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Aims and Scope

Journal of Information Technology and Education System aims to provide a platform for the analysis of the latest theories, applications, and services related to developing, managing, using, and evaluating information technologies in administrative, academic, and research, as well as other educational technologies. Publishing research articles detailing the new uses of technology in education, case studies detailing examples of technology applications in higher education; and in-depth analyses of the latest theories, applications and services in this field. The journal provides wide-ranging and independent coverage of the management, use and integration of information resources and learning technologies.

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POTENTIALS OF CHATGPT IN COMPUTER PROGRAMMING: INSIGHTS FROM PROGRAMMING INSTRUCTORS

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ABSTRACT

Aim/Purpose *This study aims to investigate the perceptions of programming instructors among the Information Technology faculty members at AL al-Bayt University regarding the effectiveness of ChatGPT in supporting the programming instructional process. This study also aims to explore their experiences concerning the potential benefits and adverse impacts of such technology on students and instructors.*

Background *Successfully integrating ChatGPT into programming instruction requires ad dressing its advantages, disadvantages, and concerns of such emerging AI-based technology. However, balancing the advantages and disadvantages, as well as addressing the concerns of using ChatGPT, poses critical challenges. This research posits that the appropriate use of ChatGPT for programming instruction, along with a careful weighing of its potential benefits against potential negative impacts, presents a promising solution and is essential for its success. However, little is known about integrating ChatGPT into programming instructional methods and their possible effects because of insufficient results from the literature for generalization. Pedagogical designs considering teaching strategies and appropriate measures should be added to the literature on integrating AI chatbots for programming instruction.*

Methodology *The research data were collected in this study through in-depth interviews with programming instructors from the School of Information Technology at AL alBayt University. A qualitative research design was adopted in this study to arrive at in-depth perceptions of IT programming instructors on integrating ChatGPT into programming instruction. Convenience sampling was used to select 12 programming instructors among IT faculty members who had familiarity with ChatGPT during their programming instruction experience. A total of 26 one on-one interviews with the participants were conducted personally to elicit de tailed and precise information on the advantages and disadvantages of using ChatGPT for programming instruction. Each interview consisted of questions that aimed to investigate the opinions and experiences of programming instructors on ChatGPT's potential and capabilities to complement traditional teaching methods, enhance students' programming learning, and support instructors in their instruction. The data were accurately read and coded to identify relevant themes and patterns from the participants' answers to the research questions. A qualitative thematic analysis was conducted to analyze the collected transcribed data through participant interviews.*

Contribution Recommendations for Practitioners This study is the first to focus on the perceptions of programming instructors and contributes to the ongoing discourse on the integration of AI, particularly ChatGPT, in programming education. The contribution lies in highlighting the positive and negative aspects of using ChatGPT and discussing the potential complementary role of ChatGPT alongside

traditional teaching methods. The participants' perceptions reported by this study provide valuable insights and evidence that could serve as a guide for the programming instructional process.

Findings *The perceptions result in this study demonstrated several advantages of ChatGPT that make it useful for the programming instruction process, including practical code applications, personalized and interactive learning, a wide range of programming problems and alternative solutions, accessibility, no programming knowledge required, debugging and feedback capabilities, and clear code explanations. Indeed, the perceptions of the participants revealed that ChatGPT can enhance students' learning by providing personalized and interactive programming practices, assisting them in coding and program writing, helping them practice the best solutions for real-life programming problems, and creating their own programs and solutions. The participants' perceptions also revealed the ability of ChatGPT to support the efficiency of programming instructors and save their time and effort by providing new instructional practices, helping address the individual learning needs of their students, assisting in performance assessment, and recommending lesson plans and teaching strategies. By contrast, several perceptions on the potential drawbacks and negatives of using ChatGPT in programming education were reported, including inaccurate responses, undesired responses, response integrity, limited programming resources, technology limitation, unstructured learning, and a lack of real programming elements. Similarly, several concerns were revealed, including ethical and transparent use, privacy and security of students' data, social impact and replacement of human interaction, overreliance, and controlling students' online behavior. Overall, the participants suggested a complementary role for ChatGPT that balances its potential benefits against its negative impacts to best enhance traditional programming teaching methods.*

Recommendations for Practitioners *The perceptions recommend practitioners develop new teaching strategies, cur riculum designs, in-class activities, and course outlines for programming curricula incorporating ChatGPT efficiently. Practitioners also need to mitigate the adverse effects of ChatGPT and embrace such AI technologies rather than banning them in several ways. Additional effort is required from instructors to assign programming tasks that require applying programming knowledge and critical thinking instead of simple or trivial tasks that can be obtained directly. Instructors and students should be upskilling their competencies and practices to meet the critical thinking and question-asking competencies required to satisfy the new demands of AI technology with appropriate support from their institutes. IT faculties need to adopt a teaching approach with a complementary role for ChatGPT that balances its potential benefits against its negative impacts to best enhance traditional programming teaching methods and maximize its benefits for students and instructors.*

Recommendations for Researchers *Researchers need to understand the factors enhancing the integration of ChatGPT and the ways of designing and implementing teaching strategies compatible with such AI technologies. Researchers are recommended to explore the impact of ChatGPT on other learners and subjects and its effects on their critical thinking and creativity.*

Impact on Society *The perceptions in this study are helpful for instructors, students, and curricu lum developers, provide additional knowledge on integrating AI chatbots into their courses, and offer valuable input for developing effective use of AI in programming instruction and pedagogical practices. The perceptions could positively influence the job market and contribute to the development of human capital by equipping learners with the latest technologies and programming technologies.*

Future Research *Additional research should be conducted to explore and measure the effect of ChatGPT on students' engagement and class collaboration. Further experimental studies on other topics in different environmental variables are also recommended.*

Keywords *computer programming, programming instructors, ChatGPT, programming in struction*

INTRODUCTION

Programming skills are a critical requirement for the development of primary business fields, espe cially in education. All business fields, including education, are moving toward digitalization and require individuals with high-level programming skills (Eteng et al., 2022; González-Pérez & RamírezMontoya, 2022; James, 2021). Computer programming is an essential capability for learners to develop and excel in their personal and professional lives and provides them with higher opportunities in the AI-equipped world. Consequently, learners, teachers, and educational institutes need to integrate the latest technologies into their educational processes, i.e., programming instruction. Programming skills play an important role in education by fostering critical thinking and problem-solving skills and improving computational thinking with digital confidence. In response, educational systems enforce programming learning on a broad scale, which extends to students other than IT disciplines and across several subjects and levels (Alam, 2022; Husain & Al-Shayeb, 2023; Strawhacker & Bers, 2019). Programming learning is crucial for creativity and innovation. Individuals with solid programming skills, even if not software developers, can understand the digital environment and solve problems in many areas of life (Liu et al., 2022; Su et al., 2022).

Common approaches for programming teaching require cooperation among students to provide adequate education. However, students are reluctant to work with others for programming learning and consider cooperation a challenge, especially on group projects (López-Pimentel et al., 2021; Malik et al., 2020; Sullivan & Strawhacker, 2021; Wei et al., 2021). Passive students in teamwork are treated equally to active students with suitable contributions (Yilmaz et al., 2020). Individual programming learning can help overcome such challenges and support each student in creatively participating in programming tasks. Indeed, the hands-on programming approach can be helpful for students to learn and practice programming (Handur et al., 2016; Yilmaz & Karaoglan Yilmaz, 2023).

Computer programming is a complex field that requires additional supplementary effort from students to understand and grasp its concepts and from teachers to deliver the learning objectives. For example, additional knowledge is required on data structures and algorithms, as well as familiarity with the latest technologies to understand abstract concepts, debugging, and troubleshooting. Students with advanced programming experience need new programming problems and examples in addition to those from

limited traditional sources. Personalized learning that enables participation in programming tasks is also an important requirement. Indeed, additional support with the latest technological approaches that provide personalized and interactive programming learning with instant feedback may be more helpful for students to better handle its complexity (Yilmaz & Karaoglan Yilmaz, 2023). With the inability of several traditional approaches to improve programming teaching and learning, AI-based chatbots, such as ChatGPT, have emerged as a promising solution that helps address such requirements and overcome its challenges.

AI-based chatbots, such as ChatGPT, offer a personalized and interactive learning experience through their ability to respond to various types of programming prompts, generate human-like and immediate responses, and tailor the responses to the needs of each individual. ChatGPT can also generate diverse programming examples and alternative code solutions. The instant feedback and immediate responses by ChatGPT can provide the required materials, practices, and examples that illustrate programming concepts and demonstrate challenging programming issues, especially programming tasks such as code completion and correction, code prediction, code optimization, error detection, and fixing (Raman et al., 2023). Personal interaction with ChatGPT can provide customized learning experiences with abilities, such as an unlimited number and type of questions, search for advanced programming topics, adapt to individual needs, and provide the required materials, practices, and examples supporting the learning process.

However, the way to deploy such new emerging tools within the programming classroom and their implications are not well understood (Ngo, 2023). ChatGPT can produce written work, but it may not necessarily improve high-level skills required for programmers, such as problem-solving and critical thinking (Qureshi, 2023). Several concerns have been raised about ChatGPT, such as its ability solve educational tasks and assignments, quizzes, and exams (Mohamed, 2023). A research gap exists regarding the specific insights and recommendations for IT faculty members (i.e., programming instructors) regarding the potential benefits and drawbacks of integrating ChatGPT into programming instructional methods.

Addressing such concerns can help develop pedagogical practices and effective programming tion significantly. Little is known about the role of ChatGPT and its capabilities for programming instruction from the viewpoints and experiences of programming instructors. According to recent AI studies, it is crucial to understand the implications and appropriate employment practices of AI technologies in computer programming instruction for efficient integration that improves learning outcomes (L. Chen et al., 2020; Hargreaves, 2023; Sun & Hoelscher, 2023). IT faculty members and programming instructors

and complement traditional programming instructional methods. From this point of view, this study aims to investigate the perceptions of programming instructors from IT faculty members at AL al-Bayt University about the effectiveness of ChatGPT in supporting programming instruction, as well as reveal its advantages and disadvantages for students' learning and instructors' instruction. Participants' perceptions may lead to superior AI-based educational tools for programming and provide insight into the opportunities and challenges of its integration with traditional teaching methods. This aims to accomplish its objectives by addressing the following questions:

RQ 1: What are the advantages and benefits of using ChatGPT in programming instruction for students and instructors, as identified by programming instructors?
RQ 2: What are the disadvantages and concerns of using ChatGPT in programming instruction for students and instructors, as identified by programming instructors?
RQ 3: How can ChatGPT be integrated within traditional programming instructional methods to enhance students' learning and the efficiency of instructors, as identified by programming instructors?

However, integrating ChatGPT into programming instructional methods and understanding their possible effects are limited and require more attention. Pedagogical designs with appropriate teaching strategies and measures should be added to the literature on integrating AI chatbots for programming instruction. This study is the first to focus on the perceptions of programming instructors and tributes to the ongoing discourse on the integration of AI, particularly ChatGPT, in programming education. The contribution lies in highlighting the positive and negative aspects of using ChatGPT and discussing the potential complementary role of ChatGPT alongside traditional teaching methods. The participants' perceptions reported by this study provide valuable insights and evidence for researchers, practitioners, and educators regarding the issues of using ChatGPT and guide designers to apply appropriate measures, which add a valuable dimension to the existing literature. These perceptions could serve as a guideline for the programming instructional process.

BACKGROUND AND LITERATURE

Solid programming education is necessary for students' success during their degree by increasing their technology awareness and improving their job creativity in the current digital world (Dorotea et al., 2021; Noh & Lee, 2020). Programming skills are essential for students to conduct problem-solving with analytical and algorithmic thinking, which ultimately improves their personality, academic, and work performance (Agbo et al., 2019; Tikva & Tambouris, 2021). As programming education progresses, students first learn fundamental programming concepts and languages to gain coding skills for simple

programs. Students then move toward more complex programming concepts that depend on data structures and algorithms to increase their ability to test, debug, and maintain pro gramming solutions for real-world programming problems (Gordon et al., 2022; Siegfried et al., 2021).

A wide range of programming online platforms and programming tools enable individuals to access programming instruction and learn software development skills (Lindberg et al., 2019; Zinovieva et al., 2021). Codecademy, Udemy, and Coursera platforms offer various programming courses ranging from beginners to advanced levels (Oktavia et al., 2018; Sharov et al., 2021). Such programming environments attract and help students improve their programming skills and understand its concepts. However, they focus on a specific programming topic and require some prior programming knowledge. AI-based language models, which differ from such programming environments and tools, can interact with people using their natural language, do not require prior knowledge, and offer different methods for programming learning (Jalil et al., 2023; Yilmaz & Karaoglan Yilmaz, 2023). ChatGPT, which is an ordinary AI chatbot, uses natural language processing and machine learning technologies to understand and respond to users' needs in their natural language without using specific syntax or concepts (OpenAI, 2023). This approach facilitates programming learning for learners without programming knowledge (Surameery & Shakor, 2023).

The integration of ChatGPT in an educational context has been studied to investigate its benefits challenges for revealing valuable insights into its impact (Lo, 2023). Halaweh (2023) emphasizes the need for responsible implementation strategies when integrating ChatGPT into educational settings, which acknowledges the risks of overreliance and the generation of inaccurate information. BaidooAnu and Owusu Ansah (2023) discuss the benefits of ChatGPT in promoting teaching and learning, including personalized instruction, critical thinking development, and reduced teacher workload. Sok and Heng (2023) comprehensively review the benefits and risks associated with ChatGPT in education and research, emphasizing the need for mitigation strategies and the integration of other tools and resources. Furthermore, Geerling et al. (2023) discuss the potential impact of ChatGPT on for mal assessments in higher education. Mhlanga (2023) provides insights into the responsible and ethical use of ChatGPT in education, highlighting the need for transparency, fairness, and privacy protection. Adiguzel et al. (2023) examine the transformative potential of ChatGPT in revolutionizing education through personalized learning and interactive experiences. Farrokhnia et al. (2023) use the SWOT analysis to outline the strengths and weaknesses of ChatGPT and discuss its opportunities for and threats to education.

The effectiveness of ChatGPT may vary across subjects. According to Lo (2023), the performance of

factory (e.g., programming) to unsatisfactory (e.g., mathematics). Researchers have explored the potential of ChatGPT in the education of different subjects, such as mathematics (Sánchez-Ruiz et al., 2023; Wardat et al., 2023), economics and finance (Geerling et al., 2023), and medical education (Arif et al., 2023; Khan et al., 2023; Lee, 2023). However, a noticeable gap exists in the application of ChatGPT within programming education (Zheng, 2023). The current literature lacks substantial attention to the effective integration of ChatGPT within traditional programming instruction methods and its support to students and teachers. Several studies have focused on useful applications for AI models like ChatGPT in program coding to explore its potential to take over the role of programmers (Zarifhonarvar, 2023). For instance, research has explored the potential roles of ChatGPT in coding and reported several useful applications, such as code generation (Kashefi & Mukerji, 2023), code optimization (Biswas, 2023), code documentation (Haleem et al., 2022), code review (Jalil et al., 2023), and debugging assistance (Surameery & Shakor, 2023).

