Exploring the Effectiveness of AI-Enabled Microlearning in Database Design and Programming Course

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***Abstract*—In this research-to-practice full paper, we explored the perceptions of AI-enabled microlearning as an instructional approach in a second-year introduction to database design and programming course for new technology primary students at an urban Midwestern university. This pilot study was built upon our prior work, where we identified the microlearning instructional design practices to maximize student learning outcomes ([1]–[3]). Our analysis of this study was based on the students' perceptions survey (n=23) and twelve semi-structured interviews. The following research questions guided this study:**

1) **What are students' overall perceptions of the effectiveness of the AI-enabled microlearning approach?**
2) **What are the perceived benefits and challenges of using an AI chatbot in microlearning modules?**

Using a single case study design, we collected student perceptions through a survey and semi-structured interviews with novice data science students. The results revealed mixed opinions about the effectiveness of the AI-enabled microlearning approach. Although students initially approached the tool with curiosity and interest, they encountered challenges due to its inconsistent and sometimes inaccurate responses. Nevertheless, participants recognized the potential of the AI tool in simplifying concepts and delivering prompt feedback, particularly for basic database queries. However, the AI tool's limitations in handling complex queries and technical errors affected its reliability. This pilot study emphasizes the need to refine AI tools to improve accuracy, consistency, and contextual understanding while incorporating interactive features and human support. Addressing these challenges would allow educators to harness AI tools more effectively for personalized, technology-enhanced learning in database management and other technical courses. Overall, the findings highlight the potential of AI-enabled microlearning as a valuable instructional approach for teaching introductory programming concepts, with key implications outlined in the study.

***Index Terms*—AI-enabled Learning, Microlearning, Database Programming**

I. Introduction

The databases and data management field are constantly changing due to the emergence of big data and AI-enhanced technologies. Education must also be transformed appropriately to keep up with the new paradigms in developing data-management strategies and systems. CIT 21400 - Introduction to Data Management is a fundamental course for our technology primary students at our university, as it helps students develop the ability to solve problems and design appropriate solutions. For novice programmers, learning SQL (Structured Query Language) programming and logical database design concepts is a challenging task because while writing SQL programs, students not only have to apply theoretical concepts such as syntax and semantics but also practical concepts such as problem-solving at the same time, which results in cognitive overload. Over time, the CIT 21400 curriculum has evolved from implementing the flipped classroom, asynchronous online class with recorded video lectures and microlearning instructional approach during the COVID-19 pandemic. However, in the Spring 2023 semester, approximately 18% of students did not complete the course successfully, indicating a further need for improvement in the pedagogical approach and instructional design. To improve students' learning experience and engage them better as they learn and apply the foundational database concepts, in spring 2024, we redesigned CIT 21400 through AI-enabled microlearning-based instruction based on student needs and course learning objectives. Microlearning allows students autonomy to learn quickly and immediately by applying the knowledge they acquired. In the microlearning approach, only the must-know information about a single topic is delivered in a focused manner, taking less than 15 minutes to complete. Thus, it prevents students from feeling overwhelmed or bored while promoting effective learning and providing a sense of autonomy during the learning process. Our previous work shows that microlearning improves students' performance and that students prefer microlearning over traditional learning ([1]–[3]).

In this pilot study, we explore the possibility of incorporating an AI-enabled agent with our microlearning-based pedagogical approach to provide students with personalized adaptive feedback in real time. With this goal in mind, in our pilot study, we evaluated the effectiveness and challenges of incorporating an AI-based conversation agent to assist students in learning database programming in the CIT 21400 course.

II. Literature Review

A. Microlearning Instructional Approach

Microlearning is "an instructional strategy where the learning content is divided into small, focused activities and delivered digitally in an easily digestible form that is outcome-oriented" ([4], p. 261). Earlier studies have highlighted the potential of microlearning, which leverages short, focused learning modules to engage students, lower cognitive load, and maintain motivation ([1]–[3]).

The microlearning instructional approach has recently gained traction in computer science and IT education. For instance, Gherman and Turcu [5] note that the COVID-19 pandemic has rapidly accelerated the adoption of digital technologies into higher education, necessitating new pedagogical strategies to help Generation Z students effectively acquire relevant knowledge and skills. The authors note that microlearning, which structures content into digestible, focused segments, has emerged as a promising approach among Generation Z learners. They proposed a personalized learning system that adapts to individual student needs to enhance engagement and compensate for gaps in educational background [5].

