ChatGPT is frequently relied upon for debugging, database integration, and interface design tasks, enabling students to save time and reduce frustration. Students reported that ChatGPT helped streamline their coding processes, allowing them to focus on understanding programming logic and higher-order learning tasks [7],[27]. By providing immediate feedback and personalized guidance, ChatGPT simplifies complex concepts, making programming more accessible and interactive [10],[14].

However, over-reliance on ChatGPT remains a significant concern. Some students admitted to relying too heavily on the tool, potentially limiting their critical thinking and independent problem-solving skills [23],[26]. Additionally, ChatGPT sometimes produces outputs that are overly advanced or misaligned with the students' academic level, requiring iterative refinement to align with coursework requirements [8],[22]. These findings underscore the need for structured guidelines to ensure that ChatGPT is used as a supplementary tool, fostering balanced engagement and deeper conceptual understanding [24],[25].

To address these challenges, educational institutions should implement clear frameworks for integrating ChatGPT into programming curricula. These frameworks must emphasize responsible use, focusing on AI literacy and prompt-crafting skills to help students critically evaluate and refine the tool's outputs [18]. Furthermore, incorporating independent problem-solving tasks can complement ChatGPT's benefits, ensuring students actively engage with programming concepts rather than passively relying on AI-generated solutions [4],[28].

The study also highlights students' positive perceptions of ChatGPT, particularly its ability to provide immediate feedback and improve productivity. However, educators must strike a balance to prevent dependency and ensure ChatGPT enhances, rather than replaces, traditional learning methods. By fostering responsible integration and encouraging active learning, ChatGPT can be a powerful tool for improving programming education outcomes while maintaining academic integrity and skill development [10],[21].

Future research should explore how long-term use of ChatGPT affects students' programming skills, including problem-solving, conceptual understanding, and knowledge retention. Experimental studies should be conducted to evaluate the impact of structured ChatGPT usage guidelines on improving learning outcomes, fostering academic integrity, and encouraging independent coding skills [18]. For instance, controlled experiments could compare student performance in environments with and without specific guidelines for ChatGPT integration.

Additionally, research should focus on integrating ChatGPT with other educational technologies to create personalized and adaptive learning environments. Experimental frameworks can assess how combining ChatGPT with traditional teaching tools influences engagement, comprehension, and performance. Special attention should be given to addressing digital literacy gaps in Technical and Vocational Education and Training (TVET) and polytechnic institutions, ensuring equitable access and effective use of AI tools in education [1],[14]. Such experiments could involve pilot programs to measure the effectiveness of AI-enhanced teaching methods in diverse educational settings.

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