Accordingly, given that the focus of this study is on computer programming pedagogical context, the capabilities of ChatGPT for programming education have been investigated concerning several useful and specific predetermined perspectives, such as solving questions of the software testing curriculum, automatic bug fixing in code, application in engineering education, a support tool for HTML code, and the future of common programming practices (Rahman & Watanobe, 2023). Yilmaz and Karaoglan Yilmaz (2023) investigated the effect of using ChatGPT for programming education on students' computational thinking skills, programming self-efficacy, and motivation. The results revealed the ability of ChatGPT to benefit the students and improve their computational thinking skills, programming self-efficacy, and motivation. E. Chen et al. (2023) leveraged ChatGPT to provide programming code explanations for students to improve their programming skills effectively. Jalil et al. (2023) examined the performance of ChatGPT in answering practical questions for the software testing curriculum. The results revealed that ChatGPT can be used effectively in software testing and training because it responds to most questions and provides correct or partially answers with correct explanations in half of the cases. Surameery and Shakor (2023) examined ChatGPT's ability to solve programming bugs. They indicated that ChatGPT can play a positive role in solving programming bugs by providing debugging assistance, bug prediction, and bug explanation to help solve programming problems. Tian et al. (2023) assessed the performance of ChatGPT in programming assistants, especially code generation, program repair, and code summarization. Their research indicated that ChatGPT handles typical programming challenges with the ability to summarize explanations of incorrect code effectively. Qureshi (2023) evaluated and addressed the prospects and obstacles associated with utilizing ChatGPT as a tool for learning and assessment in fundamental programming courses. The results revealed ChatGPT's ability to improve academic performance and help attain high

scores. Logozar (2023) investigated ChatGPT's ability to solve fundamental programming tasks in C and C++ languages and used it on a freshman programming test. The results revealed that ChatGPT passes the exam with very good grades, which outperforms most students by providing high-quality solutions with the ability to adapt or change their solutions according to additional demands.

Indeed, the considerable research reviewed in this study demonstrates several benefits of using ChatGPT in programming education and its efficiency in supporting students to perform learning tasks, including skill enhancement (Biswas, 2023; Yilmaz & Karaoglan Yilmaz, 2023), motivation (Huang et al., 2023), and learning outcomes (Qureshi, 2023). The ability of ChatGPT to provide fast, correct, and high-quality code solutions is also reported (Logozar, 2023). Meanwhile, several limitations to using ChatGPT in programming are observed, including potential biases and the inability of ChatGPT to process visual information; privacy and security issues when exposing students' information to ChatGPT during their interactions; and misuse of ChatGPT by obtaining ready solutions without understanding (Fiialka et al., 2023; Rahman & Watanobe, 2023). Megahed et al. (2023) found that ChatGPT may generate incorrect programming codes and cannot accurately detect and resolve programming errors. ChatGPT may surpass requests by providing code suggestions and additional information, which may be inaccurate, without asking. ChatGPT lacks emotions and reflections about students' behavior and engagement (Tlili et al., 2023).

However, studies that explicitly focus on the integration of ChatGPT in programming instruction and explore the potential benefits, issues, and challenges are lacking. The potential benefits of incorporating ChatGPT into programming instruction, such as personalized feedback, code generation, and improved problem-solving abilities, deserve further investigation. Building upon its efficiency in several educational domains, ChatGPT holds promise as a valuable tool for enhancing students' programming learning experiences and supporting their instructors. Therefore, the gap in the existing literature can be filled by exploring and evaluating the use of ChatGPT in programming education. This research enables educators and learners in programming to harness the potential of ChatGPT while addressing the specific challenges and requirements of the field.

In response, this study proposes to explore programming instructors' perceptions of ChatGPT to reveal potential benefits, capabilities, and concerns of its integration with programming education. Extensive discussion with programming instructors during the interviews is critical to obtain rich details and reveal further hidden or unexpected insights that may not have been highlighted previously. Programming instructors have practical experience and observations with a large number of students, either in a programming laboratory or classroom. In the context of this study, experience and

observations are obtained from programming instructors during interaction and collaboration with their students while using AI technologies for programming learning. In fact, programming provide the necessary theoretical programming knowledge in the classroom that is aligned with the learning outcomes, and students usually use ChatGPT during their study as a complementary tool to answer a wide range of programming questions and inquiries to enhance programming learning. The instructors might use ChatGPT to generate cases and problems and act as mentors to guide and support students by monitoring and controlling their usage to ensure they obtain the right knowledge properly. Thus, the perceptions and attitudes of instructors toward the ChatGPT experience are connected with their knowledge of its benefits, capabilities, and concerns that might impact their overall experience

This observation is evident in a recent study by Mohamed (2023), where ten faculty members perceive ChatGPT as a valuable tool for complementing and enhancing traditional teaching methods. They acknowledge the usefulness of ChatGPT in providing rapid and accurate responses to a range of questions, while others express concerns that ChatGPT might hinder students' development of critical thinking and research skills. Another study by Qasem et al. (2023) found that faculty members perceive ChatGPT as an essential tool for language learning that enhances students' language skills and promotes their active learning. Kohnke (2023) reported that faculty members believe that AI chatbots provide personalized feedback to students to improve their skills. Moreover, a study by Hew et al. (2023) revealed that faculty members appreciate the convenience and accessibility of AI chatbots in providing immediate responses, which help save time and reduce workload for students and teachers. Tlili et al. (2023) investigated stakeholders' perceptions of the use of ChatGPT in education. The participants perceived ChatGPT as useful, which suggests that ChatGPT is efficacious in increasing the chances of educational success and has a satisfactory degree of quality and accuracy of information. However, the participants raise several ethical concerns (e.g., plagiarism and cheating) and educational concerns (e.g., appropriateness and absence of emotions).

Precisely for programming education, Zheng (2023) gathered perspectives from students and feed back from the instructor (i.e., the author) on using ChatGPT to learn Python programming for data science education. Part of his survey investigated the ability of ChatGPT to produce high-quality programming coding with little or no human effort. The results show that half of the students provide satisfactory results, and they believe ChatGPT can help produce programming codes. Zheng stated that ChatGPT can produce perfect answers for popular algorithms but may not work effectively for complex ones. Padilla et al. (2023) extracted information and insights from students regarding their use of ChatGPT in programming learning to investigate the benefits and challenges. The study revealed several benefits of employing ChatGPT for programming, including efficient coding, understanding complex codes, and

and its capability to be used as a problem-solving tool. However, Padilla et al. highlighted critical issues and challenges, such as data privacy and ethical concerns, tendencies, and contextual understanding limitations.

Table 1. Comprehensive summary of previous studies on ChatGPT applications

Research focus	Perspective	Study
Perceptions on ChatGPT	General educational context	(Tlili et al., 2023)
	Specific educational context	(Hew et al., 2023; Kohnke, 2023; Mohamed, 2023; Qasem et al., 2023)
	Programming education, students' perceptions only	(Padilla et al., 2023; Zheng, 2023)
	Programming education, instructors' perceptions	This study
Investigate/evaluate the programming capabilities of ChatGPT from a particular perspective	Computational thinking skills, programming self-efficacy, and motivation	(Yilmaz & Karaoglan Yilmaz, 2023)
	Programming code explanation	(E. Chen et al., 2023)
	Software testing and training	(Jalil et al., 2023)
	Solving programming bugs	(Surameery & Shakor, 2023)
	Programming assistant: code generation, program repair, and code summarization	(Tian et al., 2023)
	Academic performance in programming	(Qureshi, 2023)
	Solving C++ programming tasks	(Logozar, 2023)
	Multiple and comprehensive programming perspectives	This study

Nevertheless, several research gaps have been identified and addressed in this study. First, little is known about the integration of AI into programming instruction, especially ChatGPT, without addressing its potential benefits and adverse impacts on programming education. Among the few existing studies, insights and perceptions of programming instructors based on their practical experience and observations during programming teaching are lacking. Specific insights and recommendations for integrating ChatGPT with traditional programming teaching methods and its capability to enhance students' programming learning and support their instructors are also missing.

This study is conducted to fill such gaps in research with several unique contributions that diverge from prior research. This study is the first to focus on the perceptions of programming instructors that serve as guidelines for efficient integration of AI, particularly ChatGPT, in programming education. This study addresses both positive and negative aspects of using ChatGPT and discusses the potential complementary role of ChatGPT alongside traditional teaching methods. This study provides

comprehensive, valuable insights and recommendations that help exploit and maximize ChatGPT's benefit and mitigate its adverse impacts. This research posits that a balanced approach between the potential benefits and negative impacts of ChatGPT can improve programming instruction and better aid students, instructors, and other traditional programming teaching methods. this concept, understanding the capabilities of ChatGPT and addressing its advantages and concerns contribute significantly to successful integration within programming instruction.

METHODOLOGY

The research data in this study was collected through in-depth interviews with programming instructors from the School of Information Technology at AL al-Bayt University. A qualitative research design was adopted in this study to arrive at in-depth perceptions of programming instructors on the integration of ChatGPT into programming instruction. A convenience sampling was used to select twelve programming instructors among IT faculty members who were familiar with ChatGPT during their programming instruction experience. The interviews were conducted several times with each participant according to the data collection requirements. Thus, 26 in-depth interviews with the participants were conducted personally to elicit detailed and precise information regarding the advantages and disadvantages of using ChatGPT for programming instruction. Each interview consisted of questions to investigate their opinions and experiences concerning its potential and capabilities to complement traditional teaching methods, enhance students' programming learning, and support instructors in their instruction. Consequently, the data collected from the interview questions were processed and analyzed using qualitative thematic analysis to identify patterns and themes and provide valuable insights into the potential role of ChatGPT in programming education.

PARTICIPANTS

The participants in this study were programming instructors selected from the faculty members in the School of Information Technology at AL al-Bayt University. The selection was based on their experience in programming instruction and familiarity with ChatGPT, which allows for a practical exploration of its capabilities and potential benefits and concerns. Faculty members with extensive and recent experience in teaching various programming languages to students at different levels over the past few years were selected to ensure rich responses and diverse perspectives. In addition, although the participants were chosen carefully to ensure the reliability of the findings, their familiarity with ChatGPT was further investigated using a scale ranging from one (indicating a lack of familiarity) to five (indicating a high level of familiarity). With an average familiarity score of 3.75, the convenient sample

sample comprised 12 qualified participants for the study (Croker, 2009). In other words, 12 participants with adequate experience in programming instruction and familiarity with ChatGPT were included and considered in the study sample among the IT faculty members (i.e., 34 members). The number of participants adopted aimed to obtain an in-depth understanding of the phenomenon and enrich the findings of this study (Merriam & Tisdell, 2015). This convenience sampling assisted in capturing the essence of the subjects' experiences, discerning shared patterns, and developing themes (Creswell & Creswell, 2017).

As shown in Table 2, 12 participants with significant and varying levels of experience in computer programming instruction, including males and females, who held an MA or PhD in IT-related fields, were interviewed. Each participant was interviewed personally, at least once, to elicit detailed and precise information about the advantages and disadvantages of using ChatGPT for programming instruction and to investigate his/her opinions and experiences regarding its potential and capabilities to complement traditional teaching methods, enhance students in programming learning, and support instructors in their instruction. Participants with varying levels of experience and qualifications help reveal valuable insights from different perspectives and varied viewpoints with rich, comprehensive, non-biased opinions.

Table 2. Study participants (Programming Instructors: PIs)

Participants (PIs)	Gender	Qualification	Experience/ years	Familiarity with ChatGPT
PI 1	Female	MSc in Computer Science	18	5
PI 2	Male	MSc in Computer Science	13	4
PI 3	Female	Ph.D. in Computer Science	5	3
PI 4	Male	Ph.D. in Computer Science	4	5
PI 5	Male	Ph.D. in Computer Science	9	4
PI 6	Male	Ph.D. Information Systems	12	4
PI 7	Female	Ph.D. Computer Information Systems	15	2
PI 8	Female	MSc in Information Systems	8	3
PI 9	Female	MSc in Information Systems	11	2
PI 10	Male	MSc in Computer Information Systems	6	5
PI 11	Male	MSc in Computer Information Systems	5	5
PI 12	Male	Ph.D. in Computer Information Systems	11	3

DATA COLLECTION

The data on the implications of integrating ChatGPT into programming teaching methods and their most important advantages and disadvantages for students and instructors were obtained from the selected participants, who were programming instructors, through in-depth and detailed personal interviews. Each interview session lasted approximately 40 minutes on average and was transcribed for analysis.

Interviewing is a useful technique when conducting a phenomenological study of a few selected individuals because it helps participants provide their insights and share their experiences. Interviews offer convenience and speed features as a valuable and efficient method for qualitative research, especially when the study sample participant works within the same institute (Meda et al., 2023; Merriam & Tisdell, 2015). Accordingly, extensive discussions with programming instructors during the interviews were conducted carefully and repeatedly to obtain rich details and reveal further hidden or unexpected insights that may not have been previously highlighted. The interviews were conducted several times with each participant according to the data collection requirements.

DATA ANALYSIS

A qualitative thematic analysis method was used to analyze carefully and rigorously the collected transcribed data through participant interviews. The data were read and coded accurately to identify relevant themes and patterns from the participants' answers corresponding to the research questions. Consequently, the generated codes were categorized into more extensive themes and carefully analyzed to explore the connections and relationships between themes and subthemes. Such a comprehensive systematic method facilitates a comprehensive and profound understanding of the obtained data and provides robust insights and valuable findings that contribute significantly.

ETHICAL CONSIDERATIONS

All participants were informed and consented to this study, with the ability to withdraw from the study at any time. Each participant in the study was assigned a pseudonym to ensure confidentiality and anonymity throughout the study.

INTERVIEW INSTRUMENT

The research interviews serve as the primary instrument in this study, which consists of questions designed to address the research objectives. These in-depth interviews consist of several questions developed to investigate the experiences and perceptions of programming instructors from the IT faculty members at AL al-Bayt University regarding the effectiveness of ChatGPT in supporting programming instruction and uncover its potential benefits and adverse impacts on students and instructors. The interview questions were developed based on relevant and reliable sources, such as literature reviews, previous studies, and expert opinions. In addition, unambiguous and simple words, phrases, and concepts that are acceptable and understandable to the participants were adopted. This

approach supports the design of unbiased, non-leading, and neutral questions that do not influence or manipulate responses.