B. Use of AI-based tools in teaching and learning CS&IT Education

Artificial Intelligence (AI) tools have increasingly been applied in computer science (CS) and information technology (IT) education. AI-based tools offer students personalized support and real-time feedback, allowing them to work at their own learning pace [6]. These tools can help generate code, identify errors, and provide suggestions to help students write accurate, efficient code while reducing the effort needed to complete assignments. This personalized support enhances computational thinking skills and builds confidence in programming abilities.

Despite these advantages, many students face low programming self-efficacy and a lack of motivation (e.g., [7]). Research in this area remains limited, particularly concerning the long-term effectiveness of tools like ChatGPT. Although review articles have explored the potential of AI in education [8], [9], there is a need for empirical research to understand its influence on learning processes fully.

Wang and colleagues [10] highlighted the importance of developing effective AI tools in programming education to address concerns related to academic integrity. They proposed redesigning curricula to emphasize computational thinking rather than repetitive coding tasks [10]. Alternative assessments, such as collaborative assignments and open-ended projects, can provide authentic learning experiences while measuring student understanding and concept application [10]. Understanding instructors' perspectives is crucial in devising strategies to integrate AI tools effectively into courses.

Likewise, Okonkwo and Ade-Ibijola [11] note that AI tools have already transformed traditional teaching methods. Personalized learning, automated administrative tasks, and interactive digital content generation create new opportunities for educators to streamline their work and offer tailored support. AI-based chatbots engage students in problem-solving and personalized guidance, converting static lectures into interactive dialogues. However, gaps in practice remain, particularly in how students perceive these tools. Kosar and colleagues identified challenges and opportunities presented by AI-based chatbots powered by Large Language Models (LLMs) like GPT-3 [12]. AI tools like ChatGPT can assist debugging, promptly provide accurate answers, and facilitate code comprehension. However, concerns remain about its potential to contribute to laziness and impair critical thinking. Such issues necessitate methodological shifts to better align assessment and teaching strategies with AI's influence on programming education. To address these challenges, [13] proposed the design of AI-based chatbots that prioritize emotional and personalized engagement to help students overcome programming difficulties. Their chatbot solution emphasizes continuous practice over memorization, reinforcing a deeper understanding of programming principles.

Overall, the literature consistently indicates that AI tools have significant potential in CS and IT education. Nevertheless, there is a clear need for empirical research that explores student perception of the AI tools to effectively utilize them in teaching and learning CS & IT education. This inquiry assesses the effectiveness and challenges of incorporating AI agents into teaching database programming courses.

III. Theoretical Framework

In addition to the cognitive theories of learning that underpin the microlearning instructional approach discussed in the earlier studies ([1]–[4]), the Technology Acceptance Model (shown in Figure 1) has guided the AI-based microlearning approach used in this pilot study.

Fred Davis developed the Technology Acceptance Model (TAM) theory in the late 1980s to understand the processes influencing the acceptance and adoption of new technology [14]. TAM could help us understand how perceived ease of use and usefulness influence the acceptance of technology-enhanced learning tools like AI-enabled microlearning in teaching and learning. [15] note that the primary objective of TAM was to provide theoretical insights into how users perceive technology, predict their behavior, and guide the successful implementation of systems. Perceived usefulness is the degree to which an individual believes that using a particular technology enhances their performance [14], and its conceptualization aligns with Bandura's concept of outcome judgment. Perceived ease of use relates to a person's belief that using a given system will be effort-free, stemming from Bandura's concept of self-efficacy [16]. Both constructs were pre-tested and validated through empirical research, revealing a strong correlation with user behavior or intention to use the technology [15]. TAM posits that external system features influence cognitive responses, shaping an individual's attitude toward technology use. This, in turn, affects the intention to use and actual usage behavior [17].