The first question was developed to provide the advantages of using ChatGPT in programming in struction. The second question focused on the enhancement effect of ChatGPT on students' learning experiences in programming instruction. The third question explored the use of ChatGPT to support the efficiency of programming instructors during the instructional process. The fourth question asked about the disadvantages and drawbacks encountered while using ChatGPT for programming instruction. The fifth question addressed the concerns and potential ethical or privacy issues related to integrating ChatGPT within programming instruction. The sixth question explored the integration of ChatGPT with traditional programming teaching methods for its enhancement. The last question asked participants to provide their predictions on the future role of ChatGPT in developing programming instruction. The responses were transcribed and analyzed carefully to understand programming instructors' perceptions and insights into the role of ChatGPT as a programming instructional tool for students and instructors.

Consequently, the interview questions were reviewed and validated by a jury of experts in technology-based learning and programming instruction to ensure validity. The jury of experts evaluated the ability of the interview questions to gather responses that satisfied the research questions and fulfilled the objectives of the study. Consequently, the jury specified certain issues and provided syntactic and semantic suggestions and advice, including deleting, merging, and replacing specific aspects to improve the clarity and relevance of the interview questions. Finally, after performing the required updates and modifications for improved validity, the jury approved the validity of the questions and their appropriateness and consistency with the research objectives.

RESULTS

The responses and perceptions of the programming instructors are summarized and presented in the following sections according to the research questions.

ADVANTAGES OF USING CHATGPT FOR PROGRAMMING INSTRUCTION

Several advantages and benefits of using ChatGPT in programming instruction for students and in structors were identified by the participants. The obtained perceptions were organized into themes to construct an overall understanding of the instructors' experience regarding the main advantages of programming instruction. For example, one participant states, "One amazing thing about ChatGPT is its ability to provide a program code for a specific problem, that is, n factorial**,** with several programming

languages upon request. This feature enables students to compare the programming languages, understand their strengths and weaknesses, and select a language that is best suitable for that programming problem." Accordingly, the advantages of using ChatGPT as perceived by most programming instructors as themes are listed in Table 3. Most programming instructors agree on essential benefit themes, including practical applications, personalized learning, a wide range of programming problems and alternative solutions, interactive learning, accessibility, no programming knowledge required, debugging and feedback, and clear explanations.

Table 3. Advantages of using ChatGPT for programming instruction

Practical applications	ChatGPT can execute program code and provide the output result. This feature allows students to apply their theoretical knowledge practically by running any code, trying the results, and repeatedly modifying upon request. This helps understand programming concepts better and demonstrates more accurate and appropriate code-writing guidelines. Indeed, students can perform self-evaluation and test their code before submission. Accordingly, students become more confident when writing programming tasks and assignments.
Personalized learning	ChatGPT can provide customized learning experiences by tailoring the resources, examples, and feedback to each student's unique needs, according to individual characteristics. This feature improves the learning experience of students.
Wide range of programming problems and alternative solutions	ChatGPT trains on a vast knowledge base using diverse resources such as learning materials, examples, and online programming courses. This training enables learners to gain experience with a wide range of programming problems and alternative solutions. As a result, the programming proficiency of the students is enhanced.
Interactive learning	ChatGPT allows learners to ask and search advanced topics about programming and generate programmer-like and immediate responses. Learners obtain interactive learning when engaged in conversational information exchanges. This feature helps increase the motivation and engagement of the students.
Accessibility	ChatGPT can be accessible without installing any specific tool or software. Therefore, it is an accessible, cost-effective, and time-efficient programming learning alternative.
No programming knowledge required	Learners can interact with ChatGPT using their natural and understandable language. This feature allows fresh students, even those with no programming knowledge, to understand programming concepts and solve problems. Accordingly, the learning progress of programming for students at different levels is facilitated.
Debugging and feedback	Interactions with ChatGPT allow learners to focus on primary programming skills like debugging, fixing errors, and receiving code suggestions explained practically through real-world cases. This helps students obtain and follow informal programming rules and best practices to improve their programming tasks and assignments.
Clear explanations/ Demonstrations	ChatGPT provides clear and multiple alternative demonstrations for challenging programming issues. This feature helps students attain advanced levels of understanding in programming.

In addition, to obtain more useful insights with rich details, the participants were asked precisely to provide their thoughts regarding the ability of ChatGPT to enhance students' programming learning. The programming instructors have different perspectives on the enhancing effect of ChatGPT on programming learning for students. One instructor perceived ChatGPT as an important tool providing interactive programming practices, such as completing the code, suggesting code solutions, and reducing syntax errors. These personalized interactive practices may help students improve their programming skills and increase their confidence in writing programs and projects. The responses of two instructors indicate the helpfulness of ChatGPT in coding and program writing assistance by offering students prompt and precise feedback on their programming performance. Other instructors address the ability of ChatGPT to provide student-wide opportunities to practice the best solutions for real-life programming problems rather than a textbook or limited in-class programming sources. Another response reports the ability of ChatGPT to significantly boost student motivation and engagement in the programming learning process when they can modify the code to create their own programs and solutions for programming assignments. For instance, this participant states, "One common case I am observing involves students asking for program code to solve a problem. They then use this code as a new prompt for ChatGPT to test the output. With each execution, students modify the code to observe and understand the functionality. Having such in-depth programming learning capability in real-time, anytime, and anywhere is interesting." This feature results in a positive and dynamic learning environment. In summary, all participants agree that students can have a new and exciting way of learning programming when ChatGPT is integrated properly into the programming curriculum, and it will significantly impact their writing program proficiency and software development.

Furthermore, in the same context, the participants were also asked precisely to provide their thoughts regarding the ability of ChatGPT to support the efficiency of programming instructors during their programming instruction. The participants indicated several capabilities and features for ChatGPT that can be used to support and improve their efficiency in the programming instructional process. One of the instructors stated that ChatGPT could help instructors evaluate and assess students' performance by providing accurate, immediate feedback about their assignments and programming task performance. This feature can save their time and reduce their effort, especially for a large number of students. Some instructors consider ChatGPT helpful for instructors by enhancing their students' engagement in programming tasks anytime, anywhere, especially before lectures. This way helps reduce instructional effort and enables instructors to use class time effectively to address other complex new programming issues. Other instructors believe that ChatGPT can assist instructors in the instructional and explanation process by creating diverse and more real-life and realistic programming examples and demonstrations

as a new method for delivering programming instruction. One of the participants viewed ChatGPT as an instrument that may help instructors identify difficulties where learners are struggling and provide better solutions and personalized student recommendations based on their data. This feature allows instructors to improve their instructional practices. Another respondent believed that ChatGPT can help instructors address the individual learning needs of their students by offering customized feedback and guidance for each student. Accordingly, instructors can provide more individualized instruction. Finally, one participant believed that ChatGPT might help programming instructors manage classes by providing helpful teaching strategies, offering efficient lesson plan recommendations, and preparing quizzes and exams. For example, this participant reported, "I am using ChatGPT to support the instructional design and provide an outline for my lectures by reminding me of what necessary programming skills and concepts should be included." In conclusion, integrating ChatGPT into programming instructional methods can support instructors' activities, save time, and reduce effort.

DISADVANTAGES AND CONCERNS OF USING CHATGPT FOR PROGRAMMING INSTRUCTION

Several disadvantages perceived by the participants were organized into themes for better organization and simplicity. For example, one participant stated: "The accuracy of the responses of ChatGPT depends on the type of questions provided. If the question is too general and lacks context, then the responses will not be satisfactory and cannot solve the programming problem totally. Providing questions that are sufficiently specific is critical, and I think this task is difficult for students." Accordingly, the disadvantages of using ChatGPT, as perceived by most programming instructors as themes, are presented in Table 4. Most programming instructors agree on the disadvantage themes, including undesired answers, limited resources (data structures and algorithms), technology limitation, unstructured learning, inaccurate feedback, response integrity, and a lack of actual programming elements.

Table 4. Disadvantages of using ChatGPT for programming instruction

Inaccurate responses	Errors in recommendations and inaccurate feedback that ChatGPT potentially provides for programming questions represent an issue for educators. ChatGPT might generate inaccurate or incorrect code that does not work properly when entered into programming software.
Undesired responses	Owing to the poorly formatted question or the complexity of the problem, ChatGPT may not understand all types of questions and thus give an undesired answer. This answer may be correct and can be executed through programming software, but it is incomplete to satisfy the requested programming problem requirements. Additional effort from students is needed to compare and validate the output.
Response integrity	The provision of alternative answers, which contradict previous answers on the same programming inquiry, can confuse students and reduce the reliability of the provided code.
Limited programming resources	ChatGPT may provide insufficient information on all programming algorithms and data structures to answer some programming questions. Therefore, learners may need to search for additional resources or tools to address their issues.
Technology limitation	Technical limitations create issues such as processing overhead requirements, slow response time, or the need for a high-quality connection, which may negatively impact the learning experience.
Unstructured learning	Learners may use ChatGPT for programming topics randomly without a structured approach. No specific guidance or plan is available for learners to follow during knowledge acquisition, especially when studying programming topics outside the classroom. This inadequacy requires additional learning management effort to achieve their learning goals.
Lack of real programming elements	ChatGPT does not provide a natural environment for programming applications for learners to execute and test their tasks. Learners may need to search for additional tools to run and manage the coding of their programming projects, especially for developing GUI-based applications.

The programming instructors express several concerns regarding the integration of ChatGPT into programming instruction. One major concern reported by several instructors is the potential abuse of ChatGPT by students seeking easy-to-obtain programming solutions, especially unmotivated students. Ethical concerns arise when students rely mainly on programs and codes generated by ChatGPT without developing the necessary skills. ChatGPT can facilitate cheating by providing ready solutions for programming assignments and tasks, which undermines students' efforts to think or understand. The use of such solutions and tasks must conform to ethical and transparent practices to improve student achievement. Two participants expressed concerns about the privacy and security of students' data. Privacy concerns arise from the exposure of students' private information to ChatGPT through repetitive interactions, especially when all conversations are stored, reviewed, and used to improve the

improve the ChatGPT system. Another social impact concern expressed is the potential for ChatGPT to provide interaction, guidance, and support that might replace human instructors' interaction. Human interaction is necessary for students' development.

Similarly, another instructor expressed concern about losing sight of teacher interaction and its importance for students, especially in the early stages of programming teaching. The over-reliance concern is observed by instructors when their students rely on ChatGPT to complete assignments, find errors, and receive code suggestions on all other tasks. This over-reliance can negatively affect their critical thinking, problem-solving, and programming skills, which ultimately lowers their creativity. For instance, one participant states, "I noticed several students depend on ChatGPT to solve all required programming tasks and assignments by obtaining ready and high-quality solutions. This availability limits their ability to achieve learning objectives and hinders the development of critical thinking skills." Other instructors are concerned with controlling students' online behavior while surfing the web using ChatGPT during either in-class or out-class time. Students can be distracted easily, and such technology can be misused to obtain ready solutions, especially for simple or trivial programming tasks, quizzes, and even programming exams. In conclusion, the instructors emphasize that addressing these challenges is crucial. They stress the importance of taking action to reduce negative impacts, minimize errors, and benefit students. Using ChatGPT for programming instruction should be approached carefully. The potential benefits of ChatGPT should be weighed against its negative impacts on the learners before integration.

ROLE OF CHATGPT IN ENHANCING TRADITIONAL PROGRAMMING TEACHING METHODS

All participants stated a complementary role for ChatGPT alongside traditional methods of program ming instruction instead of replacing them. ChatGPT can use other traditional programming resources in different ways. One instructor expressed the potential of ChatGPT to provide a dynamic learning source represented by rich and unlimited programming examples and problems that complement standard examples. This instructor stated, "I can generate a limited number of examples during the instruction of a specific programming aspect, such as a nested for loop. However, ChatGPT enables me to obtain several practical examples immediately to better illustrate the applications of such aspects within an actual program. I can execute each example, illustrate the output, and respond to any question practically." Two instructors consider ChatGPT a learning source that can complement traditional programming instruction methods by providing new programming cases, problems, and solution practices with the latest updates, which is possible inside and outside the classroom. Students can study

programming through direct resources such as textbooks, lectures, and videos. ChatGPT helps them learn additional programming skills through new real-life programming problems. One participant stated, "Students can have additional opportunities for dealing with real-life programming case studies and more diverse programming problems. They can provide precise prompts that deeply focus on their issues for ChatGPT, without any limit, until it is resolved." Another response stated that students can receive prompt feedback on their programming tasks and assignments as guidance for the best solutions. Some instructors also note that ChatGPT can complement and enhance traditional programming teaching methods by providing additional explanations and clarifications of programming concepts, syntax, and functions, which can be helpful for learners, particularly beginners, to understand the programming.

Some other participants viewed ChatGPT as a complementary tool that aided students in a better understanding and practicing of programming. ChatGPT facilitates the transition from simply reading programming examples to executing the code and trying out the results in several ways with multiple dynamic code alternatives. Students can input the desired code as prompts for ChatGPT, even if it contains errors, and then obtain the output result. This feature helps students apply and practice what they have learned and perform and practice programming skills, such as writing, completing, enhancing the code, and fixing errors through interaction with ChatGPT. Several responses about students' interaction with ChatGPT and its ability to support traditional instructional methods are presented. Even guidelines to ask and inquire about the ChatGPT appropriately can be a concern for several disciplines. Students can overcome this issue in the programming learning case. The reason is that the requirements and inquiries in programming instruction are clear and precise, including inputting specific code to find errors, suggesting or generating alternative code, executing the code, and checking the output. Indeed, students can prompt and inquire about ChatGPT for their programming learning requirements. Dealing with the responses of ChatGPT is also less complex and understandable due to the nature of the obtained feedback and responses, which can be a program code, specified errors in the code, and even new suggested code, all of which are clear and direct to understand.

The last respondents perceive that the feature of ChatGPT that allows students to describe their desired learning needs and requirements using their natural language and perform self-learning studies is helpful for appropriateness for various students' levels and backgrounds. In summary, according to the instructors, ChatGPT can complete other traditional programming resources by providing a dynamic and practical learning source, prompt feedback about programming performance, and additional explanations and illustration programming skills, which enhance the appropriateness of learning.

The programming instructors stated their beliefs on the future role of ChatGPT in programming instruction to obtain a complete picture and overall vision. The participants agreed on the central role of ChatGPT in the future of programming instruction. Specifically, ChatGPT will become a more sophisticated and effective tool for programming instruction and assessment, providing students with personalized and interactive learning experiences. ChatGPT offers improved assessment, a more integrated component of programming instructors' activities, a tool for training, a tool for enhancing software development, a tool for error detection and fixing, and a tool for improving programs and coding. For example, one of the participants stated, "With the continued development of ChatGPT and its abilities to understand each student's capabilities and learning style, and its ability to simulate and visualize the output responses, ChatGPT is expected to become a compulsory requirement in higher education, especially in the programming discipline. This expectation is due to the customized responses that best support students to understand data structures and advanced programming concepts creatively."

Indeed, the participants asserted the critical role of ChatGPT in providing students with personalized and effective learning experiences while also serving as a resource for programming instructors. ChatGPT is becoming a valuable resource for programming instructors in creating lesson plans and designing programming tasks and exercises tailored to individual student needs. ChatGPT can also assist in grading and provide insights into student progress, which allows instructors to track better and address areas of difficulty. These critical roles can be enhanced as ChatGPT improves its ability to adapt to individual learning styles for the development of critical thinking and problem-solving skills. Improvements in human-like interaction can also increase engagement and motivation among learners and enhance the connection with programming instruction.

Meanwhile, although ChatGPT can be a helpful tool, it cannot replicate the unique perspectives and experiences that human instructors bring to the classroom. Some are skeptical about ChatGPT's ability to replace human instructors entirely in the future. ChatGPT should be used with other teaching methods and tools and under instructors' supervision to mitigate its concerns and limitations. The limitations of ChatGPT should be considered and used appropriately to supplement, rather than replace, human interaction and engagement in programming instruction.

DISCUSSION

This section explores the ability of ChatGPT to enhance programming instruction based on the perceptions of IT faculty members, especially programming instructors. Precisely, it identifies the

effectiveness of ChatGPT in supporting the programming instructional process and explores its most important advantages and disadvantages for students and instructors. The discussion provides insights into the best ChatGPT practices in programming teaching by summarizing the findings of the study. The participants' perceptions related to the first research question suggest that the most essential benefits of ChatGPT for enhancing programming instruction are practical applications, personalized learning, a wide range of programming problems and alternative solutions, interactive learning, accessibility, no programming knowledge is required, debugging and feedback, and clear explanations. Indeed, programming instructors indicate debugging and feedback insight as an advantage that offers the ability to interact with ChatGPT and focus on debugging, fixing errors, and code suggestions as primary programming skills. This perception is consistent with earlier results by Surameery and Shakor (2023) that indicate the ability of ChatGPT to help solve programming bugs by providing debugging assistance, bug prediction, and bug explanation. In addition, the advantage of interactive learning is reported due to ChatGPT's ability to motivate students when engaged in conversational programmer-like information exchanges. This perception concurs with those of Yilmaz and Karaoglan Yilmaz (2023), who find that ChatGPT can support students and improve their motivation toward programming. The potential of ChatGPT to provide clear explanations regarding challenging programming issues, as perceived by the programming instructors, is in line with the observation of Jalil et al. (2023), who examine and prove the ability of ChatGPT to provide correct answers with correct explanations for the majority of given programming questions and tasks. However, the other advantages found in the current study are new insights that diverge from existing literature and contribute to programming instruction.

To this end, the participants' perceptions reveal that integrating ChatGPT into traditional programming instructional methods is essential for students and instructors. The results of the interviews reveal that ChatGPT has the potential to enhance students' learning and support the efficiency of their instructors in programming instruction. The participants state that ChatGPT can support students during their in-class or out-of-class programming learning by providing personalized and interactive programming practices, assisting them in coding and program writing, helping them practice the best solutions for real-life programming problems, and creating their own programs and solutions. This feature can help develop their programming skills, increase their confidence in writing programs, and lead to a positive and dynamic learning environment that boosts motivation and engagement. The potential of ChatGPT to enhance students' learning by assisting them in coding and program writing concurs with the results in previous research (E. Chen et al., 2023; Logozar, 2023; Tian et al., 2023), which affirms the ability of ChatGPT to explain programming code for students, provide programming assistance through code generation and program repair, and offer high-quality solutions for fundamental programming tasks. Similarly, the potential of ChatGPT to enhance students through personalized and interactive

programming practices concurs with the findings of Qureshi (2023), who demonstrates a positive effect of incorporating ChatGPT on students' programming practices to improve their academic performance. However, helping students practice the best solutions for reallife programming problems and creating their own programs and solutions are unique insights revealed in the present study.

The participants provided exclusive insights into the abilities of ChatGPT to enhance the program ming instructors and support them in their programming instructional tasks, which contributes new findings to this study. ChatGPT helps instructors save time and effort by providing new instructional practices and addressing the individual learning needs of their students. ChatGPT also assists in performance assessment and recommends lesson plans and teaching strategies.

By contrast, several perceptions on the potential drawbacks and concerns of using ChatGPT in programming education are reported, including inaccurate responses, undesired responses, response integrity, limited programming resources, technology limitation, unstructured learning, and a lack of real programming elements. The programming instructors indicate inaccurate responses to ChatGPT due to the common program errors they obtain through student assignments. This perception is consistent with those of Jalil et al. (2023) and Megahed et al. (2023), who indicate that ChatGPT generates incorrect programming codes and fails to detect and resolve errors. This perception also concurs with Mogali's (2023) earlier results, who obtained several errors and inaccurate information from ChatGPT when used for educational purposes. The limited programming resource disadvantage is perceived through a few cases where ChatGPT may not have sufficient information regarding specific newly emerging algorithms to respond. This insight is supported by Perkins (2023), who indicates that ChatGPT has limited knowledge and may fail to provide up-to-date responses. The other themes are key contributions from the participants of the current study exclusively for programming instruction.

Similarly, several concerns are revealed, including ethical and transparent use, privacy and security of students' data, social impact and replacement of human interaction, over-reliance, and controlling students' online behavior. However, such concerns revealed in this study are consistent with earlier findings in the literature that are discussed as common concerns about integrating ChatGPT but discussed within general educational contexts rather than emphasizing programming and its consequences and their mitigating details. For example, Mhlanga (2023) discusses ethical concerns for integrating ChatGPT in education. Privacy of students' data is indicated by Tlili et al. (2023) when revealing sensitive data through their interaction with ChatGPT. The social impact and ability of ChatGPT to replace humans are stressed by Adiguzel et al. (2023). Relying on ChatGPT to perform all

educational tasks without mental effort is asserted by Sok and Heng (2023). The theme of controlling students' online behavior is uniquely mentioned in the present study.

Ultimately, regarding ChatGPT's role in enhancing traditional programming teaching methods, the participants suggest a complementary role for ChatGPT that balances its potential benefits against its negative impacts to best enhance traditional programming teaching methods. These perceptions are consistent with those of Mohamed (2023), who revealed that ChatGPT can complement traditional EFL teaching methods in different ways. Indeed, the participants' perceptions in the present study indicate that the successful integration of ChatGPT in programming teaching can complement and support their instructional methods, including providing students with additional and more diverse real-life programming problems with multiple alternative solutions, performing additional programming skills, receiving instant feedback and guidance on their programming tasks, obtaining additional explanations and programming examples, and trying the results practically in several ways. Indeed, the ability of ChatGPT to help students perform additional programming skills and provide additional explanations and programming examples is in line with the findings of E. Chen et al. (2023), who indicate the efficiency of ChatGPT in providing programming code explanations for student and improving their programming skills. The other insights are contributions provided by the participants in the current study specified for teaching programming languages.

In summary, the participants' perceptions reveal new benefits for integrating ChatGPT into programming instruction that diverges from existing literature and contributes to programming instruction, including practical applications, personalized learning, a wide range of programming problems, and alternative solutions, and no programming knowledge is required. The abilities of ChatGPT to help students practice the best solutions for real-life programming problems and create their own programs and solutions are unique insights revealed in the present study. Moreover, participants provide exclusive insights into the abilities of ChatGPT to efficiently enhance the programming instructors by saving time and effort, providing new instructional practices, helping address the individual learning needs of their students, and managing class tasks.

Comparatively, the participants' perceptions reveal new potential drawbacks and limitations of using ChatGPT in programming education that diverge from existing literature, including undesired responses, response integrity, technology limitation, unstructured learning, and a lack of real programming elements. Furthermore, several concerns are revealed, including ethical and transparent use, privacy and security of students' data, social impact and replacement of human interaction, over-reliance, and controlling students' online behavior. Overall, the participants suggest a complementary

role for ChatGPT that balances its potential benefits against its negative impacts to best enhance traditional programming teaching methods and maximize its benefits for students and instructors. However, challenges and limitations of using ChatGPT, such as the inability to draw and create visual arts, process multiple tasks, and lack of emotion, are not fully addressed by the participants of this study.

The participants' perceptions in this study indicate that ChatGPT supports the programming instructional process and is helpful for students and their instructors in programming teaching and instruction. Understanding the capabilities and advantages of ChatGPT, as well as learning how to ask questions systematically and creatively, helps maximize the programming outputs generated from ChatGPT. This understanding can help provide better solutions to programming problems and offers advanced opportunities to enhance students' understanding of problem-solving and algorithmic thinking. Students can be assisted in solving complex programming problems and continue to receive high-quality programming learning through ChatGPT to accelerate their programming knowledge (Rahman & Watanobe, 2023). Similarly, instructors can use ChatGPT to arrange an instructional plan for programming teaching and prepare topic-related content, presentations, and questions for quizzes and exams. The perceptions recommend that careful consideration of the disadvantages and cerns is crucial. Integrating ChatGPT into educational contexts should be approached cautiously to ensure ethical use and maximize the benefits derived from ChatGPT (Mhlanga, 2023). The advantages and disadvantages of ChatGPT need to be weighed carefully, and several measures should be taken to maximize the benefits of ChatGPT and minimize potential negative impacts. Educating students and instructors on ethical concerns, assigning advanced tasks requiring human intervention and critical thinking to prevent cheating, promoting independent programming learning and practice, protecting student privacy, and fostering necessary thinking skills are helpful measures to mitigate the negative impacts of ChatGPT. Awareness of each concern and its suitable measures help protect students and ensure that ChatGPT enhances learning outcomes and benefits students and instructors to mitigate its negative impacts and ensure that it complements human instructors rather than replacing them. Ultimately, this feature ensures that students continue to receive high-quality programming learning, which facilitates the teaching process.

CONCLUSION

This study aimed to investigate the perceptions of faculty members, especially programming instructors, at AL al-Bayt University on the effectiveness of ChatGPT in supporting the programming instruction process. Another aim was to explore their experiences with the potential benefits and adverse impacts of such technology. The participants' perceptions in this study demonstrate several advantages

of ChatGPT that make it useful for the programming instruction process, including practical code applications, personalized and interactive learning, a wide range of programming problems and alternative solutions, accessibility, no programming knowledge required, debugging and feedback capabilities, and clear code explanations. By contrast, several perceptions on the potential drawbacks and negatives of using ChatGPT in programming instruction are reported, including inaccurate retion, unstructured learning, and a lack of real programming elements. Similarly, several concerns are revealed, including ethical and transparent use, privacy and security of students' data, social impact and replacement of human interaction, over-reliance, and controlling students' online behavior. Overall, the participants suggest a complementary role for ChatGPT that balances its potential benefits against its negative impacts to best enhance traditional programming teaching methods. However, they believe successfully integrating ChatGPT into the programming instruction process requires a balanced approach between potential benefits and negative impacts to better aid their students and instructors.

This study is the first to focus on the perceptions of programming instructors during their experience and their students using ChatGPT in programming extensively. The contribution lies in highlighting the positive and negative aspects of using ChatGPT and discussing the potential complementary role of ChatGPT alongside traditional teaching methods. The study concludes that, although faculty members perceive several limitations and concerns for integrating ChatGPT, a cautious approach that appropriately balances potential benefits against negative impacts before integrating ChatGPT into learning can significantly mitigate their adverse effects and achieve quality programming instruction. Understanding the capabilities of ChatGPT to exploit, as well as its concerns to overcome, helps maximize the programming outputs generated from ChatGPT. This understanding can help provide better solutions to programming problems and offers advanced opportunities to enhance students' understanding of problem-solving and algorithmic thinking. Students can be assisted in solving complex programming problems and continue to receive high-quality programming learning by ChatGPT to accelerate their programming knowledge. Similarly, the instructors can use ChatGPT to arrange an instructional plan for programming teaching and prepare topic-related content, presentations, and questions for quizzes and exams.

Exploring programming instructors' perceptions from their field of experience enables gaining valuable and unique insights and evidence for practitioners such as policymakers, instructional designers, and educators, which guide and help incorporate AI technologies efficiently. For instance, the participants' perceptions reveal several essential benefits of integrating ChatGPT into programming instruction that can enhance students' learning and support the efficiency of their instructors. These perceptions recommend practitioners exploit and maximize such benefits by developing new teaching strategies,

curriculum designs, in-class activities, and course outlines for programming curricula that in corporate ChatGPT efficiently. The potential drawbacks, limitations, and concerns of using ChatGPT in programming education that have been explored in this study also provide guidance for practitioners to take appropriate actions to mitigate their adverse effects. Indeed, practitioners are required to embrace such AI technologies rather than banning them. Additional effort is required from instructors to assign programming tasks that require applying programming knowledge and critical thinking instead of simple or trivial tasks that can be directly obtained. Instructors and students should improve their competencies and practices to meet the critical thinking and question-asking competencies required to satisfy the new demands of AI technology with appropriate support from their institutes. IT faculties need to adopt a teaching approach with a complementary role for ChatGPT that balances its potential benefits against its negative impacts to best enhance traditional programming teaching methods and maximize its benefits for students and instructors.

The implications of the participants' perceptions show that actual improvement in programming instruction can be attained through a cautious approach that appropriately balances potential benefits against negative impacts before integrating ChatGPT into learning. This way can significantly mitigate their adverse effects and achieve quality programming instruction. Integrating AI chatbots is essential, given that it enables students to improve their programming skills, critical thinking, and problem-solving skills. These perceptions are consistent with the current trend in AI-based technologies for education in different disciplines, which emphasizes the importance of incorporating such technology to improve students' 21st-century skills to succeed today.

The limitations encountered in this study may represent opportunities for future research. Thus, further research is required to investigate the efficacy of using ChatGPT on other topics in different environments. We recommend paying close attention to designing strategies and alternatives that suit ChatGPT to achieve better results. We also recommend examining the effect of ChatGPT on important attributes, such as motivation, engagement, and achievement of students. Controlling students' behavior during the in-class use of ChatGPT and using an appropriate design for tasks and assignments that best suit the subject and the students are additional challenges for consideration. Ultimately, this study recognizes sample size and subject area as limitations. Replicating this study on a larger scale, in various settings, and on other academic courses from other schools and universities is recommended.