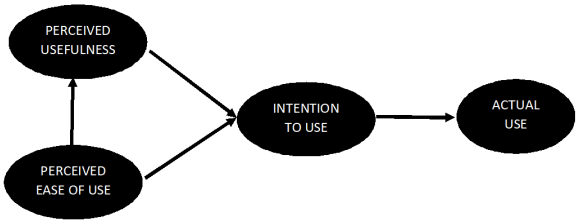

Fig. 1. Technology Acceptance Model (Adapted from Marikyan Papagiannidis, 2023 [15])

IV. Method

This pilot study used a single case study approach [18] to answer the below research questions:

1) What are students' overall perceptions of the effectiveness of the AI-enabled microlearning approach?
2) What are the perceived benefits and challenges of using an AI chatbot in microlearning modules?

We used a student perceptions survey (see Appendix A for survey instrument) to collect students' perceptions about AI-enabled microlearning design and twelve semi-structured interviews (See Appendix B for Interview Protocol) to collect students' detailed experience of the AI-based Microlearning approach. The unit of analysis, or the case, is the introductory database programming classroom. The participants were the 23 students in their sophomore year. They had little to no prior experience with database programming concepts.

This pilot study was conducted in an introductory database programming class designed to teach Structured Query Language (SQL) and database design concepts to undergraduate students at a midwestern university in the United States. This course was structured in a fifteen-week semester format. After finalizing the course learning outcomes, we revamped CIT 21400 to align with the intended learning objectives. Specifically, we designed microlearning modules and micro lessons to deliver course content. Drawing from the literature, we identified inherent principles for creating effective microlearning instruction (e.g., [19]). The course content was divided into ten distinct course topics. We created ten microlearning modules for each topic from pre-recorded video lectures using the Articulate Rise 360 tool—an instructional design platform. We chose Rise 360 for its convenient website-like interface, ease of creating modular course structures, and responsiveness across different screen sizes and devices (including mobile, laptop, and tablet). The course utilized the canvas LMS to deliver the course content and to assess the students' learning.

In addition to the microlearning intervention, we incorporated an AI-based conversation agent named "SQL Pal" for the "Module 5: Multiple Table Queries" topic using the Poe application (See Figure 2). Poe is a platform for people to discover and chat with AI-powered bots. In addition to providing access to popular bots, Poe allows any individual or business to create new Conversational-based agents. Conversational-based agents (CBAs) provide an interactive assessment environment that facilitates student-computer interactions, evaluates their

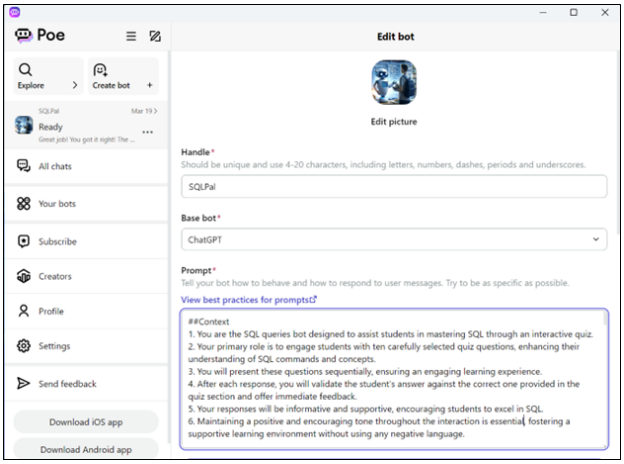

Fig. 2. SQLPal – Poe Application

learning, and offers automated or adaptive feedback to enhance student learning and deliver timely evaluations [20]. Thus, conversational agents advance computer-based assessment by integrating interactive feedback to enhance student learning. Figure 3 depicts the SQLPal Chat Interface.

A. Perception Survey

To capture the students' perceptions using AI-based microlearning instruction, a 9-item survey instrument questionnaire (see Appendix A for the survey instrument). The survey aimed to gather insights on students' perceptions of AI chatbots for learning, the effectiveness of the AI chatbot in aiding the understanding of multiple-table queries, its clarity in explanations, and the accuracy of its feedback. The survey also identified the primary benefits and challenges faced by students using the AI tool and solicited suggestions for its improvement in future database management courses. This survey was created and administered using the Qualtrics application and distributed to students in Week 10. An expert reviewed the survey instrument, and validity and reliability checks were conducted on the survey questions. The overall internal reliability of the survey instrument was high (alpha = 0.87).