REFERENCES

Adiguzel, T., Kaya, M. H., & Cansu, F. K. (2023). Revolutionizing education with AI: Exploring the

transformative potential of ChatGPT. Contemporary Educational Technology, 15(3), Article ep429. https://doi.org/10.30935/cedtech/13152

Agbo, F. J., Oyelere, S. S., Suhonen, J., & Adewumi, S. (2019). A systematic review of computational thinking approach for programming education in higher education institutions. Proceedings of the 19th Koli Calling International Conference on Computing Education Research (Article 12). Association for Computing Machinery. https://doi.org/10.1145/3364510.3364521

Alam, A. (2022, March). Educational robotics and computer programming in early childhood education: A conceptual framework for assessing elementary school students' computational thinking for designing powerful educational scenarios. Proceedings of the International Conference on Smart Technologies and Systems for Next Generation Computing, Villupuram, India. https://doi.org/10.1109/ICSTSN53084.2022.9761354

Arif, T. B., Munaf, U., & Ul-Haque, I. (2023). The future of medical education and research: Is ChatGPT a blessing or blight in disguise? Medical Education Online, 28(1), Article 2181052. https://doi.org/10.1080/10872981.2023.2181052

Baidoo-Anu, D., & Owusu Ansah, L. (2023). Education in the era of generative artificial intelligence (AI): Understanding the potential benefits of ChatGPT in promoting teaching and learning. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.4337484

Biswas, S. (2023). Role of ChatGPT in computer programming. Mesopotamian Journal of Computer Science, 2023, 816. https://doi.org/10.58496/mjcsc/2023/002

Chen, E., Huang, R., Chen, H.-S., Tseng, Y.-H., & Li, L.-Y. (2023). GPTutor: A ChatGPT-powered programming tool for code explanation. In N. Wang, G. Rebolledo-Mendez, V. Dimitrova, N. Matsuda, O. C. Santos (Eds.), Artificial intelligence in education. Posters and late breaking results, workshops and tutorials, industry and innovation tracks, practitioners, doctoral consortium and blue sky. Springer. https://doi.org/10.1007/978-3031-36336-8_50

Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. IEEE Access, 8, 75264 75278. https://api.semanticscholar.org/CorpusID:218493891

Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches (4th ed.). Sage.

Croker, R. A. (2009). An introduction to qualitative research. In J. Heigham, & R. A. Croker (Eds.), Qualitative research in applied linguistics: A practical introduction (pp. 3–24). Palgrave Macmillan. https://doi.org/10.1057/9780230239517

Dorotea, N., Piedade, J., & Pedro, A. (2021). Mapping K-12 computer science teacher's interest, self confidence, and knowledge about the use of educational robotics to teach. Education Sciences, 11(8), 443. https://doi.org/10.3390/educsci11080443

Eteng, I., Akpotuzor, S., Akinola, S. O., & Agbonlahor, I. (2022). A review on effective approach to

teaching computer programming to undergraduates in developing countries. Scientific African, 16, e01240. https://doi.org/10.1016/j.sciaf.2022.e01240

Farrokhnia, M., Banihashem, S. K., Noroozi, O., & Wals, A. (2023). A SWOT analysis of ChatGPT: Implications for educational practice and research. Innovations in Education and Teaching International. https://doi.org/10.1080/14703297.2023.2195846

Fiialka, S., Kornieva, Z., & Honcharuk, T. (2023). ChatGPT in ukrainian education: Problems and prospects. International Journal of Emerging Technologies in Learning, 18(17), 236–250. https://doi.org/10.3991/ijet.v18i17.42215

Geerling, W., Mateer, G. D., Wooten, J., & Damodaran, N. (2023). ChatGPT has aced the test of understanding in college economics: Now what? American Economist, 68(2), 233–245. https://doi.org/10.1177/05694345231169654

González-Pérez, L. I., & Ramírez-Montoya, M. S. (2022). Components of Education 4.0 in 21st century skills frameworks: Systematic review. Sustainability, 14(3), 1493. https://doi.org/10.3390/su14031493

Gordon, C., Lysecky, R., & Vahid, F. (2022, August). Programming learners struggle as much in Python as in C++ or Java. Paper presented at ASEE Annual Conference & Exposition, Minneapolis, MN. https://peer.asee.org/41410

Halaweh, M. (2023). ChatGPT in education: Strategies for responsible implementation. Contemporary Educational Technology, 15(2), ep421. https://doi.org/10.30935/cedtech/13036

Haleem, A., Javaid, M., & Singh, R. P. (2022). An era of ChatGPT as a significant futuristic support tool: A study on features, abilities, and challenges. BenchCouncil Transactions on Benchmarks, Standards and Evaluations, 2(4), 100089. https://doi.org/10.1016/j.tbench.2023.100089

Handur, V., Kalwad, P. D., Patil, M. S., Garagad, V. G., Yeligar, N., Pattar, P., Mehta, D., Baligar, P., & Joshi, G. H. (2016, December). Integrating class and laboratory with hands-on programming: Its benefits and challenges. Proceedings of the IEEE 4th International Conference on MOOCs, Innovation and Technology in Education, Madurai, India, 163–168. https://doi.org/10.1109/mite.2016.041

Hargreaves, S. (2023). 'Words are flowing out like endless rain into a paper cup': ChatGPT & law school assessments. Legal Education Review, 33(1). https://doi.org/10.53300/001c.83297

Hew, K. F., Huang, W., Du, J., & Jia, C. (2023). Using chatbots to support student goal setting and social presence in fully online activities: learner engagement and perceptions. Journal of Computing in Higher Education, 35, 40–68. https://doi.org/10.1007/s12528-022-09338-x

Huang, A. Y. Q., Lu, O. H. T., & Yang, S. J. H. (2023). Effects of artificial intelligence-enabled personalized recommendations on learners' learning engagement, motivation, and outcomes in a flipped classroom. Computers and Education, 194, 104684. https://doi.org/10.1016/j.compedu.2022.104684

Husain, A. J. A., & Al-Shayeb, A. Q. (2023). Improvement in student achievement through a flipped database management classroom: Shifting from passive traditional to active learning. International Journal of Emerging Technologies in Learning, 18(8), 210–221. https://doi.org/10.3991/ijet.v18i08.37699

Jalil, S., Rafi, S., Latoza, T. D., Moran, K., & Lam, W. (2023, April). ChatGPT and software testing education: Promises & perils. Proceedings of the IEEE International Conference on Software Testing, Verification and Validation Workshops, Dublin, Ireland, 4130–4137. https://doi.org/10.1109/ICSTW58534.2023.00078

James, J. (2021). Confronting the scarcity of digital skills among the poor in developing countries. Development Policy Review, 39(2), 324–339. https://doi.org/10.1111/dpr.12479

Kashefi, A., & Mukerji, T. (2023). ChatGPT for programming numerical methods. Journal of Machine Learning for Modeling and Computing, 4(2), 1–74. https://doi.org/10.1615/jmachlearnmodelcomput.2023048492

Khan, R. A., Jawaid, M., Khan, A. R., & Sajjad, M. (2023). ChatGPT – Reshaping medical education and clinical management. Pakistan Journal of Medical Sciences, 39(2), 605–607. https://doi.org/10.12669/pjms.39.2.7653

Kohnke, L. (2023). L2 learners' perceptions of a chatbot as a potential independent language learning tool. International Journal of Mobile Learning and Organisation, 17(1–2), 214–226. https://doi.org/10.1504/ijmlo.2023.128339

Lee, H. (2023). The rise of ChatGPT: Exploring its potential in medical education. Anatomical Sciences Education. https://doi.org/10.1002/ase.2270

Lindberg, R. S. N., Laine, T. H., & Haaranen, L. (2019). Gamifying programming education in K-12: A review of programming curricula in seven countries and programming games. British Journal of Educational Technology, 50(4), 1979–1995. https://doi.org/10.1111/bjet.12685

Liu, J., Sun, M., Dong, Y., Xu, F., Sun, X., & Zhou, Y. (2022). The mediating effect of creativity on the relationship between mathematic achievement and programming self-Efficacy. Frontiers in Psychology, 12, 772093. https://doi.org/10.3389/fpsyg.2021.772093

Lo, C. K. (2023). What is the impact of ChatGPT on education? A rapid review of the literature. Education Sciences, 13(4), 410. https://doi.org/10.3390/educsci13040410

Logozar, R. (2023, September). ChatGPT on the freshman test in C/C ++ programming. Proceedings of the IEEE 21st International Symposium on Intelligent Systems and Informatics, Pula, Croatia, 255-264.

López-Pimentel, J. C., Medina-Santiago, A., Alcaraz-Rivera, M., & Del-Valle-Soto, C. (2021). Sustainable project-based learning methodology adaptable to technological advances for web programming. Sustainability, 13(15), 8482. https://doi.org/10.3390/su13158482

Malik, S. I., Al-Emran, M., Mathew, R., Tawafak, R. M., & Alfarsi, G. (2020). Comparison of E-learning,

M learning and Game-based learning in programming education. International Journal of Emerging Technologies in Learning, 15(15), 133–146. https://doi.org/10.3991/ijet.v15i15.14503

Meda, L., Baroudi, S., & Hojeij, Z. (2023). Faculty perceptions of virtual field experience placement in a teacher preparation program in the uae. Journal of Information Technology Education: Research, 22, 25–40. https://doi.org/10.28945/5066

Megahed, F. M., Chen, Y. J., Ferris, J. A., Knoth, S., & Jones-Farmer, L. A. (2023). How generative AI models such as ChatGPT can be (mis)used in SPC practice, education, and research? An exploratory study. Quality Engineering. https://doi.org/10.1080/08982112.2023.2206479

Merriam, S. B., & Tisdell, E. J. (2015). Qualitative research: A guide to design and implementation. John Wiley & Sons. Mhlanga, D. (2023). Open AI in education, the responsible and ethical use of chatgpt towards lifelong learning. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.4354422

Mogali, S. R. (2023). Initial impressions of ChatGPT for anatomy education. Anatomical Sciences Education. https://doi.org/10.1002/ase.2261

Mohamed, A. M. (2023). Exploring the potential of an AI-based Chatbot (ChatGPT) in enhancing English as a Foreign Language (EFL) teaching: Perceptions of EFL faculty members. Education and Information Technologies. https://doi.org/10.1007/s10639-023-11917-z

Ngo, T. T. A. (2023). The perception by university students of the use of chatgpt in education. International Journal of Emerging Technologies in Learning, 18(17), 4–19. https://doi.org/10.3991/ijet.v18i17.39019

Noh, J., & Lee, J. (2020). Effects of robotics programming on the computational thinking and creativity of elementary school students. Educational Technology Research and Development, 68(1), 463–484. https://doi.org/10.1007/s11423-019-09708-w

Oktavia, T., Prabowo, H., Meyliana, & Supangkat, S. H. (2018, September). The comparison of MOOC (Massive open online course) platforms of edX and Coursera (Study case: Student of programming courses). Proceedings of the International Conference on Information Management and Technology, Jakarta, Indonesia, 339–344. https://doi.org/10.1109/ICIMTech.2018.8528178

OpenAI. (2023). ChatGPT. https://openai.com/chatgpt Padilla, J. R. C., Montefalcon, M. D., & Hernandez, A. A. (2023, December). Language AI in programming : A case study of ChatGPT using natural language processing. Proceedings of the 11th IEEE Conference on Systems, Process and Control, Malacca, Malaysia.

Perkins, M. (2023). Academic integrity considerations of AI large language models in the post-pandemic era: ChatGPT and beyond. Journal of University Teaching and Learning Practice, 20(2). https://doi.org/10.53761/1.20.02.07

Qasem, F., Ghaleb, M., Mahdi, H. S., Al Khateeb, A., & Al Fadda, H. (2023). Dialog chatbot as an interactive online tool in enhancing ESP vocabulary learning. Saudi Journal of Language Studies, 3(2),

76–86. https://doi.org/10.1108/sjls-10-2022-0072

Qureshi, B. (2023). ChatGPT in computer science curriculum assessment: An analysis of its successes and shortcomings. Proceedings of the 9th International Conference on e-Society, e-Learning and e-Technologies (pp. 7–13). Association for Computing Machinery. https://doi.org/10.1145/3613944.3613946

Rahman, M. M., & Watanobe, Y. (2023). ChatGPT for education and research: Opportunities, threats, and strategies. Applied Sciences, 13(9), 5783. https://doi.org/10.3390/app13095783

Raman, R., Vishwa, A., Hiran Lathabhai, V., Shyam, V., Amrita, D., & Vidyapeetham, V. (2023). Early research trends on ChatGPT: A review based on Altmetrics and science mapping analysis. International Journal of Emerging Technologies in Learning, 18(19), 13–31. https://doi.org/10.3991/ijet.v18i19.41793

Sánchez-Ruiz, L. M., Moll-López, S., Nuñez-Pérez, A., Moraño-Fernández, J. A., & Vega-Fleitas, E. (2023). ChatGPT challenges blended learning methodologies in engineering education: A case study in mathematics. Applied Sciences, 13(10), 6039. https://doi.org/10.3390/app13106039

Sharov, S., Kolmakova, V., Sharova, T., & Pavlenko, A. (2021). Analysis of MOOC on programming for IT specialist training. TEM Journal, 10(4), 1884–1894. https://doi.org/10.18421/TEM104-52

Siegfried, R. M., Herbert-Berger, K. G., Leune, K., & Siegfried, J. P. (2021, August). Trends of commonly used programming languages in CS1 and CS2 learning. Proceedings of the IEEE 16th International Conference on Computer Science and Education, Lancaster, United Kingdom, 407–412. https://doi.org/10.1109/ICCSE51940.2021.9569444

Sok, S., & Heng, K. (2023). ChatGPT for education and research: A review of benefits and risks. SSRN. https://doi.org/10.2139/ssrn.4378735

Strawhacker, A., & Bers, M. U. (2019). What they learn when they learn coding: Investigating cognitive domains and computer programming knowledge in young children. Educational Technology Research and Development, 67(3), 541–575. https://doi.org/10.1007/s11423-018-9622-x

Su, Y. S., Shao, M., & Zhao, L. (2022). Effect of mind mapping on creative thinking of children in scratch visual programming education. Journal of Educational Computing Research, 60(4), 906–929. https://doi.org/10.1177/07356331211053383

Sullivan, A., & Strawhacker, A. (2021). Screen-free STEAM: Low-cost and hands-on approaches to teaching coding and engineering to young children. In C. Cohrssen, & S. Garvis (Eds.), Embedding STEAM in early childhood education and care (pp. 87–113). Palgrave Macmillan. https://doi.org/10.1007/978-3-030-65624-9_5

Sun, G. H., & Hoelscher, S. H. (2023). The ChatGPT storm and what faculty can do. Nurse Educator, 48(3), 119–124. https://doi.org/10.1097/NNE.0000000000001390

Surameery, N. M. S., & Shakor, M. Y. (2023). Use ChatGPT to solve programming bugs. International

Journal of Information Technology and Computer Engineering, 31, 17–22. https://doi.org/10.55529/ijitc.31.17.22

Tian, H., Lu, W., Li, T. O., Tang, X., Cheung, S.-C., Klein, J., & Bissyandé, T. F. (2023). Is ChatGPT the ultimate programming assistant – How far is it? arXiv. https://doi.org/10.48550/arXiv.2304.11938

Tikva, C., & Tambouris, E. (2021). Mapping computational thinking through programming in K-12 education: A conceptual model based on a systematic literature Review. Computers and Education, 162, 104083. https://doi.org/10.1016/j.compedu.2020.104083

Tlili, A., Shehata, B., Adarkwah, M. A., Bozkurt, A., Hickey, D. T., Huang, R., & Agyemang, B. (2023). What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education. Smart Learning Environments, 10, Article 15. https://doi.org/10.1186/s40561-023-00237-x

Wardat, Y., Tashtoush, M. A., AlAli, R., & Jarrah, A. M. (2023). ChatGPT: A revolutionary tool for teaching and learning mathematics. Eurasia Journal of Mathematics, Science and Technology Education, 19(7), Article em2286. https://doi.org/10.29333/ejmste/13272

Wei, X., Lin, L., Meng, N., Tan, W., Kong, S. C., & Kinshuk. (2021). The effectiveness of partial pair programming on elementary school students' computational thinking skills and self-efficacy. Computers and Education, 160, 104023. https://doi.org/10.1016/j.compedu.2020.104023

Yilmaz, R., & Karaoglan Yilmaz, F. G. (2023). 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, 4, 100147. https://doi.org/10.1016/j.caeai.2023.100147

Yilmaz, R., Karaoglan Yilmaz, F. G., & Keser, H. (2020). Vertical versus shared e-leadership approach in online project-based learning: a comparison of self-regulated learning skills, motivation and group collaboration processes. Journal of Computing in Higher Education, 32(3), 628–654. https://doi.org/10.1007/s12528-02009250-2

Zarifhonarvar, A. (2023). Economics of ChatGPT: A labor market view on the occupational impact of artificial intelligence. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.4350925

Zheng, Y. (2023). ChatGPT for teaching and learning: An experience from data science education. Proceedings of the 24th Annual Conference on Information Technology Education (pp. 66–72). Association for Computing Machinery. https://doi.org/10.1145/3585059.3611431

Zinovieva, I. S., Artemchuk, V. O., Iatsyshyn, A. V., Popov, O. O., Kovach, V. O., Iatsyshyn, A. V., Romanenko, Y. O., & Radchenko, O. V. (2021). The use of online coding platforms as additional distance tools in programming education. Journal of Physics: Conference Series, 1840, 012029. https://doi.org/10.1088/1742-6596/1840/1/012029

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THE ROLE OF CHATGPT IN EDUCATION: APPLICATIONS, CHALLENGES: INSIGHTS FROM A SYSTEMATIC REVIEW

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ABSTRACT

Aim/Purpose *The purpose of this systematic review is to identify and analyze the current findings of empirical research on the use of ChatGPT in school and higher education.*

Background *As AI reshapes education, the adoption of ChatGPT has the potential to revolutionize teaching and learning in school and higher educational settings. Meanwhile, substantial ethical questions and practical challenges are raised by the implementation of such technology at these educational levels, which must be carefully considered.*

Methodology *To address the research questions, a systematic literature review (SLR) was con ducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol. As part of the SLR, articles published between January 2023 and January 2024 were sought. The search query consisted of the various Boolean operators and search terms. The search was conducted in Scopus, Web of Science, ProQuest, SSRN, ERIC and DOAJ, Science Direct, Springer Link, Taylor & Francis, and IEEEXplore. Additionally, a manual search was carried out in scientific journals focusing on the field of emerging technologies in education. Of the 1,653 articles identified, 77 were selected through the application of inclusion and exclusion criteria. After reviewing the abstracts of the selected studies, 50 articles were included in the review.*

Contribution *This SLR presents an innovative exploration of ChatGPT's potential in both university and school education. By examining its performance, ethical implications, and impact on student outcomes, the review provides a valuable resource for educators and researchers. It not only updates existing knowledge but also provides new insights into educational practices and use cases.*

Findings *The study revealed that while ChatGPT can enhance students' cognitive performance and critical thinking skills, its capacity for deep, creative, and complex problem-solving is limited. Additionally, ethical challenges such as academic integrity violations, copyright infringements, and the propagation of biased content were identified.*

Recommendations for Practitioners *Practitioners are encouraged to foster a culture of prompt engineering and AI literacy among educators and students, enabling the effective integration of AI conversational agents into educational settings while addressing potential limitations and ethical concerns.*

Recommendations for Researchers *Researchers should direct their efforts towards more empirical*

research evidence in the domain of K-12 education with a specific focus on both secondary and primary education.

Impact on Society *ChatGPT and similar tools have the potential to revolutionize education. Their effective integration can create more engaging and effective learning experiences, preparing students for the future.*

Future Research *Further investigation is needed in terms of the use of advanced conversational AI models in the areas of primary education and ethical frameworks, which are underrepresented as well as in non-formal, informal, and special education settings*

Keywords *artificial intelligence, chatbot, ChatGPT, formal education, ethical issues, institutional framework, systematic literature review, PRISMA*

INTRODUCTION

In recent years, our daily lives have been inundated with a multitude of Artificial Intelligence (AI) applications and artifacts, often without our conscious awareness. Programs such as internet search engines, smartphone digital assistants, automated translation tools, GPS navigation systems, and autonomous vehicles rely on AI and contribute to facilitating our lives (European Commission, 2022; European Parliament, 2023).

As an integral part of society, education is undergoing a digital transformation as it harnesses the power of AI (Bozkurt et al., 2021). Combining theoretical knowledge with practical application, the science of Artificial Intelligence in Education (AIED) focuses on developing foundational theories for integrating AI into educational systems while simultaneously creating tools aimed at enhancing the learning experience and improving learning outcomes (Holmes & Porayska-Pomsta, 2022).

While the initial use of AIED can be traced back to the late 1970s (Self, 1974), significant advancements in the field emerged in the early 2000s (Villan & dos Santos, 2023). However, factors such as improved computational infrastructure, algorithm development, advancements in CPUs and cloud computing, increased research investments, and growing demand from industries integrating AI technologies have led to a surge in research interest in AIED in the late 2010s (İpek et al., 2023). Moreover, the urgent need for advanced, intelligent, and flexible technological tools to facilitate the pressing digital and remote learning process during the COVID-19 pandemic has acted as a catalyst for rapid advancements in AIED (Churi et al., 2022; Kostas et al., 2023).

AIED leverages methods such as cloud-based big data storage, big data analytics systems, and machine learning algorithms employing deep learning techniques to provide personalized support and create more flexible and effective learning environments, opening new possibilities for learning (Yu & Lu, 2021). Towards this end, the development of tools based on these techniques, such as Natural Language Processing (NLP), which uses algorithms to enable computers to understand, process, generate human language, and computer vision, which allows computers to 'see' and understand visual data, and sensors that capture various physical states and convert them into electronic signals, has been pursued (UNESCO, 2022).

Based on the aforementioned techniques and tools, AIED finds application in three primary categories of educational AI programs (European Commission, 2018):

• Learning support systems tailored to student needs, such as Intelligent Tutoring Systems (ITS), Learning Management Systems (LMS), virtual and augmented reality, chatbots, assistive technologies for children with disabilities, and robotic tutors (Churi et al., 2022; OECD, 2020; UNESCO, 2022; Yu & Lu, 2021).
• Teaching support systems designed to meet the needs of educators, including AI tutors, learning analytics systems, automated assessment programs, and Large Language Models (LLMs) like ChatGPT (Churi et al., 2022; Lee, 2023; UNESCO, 2021).
• Educational system support systems include methods for collecting and processing learning data and the integration of AI into school and academic libraries (Churi et al., 2022).

Despite the abundance of AI tools, the widespread implementation of AI systems, particularly in education, raises ethical and deontological concerns that necessitate the establishment of an ethical framework.

The emerging field of AI ethics, situated within applied ethics and the philosophy of technology, aims to examine the ethical dilemmas and implications of developing and deploying AI systems (Waelen, 2022). According to Tzimas (2021), AI ethics focuses on creating ethical AI systems and establishing an ethical framework for human-machine interaction in an ever-evolving technological landscape. A significant trend is the increasing use of the term "ethically aligned design," which encompasses design processes for AI systems that explicitly integrate human values (IEEE, 2018, in World Commission on the Ethics of Scientific Knowledge and Technology, 2019). Similarly, the principle of human-centric AI pervades many international recommendations and agreements on AI use, emphasizing that AI should be under human control and work for the benefit of humanity while safeguarding human rights and

upholding fundamental ethical principles (European Commission, 2018; OECD, 2020).

Key principles and ethical values identified in the literature regarding the development and use of AI systems include:

(a) Transparency, linked to security, involves access to and understanding of data, algorithms, and decision-making processes (Tzimas, 2021), as well as awareness of personal data collection and processing and the need to ensure privacy (Holmes et al., 2022; UNESCO, 2021; Waelen, 2022).
(b) Justice and equality are challenged by unequal access to AI and the exacerbation of the digital divide (UNESCO, 2021; Waelen, 2022), as well as the perpetuation of biases and stereotypes reinforced by AI (Holmes et al., 2022; Tzimas, 2021) – in educational contexts, academic integrity is threatened when students use AI-generated outputs as their own (Churi et al., 2022; Holmes et al., 2022).
(c) Promoting social and environmental well-being, sustainable development, and avoiding harm are examples of beneficial AI, including systems for predicting natural disasters or saving energy. Conversely, the use of nuclear or autonomous weapons powered by AI can be harmful or even highly dangerous (Tzimas, 2021; Waelen, 2022).
(d) Accountability is a cornerstone of AI development. While AI systems can make decisions with significant human impact, their inability to assume moral responsibility means that humans must be held accountable for their actions (Waelen, 2022). Applications such as student assessment and job recruitment using AI require careful oversight, as errors can have serious consequences for individuals (Churi et al., 2022).

While efforts are underway to establish ethical frameworks for AI by international organizations, governments, and private entities, the rapid advancements in the field and the emergence of new AI systems necessitate the continuous updating of guidelines to address emerging ethical challenges and ensure the optimal utilization of emerging AI technologies. Such an emerging AI tool is conversational agents or chatbots, which mimic human conversation (UNESCO, 2022) and serve as digital assistants, providing information and personalized support to learners without time or location constraints (UNESCO, 2021; Lee, 2023).

In late 2022, ChatGPT marked a milestone in chatbot development. This large language (LLM) is based on Generative Pre-trained Transformer (GPT) technology (UNESCO, 2023). After being trained on a massive dataset (Wolfram, 2023) using machine learning techniques (Javaid et al., 2023), ChatGPT can engage in written conversations using coherent natural language that simulates human communication Skrabut, 2023). Its ability to perform Natural Language Processing (NLP) tasks, such as creating

creating customized educational materials and exercises, providing immediate feedback on tasks like summarizing texts, proofreading, and generating original essays (Skrabut, 2023), highlights its potential as a valuable tool for both teachers and students.

The model's significant impact is mirrored by a surge in research activity, focusing on both the benefits and ethical concerns of integrating ChatGPT, primarily in higher education (Athanassopoulos et al., 2023), as well as on the model's performance across various disciplines (Elkhatat, 2023; Kortemeyer, 2023; Meo et al., 2023; Vázquez-Cano et al., 2023).

A preliminary review of the literature for this research revealed a limited number of reviews focusing on the application of ChatGPT across the entire spectrum of formal education. Of these, some examine articles published in the first few months after the model's release (AlBadarin et al., 2023; İpek et al., 2023; Lo, 2023; Lo & Hew, 2023), while others primarily analyze theoretical articles (İpek et al., 2023; Montenegro-Rueda et al., 2023). Consequently, it was deemed necessary for the Systematic Literature Review (SLR) to focus exclusively on empirical studies, incorporating the latest data on the integration of ChatGPT into educational settings.

Additionally, most of the previous Systematic Literature Reviews examine the ways of utilizing, the limitations, and the ethical implications of the model in education in general or with a focus on higher education (Lo, 2023; Vargas-Murillo et al., 2023), with very few addressing K-12 education (Zhang & Tur, 2023). Therefore, it was considered important to examine various aspects of the topic through a comparative analysis of data from the application of ChatGPT in specific subject areas, focusing on the practical challenges and ethical concerns such as academic integrity and student dependency on AI, both in higher education and in K-12 education.

Furthermore, the literature review revealed studies exploring scenarios for using the model in various scientific disciplines and courses. Additionally, studies were identified that evaluate the quality of ChatGPT's responses in different subject areas, as well as its impact on students' performance and skills. However, these dimensions of the topic have not been sufficiently analyzed in existing literature reviews. Consequently, there is a need for further research in these areas.

Therefore, this SLR enriches the literature by aiming to collect and analyze recent data from empirical studies focusing on the integration of ChatGPT into educational settings in both K12 and higher education, to highlight the ways of application, limitations, and the effects of using the model on students' performance and skills. This work can be a valuable tool for educators, researchers, and policy makers considering the use of ChatGPT or similar chatbots in the field of education. To achieve the

above objectives, this study will attempt to answer the following research questions:

• RQ1: What is the identity and methodological design of the studies under investigation?
• RQ2: How is ChatGPT used by teachers and students? Indicative best practices and use cases in K-12 and higher education.
• RQ3: What is the performance of ChatGPT during exploratory use in various subject areas?
• RQ4: What limitations and ethical issues arise from the use of ChatGPT in formal education?
• RQ5: What is the impact of using ChatGPT on students' performance, higher-order thinking skills, and motivation?

Subsequent sections detail the SLR methodology employed, the findings obtained for each research question, a discussion comparing these results with previous studies, and concluding remarks

METHODOLOGY

To address the research questions, a systematic literature review (SLR) was conducted, following a clear, strictly predefined methodology with specific implementation stages (Page et al., 2021), elements that constitute its validity criteria (Fink, 2005; Lame, 2019). This methodology, based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses protocol (PRISMA), involves a 27-item checklist and a revised three-stage flow diagram as illustrated in Figure 1. Strict inclusion and exclusion criteria (Haddaway et al., 2022; Page et al., 2021) were applied to identify and select relevant articles.