B. Semi-structured Interviews

While the survey responses could help with whether AI-based microlearning was a viable strategy for understanding database concepts, the semi-structured interviews could help understand why AI-based microlearning may or may not be a viable strategy for understanding database programming concepts. Through these semi-structured interviews, participants explained in detail how they experienced AI-based microlearning as an instructional method and whether it aligned with their expectations. For the pilot study, the researcher conducted 12 semi-structured interviews with the students at the end of the Spring 2024 semester. The pilot interview questions mainly focused on their experiences using AI-based microlearning related to their learning performance, challenges faced while

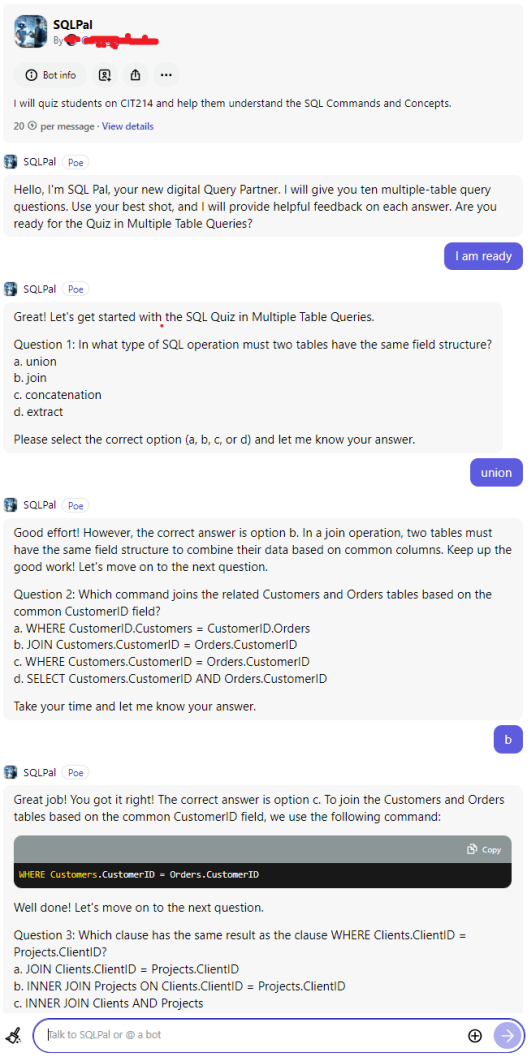

Fig. 3. SQLPal – Chat Interface

using microlearning content, and the usefulness of microlearning content to support their understanding of database concepts (See Appendix B for pilot interview protocol). These pilot interviews are recorded, transcribed, and member-checked.

C. Data Analysis

We used descriptive statistics to analyze the perceptions survey data. The semi-structured interviews verbatim were analyzed using Braun and Clarke's six-phase thematic analysis approach [21]. A coding scheme was developed to identify themes for improving the AI-based microlearning modules. The perception survey results and pilot interview findings suggested improvements and changes for future implementation.

V. Results

Below, we share the findings with respect to the two research questions: (RQ1) What are students' overall perceptions of the effectiveness of the AI-enabled microlearning approach?

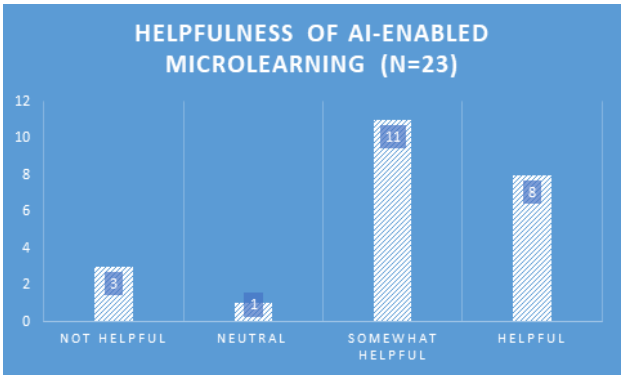

Fig. 4. Helpfulness of AI-Enabled Microlearning

And (RQ2) What are the perceived benefits and challenges of using an AI chatbot in microlearning modules?

(RQ1) What are students' overall perceptions of the effectiveness of the AI-enabled microlearning approach?

The data collected from the survey and interview responses indicate that students had mixed perceptions about the effectiveness of the AI chatbot/tutor in the microlearning modules. While some students found the AI helpful and appreciated its explanations and examples, others experienced challenges with the accuracy and consistency of the AI's responses.

A significant portion of students (83%) found the AI chatbot/tutor to be "somewhat helpful" or "helpful" in understanding multiple-table queries. Regarding the clarity of explanations provided by the AI, 31% of students agreed or strongly agreed that the AI provided clear and understandable explanations, while 23% disagreed or strongly disagreed.

The feedback on the AI's accuracy was divided. While approximately one-third (31%) of the respondents stated that AI response was "mostly accurate," another 43% of students indicated that the AI was "sometimes accurate/inaccurate. Another 17% found it "mostly inaccurate." This inconsistency in the AI's performance was a common theme in the responses, with several students reporting that the AI would sometimes provide incorrect answers or mark their correct answers as wrong.

(RQ2) What are the perceived benefits and challenges of using an AI chatbot in microlearning modules?

Students revealed several perceived benefits and challenges of using the AI chatbot in microlearning modules. Regarding the perceived benefits of using AI-enabled microlearning, one of the students stated,

"AI gave good explanations of what or why it may be wrong, *but it wasn't able to accurately connect my answers to the correct answers. It was also nice being able to ask questions as well as get a summary when it its over.*"

Another student mentioned, *"There were some queries that I didn't fully understand, like left join, for example. When I asked the chatbot it did help a lot, giving a solid example when I asked it to give me a simple example."*

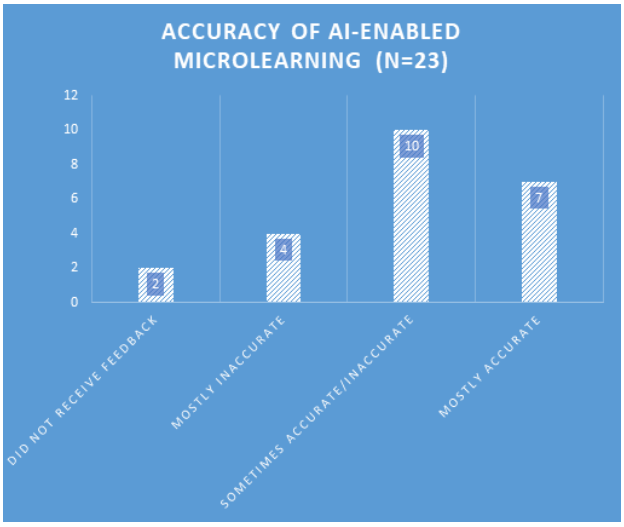

Fig. 5. Accuracy of AI-Enabled Microlearning

Some of the perceived benefits mentioned by the participants included:

- Providing explanations, examples, and breaking down concepts (mentioned by multiple students)
- Allowing students to ask questions and receive feedback instantly.
- Helping students understand the reasoning behind correct answers.

Likewise, when asked about the perceived challenges of using AI-enabled microlearning, one of the students mentioned, *"There were multiple challenges. For example, I answered one question correctly, yet it said I got it incorrect, and in that very same explanation chat, it explained what the correct answer was."*

Another student echoed the same sentiment: *"The chatbot was inconsistent with its answers. When I was getting quizzed by it, a couple of answers I was certain were correct were marked wrong."*

One of the students summarized, *"The main challenge was the AI's limited ability to understand context and provide detailed explanations, especially for complex queries."*

Some of the perceived challenges included:

- Inaccuracy and inconsistency in the AI's responses (mentioned by multiple students)
- Inability to recognize correct answers or variations in answer format.
- Difficulty in understanding context or handling complex queries.
- Lack of trust in the AI's responses due to frequent errors

Several students suggested improvements for future use, such as improving the accuracy and consistency of the AI's responses, recognizing variations in answer formats, and providing more examples and explanations before presenting questions.

For example, one of the student participants stated,

"Improvements for the AI chatbot/tutor could include enhancing its ability to handle complex queries, adding interactive features like quizzes, and providing access to human instructors for personalized assistance."

In summary, while students acknowledged the potential benefits of using an AI chatbot in microlearning modules, the perceived effectiveness was limited by issues with accuracy, consistency, and the AI's ability to handle complex queries or variations in user inputs.