As part of the SLR, articles published between January 2023 and January 2024 were sought. The search query consisted of the following Boolean operators and search terms: [ChatGPT OR "conversational agents" OR "chatbot AI"] AND ["empirical research"] AND [education OR learning practices OR didactic strategies OR "classroom intervention" OR "case scenarios"]. The search was conducted in the general databases Scopus, Web of Science, ProQuest, and SSRN, in the educational databases ERIC and DOAJ, and in the publishers Science Direct, Springer Link, Taylor & Francis, and IEEEXplore. Additionally, a manual search was carried out in scientific journals focusing on the field of emerging technologies in education.

Of the 1,653 articles identified, 77 were selected through the application of inclusion and exclusion criteria, as shown in Table 1. After reviewing the abstracts of the selected studies, 50 articles were ultimately included in the review.

The data were managed with the help of the open-source reference management software Zotero (Trinoskey et al., 2009). Additionally, based on the research questions of this study, a Google Sheets spreadsheet was developed for the extraction, organization, and categorization of information provided by the selected articles. This resulted in a table, where the first column contained the article references, and the subsequent columns recorded data related to the identity of the studies (location and time of the study, publication journal, and database of identification), their methodological design (target group, educational context, and subject area of ChatGPT application, purpose and research questions, data collection and analysis tools), as well as the results and conclusions of the studies in cluded in this work. This was followed by the narrative synthesis of the data (Petticrew & Roberts, 2006), combined with the creation of tables to highlight the connection between the results and the evidence from the SLR. The coding of data within systematic reviews is different than coding primary research, as participant data and author analysis are interpreted to provide third-order constructs, as Crompton et al. (2021) suggested. Two types of coding were used in this study, a priori coding and grounded coding, following Crompton's et al. (2021) approach. A priori coding was used for articles' identity, educational level, education type, and methodology extraction categories, and grounded coding was used for research extraction categories, initially using in-vivo coding (Saldana, 2015). Finally, regarding the limitations of this study, no separate analysis of quantitative and qualitative studies was conducted, and no interrater reliability was calculated for the content analysis

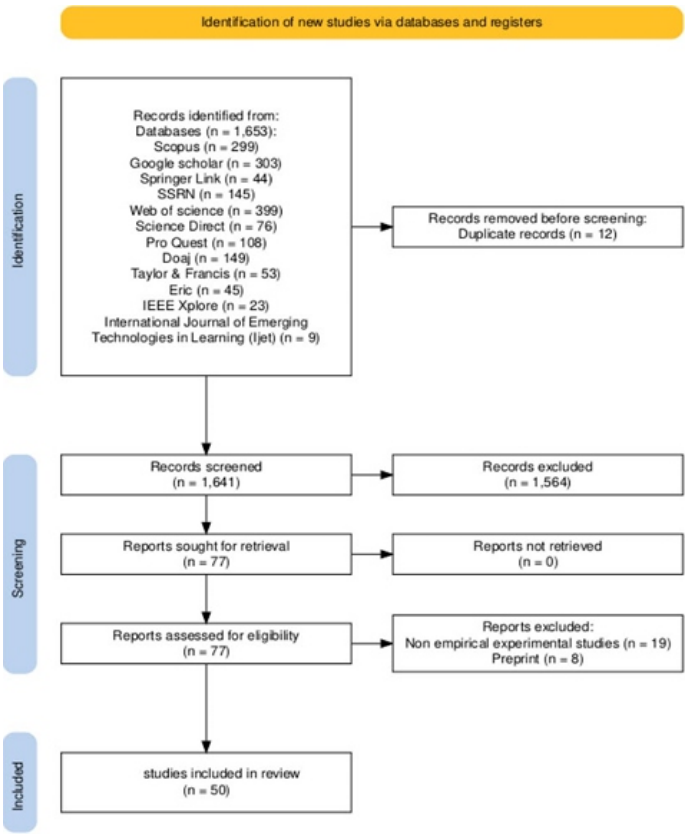

Figure 1. PRISMA flow diagram

Table 1. Inclusion and exclusion criteria for research articles

Category	Inclusion criteria	Exclusion criteria
Publication type	Research articles in scientific journals and reputable digital libraries, following peer-review	Articles not peer-reviewed, position papers, theoretical reports, literature reviews
Publication year	From January 2023 to January 2024	Before January 2023 and after January 2024
Research objective	Highlighting best practices, usage scenarios of ChatGPT, and identification of ethical and ideological limitations in the use of ChatGPT in educational contexts	Applications and uses of ChatGPT that are not related to the educational process
Category	**Inclusion criteria**	**Exclusion criteria**
Educational content	School and university education	Non-educational contexts, non-formal and informal education
Methodological design	Empirical studies of any methodological design	Theoretical articles
Language	English	Languages other than English
Accessibility	Open or institutional access to the full text of the articles	Theoretical articles; limited or paid access; no full access to the complete text

RESULTS

This section provides a comprehensive review of the data, drawing on the analysis and synthesis of 50 papers using the PRISMA methodology. The five research questions are outlined, accompanied by their corresponding findings.

RQ1: WHAT IS THE IDENTITY AND METHODOLOGICAL DESIGN OF THE STUDIES UNDER INVESTIGATION?

Studies identity

Most studies originate from the US, accounting for 12% of all articles, followed by China with 10%. Saudi Arabia contributes 6%, while Greece, Germany, Spain, Turkey, India, and Australia each contribute two articles (4%). Numerous other countries, primarily from Asia, as well as from Europe, America, and Africa, participate in the SLR, each with one article. Figure 2 presents a global map illustrating the distribution of articles by country of origin.

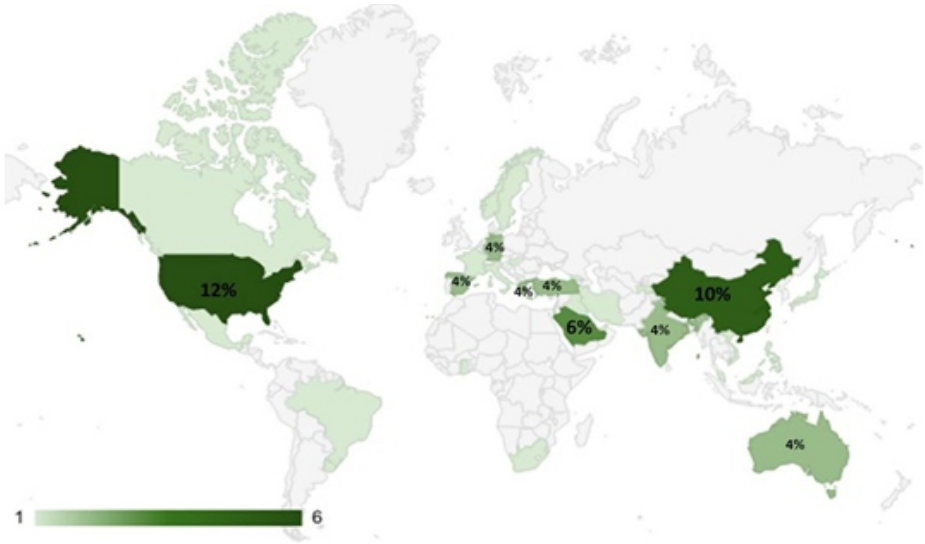

Figure 2. Geographical distribution of articles

Regarding the temporal distribution of articles, a gradual increase in publication is observed over the months, culminating in a peak during July and autumn of 2023, as illustrated in Figure 3. In terms of the journals in which the studies are published, a wide dispersion of results is evident, with most publications (6%) appearing in Computers and Education: Artificial Intelligence and Education Sciences.

Concerning the educational context, most studies, representing 62% of all records (31 articles), are situated within the higher education sector. Secondary and primary education follow with 14% and 10%, respectively, while a single study is found in preschool education. A total of 12% of the articles, corresponding to six publications, made general references to education or encompassed multiple educational levels, as shown in Table 2.

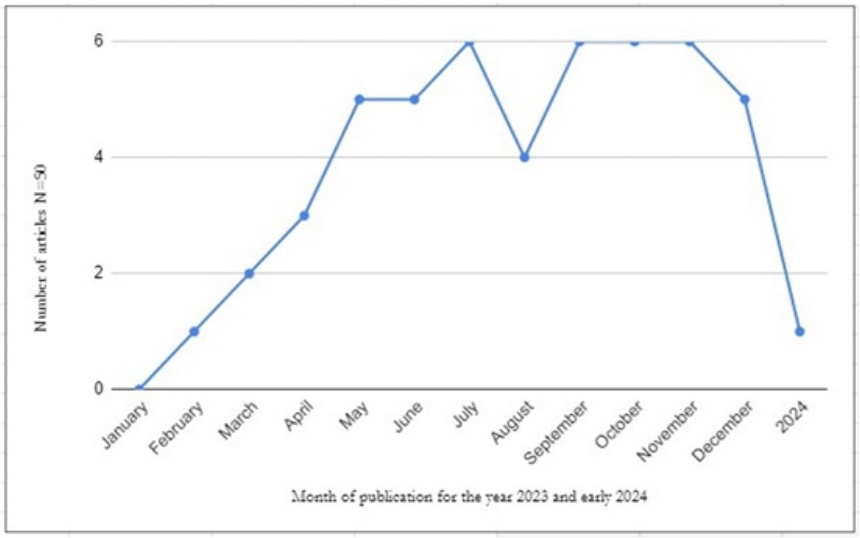

Figure 3. Timeline of article publications

Table 2. Educational level of selected articles

Educational level	References
Preschool education (1 article)	(Luo et al., 2024)
Primary education (5 articles)	(Abdelghani et al., 2024; Jauhiainen & Guerra, 2023; Jeon & Lee, 2023; Yan, 2023; Young & Shishido, 2023)
Secondary education (8 articles)	(Alneyadi & Wardat, 2023; Athanassopoulos et al., 2023; Bitzenbauer, 2023; Chen et al., 2023; Forman et al., 2023; Javier & Moorhouse, 2024; Villan & dos Santos, 2023; Waltzer et al., 2023)
Higher education (30 articles)	(Akiba & Fraboni, 2023; Albdrani & Al-Shargabi, 2023; Albert & Li, 2023; Al-Garaady & Mahyoob, 2023; Al-Obaydi et al., 2023; Aydin Yildiz, 2023; Baglivo et al., 2023; Escalante et al., 2023; Essel et al., 2024; Farazouli et al., 2023; Guo & Lee, 2023; Han et al., 2023; Ho et al., 2023; Irfan et al., 2023; Kong et al., 2023; Küchemann et al., 2023; Matzakos et al., 2023; Meron & Tekmen Araci, 2023; Michalon & Camacho-Zuñiga, 2023; Nguyen, 2023; Niu & Xue, 2023; Roy & Putatunda, 2023; Sánchez-Ruiz et al., 2023; Shaikh et al., 2023; Swargiary, 2023; Tirado-Olivares et al., 2023; Uddin et al., 2023; van den Berg & du Plessis, 2023; Xiao & Zhi, 2023; Yilmaz & Karaoglan Yilmaz, 2023)
General education or different levels of education (6 articles)	(Cooper, 2023; Daher et al., 2023; Ghafouri, 2024; Li et al., 2023; Tlili et al., 2023; Wardat et al., 2023)

Pertaining to the target group, university students constitute the target population in most articles, with 24 recorded instances, while secondary school students follow with seven recorded instances.

Subsequently, a mixed sample of university students and educators is employed in six studies, while a purely university educator sample is used in four studies. In three studies, the sample consists of both secondary school students and educators simultaneously. The fewest instances are observed among primary school students and educators.

Regarding the subject areas in which ChatGPT is implemented, the highest frequency, with a total of 15 articles, is observed in the field of language learning, with English as a foreign language being the dominant focus. This is followed by applications in the natural sciences, with Physics appearing in four articles, while Mathematics, Chemistry, Computer Science, and Education each have three records. Additionally, five articles make general references to education without specifying a particular subject area. Table 3 provides a detailed overview of the target groups and subject areas where ChatGPT was applied in the studies.

Table 3. Distribution of subject area by target group

Subject area	Target group	References
Foreign languages (15 articles)	Primary school teachers	(Jeon & Lee, 2023)
	Higher education teachers	(Nguyen, 2023)
	Secondary school students	(Athanassopoulos et al., 2023; Javier & Moorhouse, 2024; Li et al., 2023; Young & Shishido, 2023)
	Undergraduate students - Higher education	(Al-Obaydi et al., 2023; Aydin Yildiz, 2023; Escalante et al., 2023; Xiao & Zhi, 2023)
	Undergraduate and postgraduate students – Higher education	(Shaikh et al., 2023)
	Secondary school students and teachers	(Ghafouri, 2024; Waltzer et al., 2023)
	Higher education students and teachers	(Al-Garaady & Mahyoob, 2023; Roy & Putatunda, 2023)
General education (5 articles)	Higher education teachers	(Luo et al., 2024; Swargiary, 2023)
	Primary school students	(Abdelghani et al., 2024)
	Secondary school students	(Forman et al., 2023)
	Higher education students and teachers	(Tlili et al., 2023)
Physics (4 articles)	Secondary school teachers	(Cooper, 2023)
	Secondary school students	(Alneyadi & Wardat, 2023; Bitzenbauer, 2023)
	Undergraduate students - Higher education	(Küchemann et al., 2023)
Mathematics (3 articles)	Secondary school teachers	(Wardat et al., 2023)
	Undergraduate students - Higher education	(Sánchez-Ruiz et al., 2023)
	Higher education students and teachers	(Matzakos et al., 2023)
Chemistry (3 articles)	Secondary school students	(Daher et al., 2023)
	Undergraduate students - Higher education	(Guo & Lee, 2023)
	Higher education students and teachers	(Kong et al., 2023)
Computer science (3 articles)	Undergraduate students - Higher education	(Albdrani & Al-Shargabi, 2023; Niu & Xue, 2023; Yilmaz & Karaoglan Yilmaz, 2023)

Subject area	Target group	References
Elementary education (3 articles)	Higher education teachers	(Meron & Tekmen Araci, 2023)
	Undergraduate students - Higher education	(Akiba & Fraboni, 2023; van den Berg & du Plessis, 2023)
Diverse fields (2 articles)	Higher education teachers	(Farazouli et al., 2023)
	Undergraduate students - Higher education	(Swargiary, 2023)
History (2 articles)	Primary school students	(Jauhiainen & Guerra, 2023)
	Undergraduate students - Higher education	(Tirado-Olivares et al., 2023)
Scientific research (2 articles)	Primary school students and teachers	(Villan & dos Santos, 2023)
	Undergraduate students - Higher education	(Essel et al., 2024)
Medicine (2 articles)	Undergraduate students - Higher education	(Baglivo et al., 2023)
	Higher education students and teachers	(Han et al., 2023)
International relations (1 article)	Undergraduate students - Higher education	(Michalon & Camacho-Zuñiga, 2023)
Journalism (1 article)	Undergraduate students - Higher education	(Irfan et al., 2023)
World religions (1 article)	Secondary school students and teachers	(Chen et al., 2023)
Construction industry (1 article)	Undergraduate students - Higher education	(Uddin et al., 2023)
Business administration (1 article)	Undergraduate and postgraduate students – Higher education	(Albert & Li, 2023)

Methodological design

Regarding the methodological design, 21 studies (42%) employ a mixed research approach, 19 (38%) use qualitative methods, and 10 articles (20%) apply quantitative methods. Sixteen studies (32%) are exploratory, making this the most frequent research type in the SLR. Case studies with a single experimental group are used in 10 studies (20%), while experimental studies with a within-group design and between-group design are found in seven (14%) and six (12%) articles, respectively. Additionally, five studies (10%) applied field research, while smaller percentages are recorded for action research and case studies with a between-group design, as shown in Table 4.