VI. Discusssion

Survey and interview data revealed that students perceive AI-enabled microlearning as beneficial due to its personalized and adaptive nature. In the context of the Technology Acceptance Model (TAM), the perceived usefulness of AI-enhanced microlearning derives from its formative assessment capabilities, which align with student preferences for timely, personalized feedback. The perceived ease of use is evidenced by students' appreciation of how AI tailors the learning experience to their needs and adapts the feedback to inform their progress.

Students build knowledge by interacting with microlearning modules, which provide personalized, relevant, and contextualized content. These AI tools promote learning by allowing students to engage with material at their own pace while constructing their understanding based on the immediate feedback they receive.

These findings are consistent with existing research that underscores the value of microlearning in enhancing student engagement and motivation (e.g., [20]). Combined with formative assessment, AI enriches the learning experience by adapting instruction to individual learning needs, as supported by studies advocating for adaptive technologies in education. Such technologies provide personalized and context-aware feedback, helping students grasp complex programming concepts and offering clarity in their progress.

This study has an important implication for educators teaching introductory programming courses. In line with TAM and constructivist learning theory, implementing AI-enabled microlearning can enhance perceived usefulness and ease of use, thus improving learning outcomes by tailoring educational content to student needs. However, technical clarity and troubleshooting support should be addressed to ensure these technologies maintain their perceived ease of use. Clear guidelines and supportive resources would help students better navigate the adaptive learning environment and derive maximum benefit from these AI-enabled tools.

VII. Conclusion

Our earlier work established the benefits of microlearning instructional design in enhancing student learning outcomes. In this pilot study, we explored how AI-enhanced microlearning approaches affect student learning and perceptions in an introductory database management course. The participants noted that the immediate feedback and personalized pathways of AI-enabled microlearning are particularly beneficial. Having said

that, many challenges must be addressed before implementing this as an instructional approach. Moreover, the study's single-case focus and sample size limit the findings' generalizability. Future research could explore similar approaches in other courses and institutions to establish broader applicability.

APPENDIX

A. Perceptions Survey

1) Before this course, have you used an AI chatbot/tutor for learning purposes?
   a) Yes
   b) No
2) How would you rate your proficiency in database management before this course?
   a) Beginner
   b) Intermediate
   c) Advanced
3) How frequently did you use the AI chatbot/tutor during the multiple-table query unit?
   a) Not at all
   b) Rarely
   c) Sometimes
   d) Often
   e) Very Often
4) How helpful was the AI chatbot/tutor in understanding multiple-table queries?
   a) Not helpful
   b) Somewhat helpful
   c) Neutral
   d) Helpful
   e) Very helpful
5) To what extent do you agree with the following statement: "The AI chatbot/tutor provided clear and understandable explanations."
   a) Strongly disagree.
   b) Somewhat disagree.
   c) Neither agree nor disagree
   d) Somewhat agree
   e) Strongly agree
6) Which of the following best describes your experience with the AI chatbot/tutor's feedback on your queries?
   a) Always accurate
   b) Mostly accurate
   c) Sometimes accurate/ inaccurate
   d) Mostly inaccurate
   e) Always inaccurate
   f) I did not receive feedback
7) What was most beneficial about using the AI chatbot/tutor for learning multiple-table queries?
8) Did you face any challenges while using the AI chatbot/tutor? Please describe.
9) How do you think the AI chatbot/tutor could be improved for future use in database management courses?

B. Interview protocol

1) Initial Impressions:
   - What were your first thoughts when you started using the AI chatbot/tutor in this course?
2) Effectiveness:
   - Can you give an example of how the AI chatbot/tutor helped or didn't help you understand multiple-table queries?
3) Feedback Quality:
   - How did you find the AI chatbot/tutor feedback on your queries?
4) Challenges:
   - What challenges did you encounter while using the AI chatbot/tutor?
5) Improvements:
   - What improvements would you suggest for the AI chatbot/tutor in future database management courses?

REFERENCES

[1] S. Mithun and R. Sankaranarayanan, "Integrating microlearning instructional approach into an introductory data-management course," in *2023 ASEE Annual Conference & Exposition*, 2023.

[2] R. Sankaranarayanan, M. Yang, and K. Kwon, "Exploring the role of a microlearning instructional approach in an introductory database programming course: An exploratory case study," *Journal of Computing in Higher Education*, 2024.

[3] R. Sankaranarayanan and S. Mithun, "Exploring the differences in student perceptions and student performances using microlearning instruction and video lectures: A comparison study," in *2023 IEEE Frontiers in Education Conference (FIE)*, 2023.

[4] R. Sankaranarayanan, J. Leung, V. Abramenka-Lachheb, G. Seo, and A. Lachheb, "Microlearning in diverse contexts: A bibliometric analysis," *TechTrends*, vol. 67, no. 2, pp. 260–276, 2023.

[5] O. Gherman, C. E. Turcu, and C. O. Turcu, "An approach to adaptive microlearning in higher education," *arXiv preprint arXiv:2205.06337*, 2022.

[6] R. Yilmaz and F. G. K. Yilmaz, "The effect of generative artificial intelligence (ai)-based tool use on students' computational thinking skills, programming self-efficacy and motivation," *Computers and Education: Artificial Intelligence*, vol. 4, p. 100147, 2023.

[7] M. Liu, L. Liu, Z. Lv, F. Ma, Y. Mao, and Y. Liu, "Effects of burnout and work engagement in the relationship between self-efficacy and safety behaviours—a chained mediation modelling analysis," *Journal of Advanced Nursing*, vol. 80, no. 4, pp. 1473–1483, 2024.

[8] E. Kasneci, K. Seßler, S. Küchemann, M. Bannert, D. Dementieva, F. Fischer, U. Gasser, G. Groh, S. Günnemann, E. Hüllermeier *et al.*, "Chatgpt for good? on opportunities and challenges of large language models for education," *Learning and individual differences*, vol. 103, p. 102274, 2023.

[9] A. Tlili, R. Huang, M. Y. Mustafa, J. Zhao, A. Bozkurt, L. Xu, H. Wang, S. Salha, F. Altinay, S. Affouneh *et al.*, "Speaking of transparency: Are all artificial intelligence (ai) literature reviews in education transparent?" *Journal of Applied Learning and Teaching*, vol. 6, no. 2, 2023.

[10] T. Wang, D. V. Díaz, C. Brown, and Y. Chen, "Exploring the role of ai assistants in computer science education: Methods, implications, and instructor perspectives," in *2023 IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC)*. IEEE, 2023, pp. 92–102.

[11] C. W. Okonkwo and A. Ade-Ibijola, "Revision-bot: A chatbot for studying past questions in introductory programming." *IAENG International Journal of Computer Science*, vol. 49, no. 3, 2022.

[12] T. Kosar, D. Ostojić, Y. D. Liu, and M. Mernik, "Computer science education in chatgpt era: Experiences from an experiment in a programming course for novice programmers," *Mathematics*, vol. 12, no. 5, p. 629, 2024.

[13] M. Ismail and A. Ade-Ibijola, "Lecturer's apprentice: A chatbot for assisting novice programmers," in *2019 international multidisciplinary information technology and engineering conference (IMITEC)*. IEEE, 2019, pp. 1–8.
[14] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology," *MIS quarterly*, pp. 319–340, 1989.
[15] D. Marikyan, S. Papagiannidis, and G. Stewart, "Technology acceptance research: Meta-analysis," *Journal of Information Science*, p. 01655515231191177, 2023.
[16] A. Bandura, "Self-efficacy mechanism in human agency." *American psychologist*, vol. 37, no. 2, p. 122, 1982.
[17] F. D. Davis, "User acceptance of information technology: system characteristics, user perceptions and behavioral impacts," *International journal of man-machine studies*, vol. 38, no. 3, pp. 475–487, 1993.
[18] R. K. Yin, *Case study research: Design and methods*. sage, 2009, vol. 5.
[19] I. Jahnke, Y.-M. Lee, M. Pham, H. He, and L. Austin, "Unpacking the inherent design principles of mobile microlearning," *Technology, Knowledge and Learning*, vol. 25, pp. 585–619, 2020.
[20] S. Yildirim-Erbasli, C. D. Epp, O. Bulut, and Y. Cui, "Design and evaluation of a conversational agent for formative assessment in higher education," in *Proceedings of the 17th International Conference of the Learning Sciences-ICLS 2023, pp. 194-201*. International Society of the Learning Sciences, 2023.
[21] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qualitative research in psychology*, vol. 3, no. 2, pp. 77–101, 2006.