Table 4. Classification of articles according to research type and case study

Case study	References according to research type		
	Quantitative methods	Qualitative methods	Mixed research approach
Exploratory studies (16 articles)	(Forman et al., 2023; Matzakos et al., 2023; Shaikh et al., 2023; Young & Shishido, 2023)	(Akiba & Fraboni, 2023; Cooper, 2023; Han et al., 2023; Ho et al., 2023; Jeon & Lee, 2023; Kong et al., 2023; Luo et al., 2024; Meron & Tekmen Araci, 2023; van den Berg & du Plessis, 2023; Xiao & Zhi, 2023)	(Daher et al., 2023; Nguyen, 2023)

Case study	References according to research type		
	Quantitative methods	Qualitative methods	Mixed research approach
Case studies with a single experimental group (10 articles)	(Athanassopoulos et al., 2023)	(Javier & Moorhouse, 2024; Roy & Putatunda, 2023; Tlili et al., 2023; Wardat et al., 2023)	(Albert & Li, 2023; Baglivo et al., 2023; Farazouli et al., 2023; Jauhiainen & Guerra, 2023; Sánchez-Ruiz et al., 2023)
Experimental studies with a within-group design (7 articles)	(Uddin et al., 2023)	(Al-Obaydi et al., 2023)	(Escalante et al., 2023; Guo & Lee, 2023; Irfan et al., 2023; Niu & Xue, 2023; Tirado-Olivares et al., 2023)
Experimental study with a between-groups design (6 articles)	(Aydin Yildiz, 2023; Ghafouri, 2024; Yilmaz & Karaoglan Yilmaz, 2023)		(Essel et al., 2024; Küchemann et al., 2023; Swargiary, 2023)
Field research (5 articles)	(Bitzenbauer, 2023)	(Abdelghani et al., 2024; Li et al., 2023)	(Al-Garaady & Mahyoob, 2023; Waltzer et al., 2023)
Action research (3 articles)		(Chen et al., 2023)	(Michalon & Camacho-Zuñiga, 2023; Villan & dos Santos, 2023)
Case studies with a between-group design (2 articles)			(Albdrani & Al-Shargabi, 2023; Alneyadi & Wardat, 2023)
Multiple methods qualitative research (1 article)		(Yan, 2023)	

RQ2: HOW IS CHATGPT USED BY TEACHERS AND STUDENTS? INDICATIVE BEST PRACTICES AND USE CASES IN SCHOOLAND UNIVERSITY EDUCATION

The research revealed various practices and use cases from preschool to university education. Due to the large volume of studies in the field of foreign language education within formal education, a separate analysis is dedicated to the data generated in this area, as shown in Table 5.

Applications of ChatGPT in school education

Teachers in preschool and primary education use it for creating personalized materials (Jauhiainen & Guerra, 2023; Luo et al., 2024). In primary education, it is generally used by teachers to create (Tlili et al., 2023), while in physics, it is employed for designing lesson plans and assessment rubrics (Cooper, 2023).

Preschool students use it as a conversation agent to develop interactive dialogues (Luo et al., 2024),

while in primary education, it is generally used as a personal assistant for completing assignments and preparing for exams (Forman et al., 2023). In physics and mathematics, students use it to receive immediate assistance in clarifying complex concepts, finding examples, and solving problems (Alneyadi & Wardat, 2023; Wardat et al., 2023). In the study by Chen et al. (2023), students use it as a tool in a scenario for knowledge-building in a course on world religions, while in Bitzenbauer's (2023) study, the tool is applied through a structured think-pair-share activity in Physics.

Applications of ChatGPT in university education

In university education, in the field of mathematics, educators use it to find steps for problem-solving, although they perform calculations in Mathematica or via the Wolfram plugin (Matzakos et al., 2023; Sánchez-Ruiz et al., 2023). In physics, computer science, and medicine, it is used for creating assessment exercises (Han et al., 2023; Küchemann et al., 2023; Niu & Xue, 2023). In business administration, it serves as a post hoc grader, with educators applying a three-stage scenario for developing appropriate prompts (Albert & Li, 2023).

Students, on the other hand, leverage ChatGPT for comprehending mathematical and data science concepts (Albdrani & Al-Shargabi, 2023; Sánchez-Ruiz et al., 2023), solving memorization-based chemistry problems (Daher et al., 2023) primarily, finding the steps in mathematical problem-solving (Sánchez-Ruiz et al., 2023), and aiding in programming tasks such as code generation and debugging (Yilmaz & Karaoglan Yilmaz, 2023). Future teachers use it for creating lesson plans and materials (Meron & Tekmen Araci, 2023; van den Berg & du Plessis, 2023) and as an academic advisor (Akiba & Fraboni, 2023). In medicine, it is utilized for drafting medical reports (Ho et al., 2023), while in business administration, it enriches and reviews assignments (Albert & Li, 2023). In chemical engineering, Kong et al. (2023) apply a use scenario of ChatGPT in a mass transfer course, while in chemistry, Guo and Lee (2023) implement a scenario for generating an essay.

Applications of ChatGPT in foreign language education

In foreign language teaching, educators use it to create assessment tests, dialogues (Aydin Yildiz, 2023; Jeon & Lee, 2023; Young & Shishido, 2023), short stories, and personalized educational materials, as well as for the automatic evaluation of assignments (Al-Garaady & Mahyoob, 2023; Nguyen, 2023). Learners, on the other hand, use it as a conversational partner for language practice (Javier & Moorhouse, 2024; Li et al., 2023; Roy & Putatunda, 2023) and as a mentor for providing immediate feedback during essay writing (Xiao & Zhi, 2023) and for improving assignments (Athanassopoulos et al., 2023; Li et al., 2023). In English language learning, Ghafouri (2024) applies a use scenario for

Implementing a Relationship Building Protocol, Yan (2023) combines laboratory lessons with collaborative practices within a structured educational approach, while Roy and Putatunda (2023) follow a process for creating high-level critical knowledge using ChatGPT in an English literature course. Furthermore, Athanassopoulos et al. (2023) describe the stages of integrating ChatGPT as an assessment tool to support German writing, while Li et al. (2023) outline the process of supporting autonomous learning in academic Chinese writing. Finally, Escalante et al. (2023) implement a gradual role ment process for GPT-4 as a grader in an academic reading and writing course for English as a new language.

Table 5. Best practices and use scenarios by subject area for educators and students in preschool, primary, university, and foreign language education

Educational level	Subject area	Best practices for educators	Best practices for students	References
Preschool education		Smart assistant (lesson planning, creation of personalized materials, ideas for classroom management)	Conversational agent that creates social stories and develops interactive dialogues	(Luo et al., 2024)
School education	General primary education	Creation of quizzes	Assistant in assignments, exam preparation, research, finding ideas for essays, and understanding concepts	(Forman et al., 2023; Tlili et al., 2023)
	History (Primary)	Development of personalized educational material		(Jauhiainen & Guerra, 2023)
	Physics (Primary and Secondary) Mathematics (Secondary)	Creation of lesson plans, assessment rubrics, and knowledge evaluation tests	Immediate personalized assistance for concept comprehension, example identification, rapid task completion, and problem-solving. Productive and critical utilization of the model through a structured approach involving think-pair-share activities	(Alneyadi & Wardat, 2023; Bitzenbauer, 2023; Cooper, 2023; Wardat et al., 2023)
	Scientific research		Pedagogical mediator, co-advisor.	(Villan & dos Santos, 2023)
	World religions (Secondary)	Integration of ChatGPT into the curriculum involving the application of "prompt engineering" techniques and the verification of outputs	Assignment review aid and tool in a use case for knowledge building	(Chen et al., 2023)
University education	Mathematics	Leveraging ChatGPT for identifying problem-solving steps and then executing mathematical calculations in Mathematica or via a Wolfram add-on	Assistant for understanding and solving math problems	(Matzakos et al., 2023; Sánchez-Ruiz et al., 2023)
	Physics	Developing quality assessment tasks		(Küchemann et al., 2023)

	Chemistry, Chemical Engineering		Problem-solving assistant, mass transfer application scenario, essay development scenario	(Daher et al., 2023; Guo & Lee, 2023; Kong et al., 2023)
	Training of future teachers		Academic advisor providing course material development, syllabus design, and assessment task creation	(Akiba & Fraboni, 2023; Meron & Tekmen Araci, 2023; van den Berg & du Plessis, 2023)
	Journalism		Assistance in improving writing skills and idea generation	(Irfan et al., 2023)

Educational level	Subject area	Best practices for educators	Best practices for students	References
	Data science and Programming	Development of personalized exercises	Coding snippet generation and debugging	(Albdrani & Al-Shargabi, 2023; Niu & Xue, 2023; Yilmaz & Karaoglan Yilmaz, 2023)
	Medicine	Curriculum development and assessment assistant	Simulated public health dialogue partner scenario for creating medical reports	(Baglivo et al., 2023; Han et al., 2023; Ho et al., 2023)
	Construction industry		Hazard recognition assistant	(Uddin et al., 2023)
	Business administration	Post-assessment grader and three-phase scenario for prompt engineering	Task enrichment and assessment support	(Albert & Li, 2023)
	International relations		Prompt optimization and conversation quality metrics	(Michalon & Camacho-Zuñiga, 2023)
	Language learning German English (K12)	Creating dialogues and short stories, personalizing materials, identifying errors, creating assessment tests, and contributing to a supportive learning environment	Language practice, personalized feedback, essay improvement before submission, productive and critical use	(Athanassopoulos et al., 2023; Ghafouri, 2024; Javier & Moorhouse, 2024; Jeon & Lee, 2023; Xiao & Zhi, 2023; Young & Shishido, 2023)
	Chinese English (higher education)	Suggestions for students' essays, creating assessment exercises, automatic grading of written work, creating personalized educational materials, learning resources, and assignments	Vocabulary and grammar practice, provider of cultural information, immediate feedback for works, adapting text to formal or informal writing, experiential learning through written dialogues, partner in a scenario for the development of high-level critical thinking	(Al-Garaady & Mahyoob, 2023; Al-Obaydi et al., 2023; Aydin Yildiz, 2023; Escalante et al., 2023; Li et al., 2023; Nguyen, 2023; Roy & Putatunda, 2023; Shaikh et al., 2023; Yan, 2023)

RQ3: WHAT IS THE PERFORMANCE OF CHATGPT DURING EXPLORATORY USE IN VARIOUS SUBJECT AREAS?

The analysis of the studies reveals ChatGPT's strong performance across diverse fields within both the theoretical and empirical sciences, as shown in Table 6. In Chemistry, the model excels in theoretical problem-solving (Daher et al., 2023). In Mathematics, it provides detailed steps for problem Solving and can solve simple calculations, although limitations are observed in numerical computations (Matzakos et al., 2023; Sánchez-Ruiz et al., 2023; Wardat et al., 2023). In the field of Medicine, it outperforms medical students in answering complex questions related to vaccination (Baglivo et al., 2023).

Additionally, in History, the tool demonstrates high performance in developing argumentative historical texts according to most dimensions of historical thinking (Tirado-Olivares et al., 2023). In the field of Humanities and Social Sciences, it achieves high scores in the context of homework assignments (Farazouli et al., 2023).

Furthermore, in the research by Abdelghani et al. (2024), the GPT-3 model is highly effective in creating prompts that can help primary school children formulate divergent questions. Moreover, in the field of English as a Foreign Language, ChatGPT, as evidenced by the results of the SLR, can produce high-level literary and proverbial essays (Waltzer et al., 2023) as well as reference dialogues based on the criteria of readable writing (Young & Shishido, 2023).

Table 6. ChatGPT's performance in exploratory applications across various disciplines

Subject area	ChatGPT's performance	References
General Education	Effectiveness of GPT-3 to generate prompts that aid children in formulating divergent questions	(Abdelghani et al., 2024)
Chemistry	High performance in conceptual understanding and reasoning in chemistry problem-solving depth difficulties and errors in numerical calculations	(Daher et al., 2023)
Chemical Engineering	Guide with general instructions for designing a distillation column: challenges in providing accurate and detailed results	(Kong et al., 2023)
History	Effective performance in developing argumentative historical text based on most dimensions of historical thinking	(Tirado-Olivares et al., 2023)
Mathematics	High reliability in the theoretical solution of mathematical problems. Reliable results in simple operations and symbolic computations. Limitations in complex calculations	(Matzakos et al., 2023; Sánchez-Ruiz et al., 2023; Wardat et al., 2023)
Medicine	High performance in complex medical questions in the field of vaccination (in Italian) compared to medical students.	(Baglivo et al., 2023)
Humanities and Social Sciences	High scores on home-based assignments	(Farazouli et al., 2023)
English	Generation of reference dialogues adhering to readability criteria	(Young & Shishido, 2023)
	Generation of high-quality essays incorporating literary and proverbial elements	(Waltzer et al., 2023)

RQ4: WHAT LIMITATIONS AND ETHICAL ISSUES ARISE FROM THE USE OF CHATGPT IN FORMAL EDUCATION?

Despite the benefits and numerous applications of ChatGPT, this SLR highlights the potential challenges of using ChatGPT in education. The key concerns identified in these studies include the model's inherent limitations and the ethical implications arising from its integration.

Most researchers (22.6%, 17 articles) highlight issues with the quality of ChatGPT responses, including inaccuracies, irrelevance, and lack of depth, as well as unreliable or fabricated references. Additionally, 12.5% (9 articles) of studies note limitations in the model's ability to exhibit higher-order cognitive functions, such as creative thinking, critical reasoning, and emotional expression. Concerns regarding academic integrity and potential copyright infringement are raised in 11.1% (8 articles) and 9.7% (7 articles) of studies, respectively. The risk of students becoming overly dependent on AI, negatively impacting critical thinking skills, as well as the ethical implications arising from unequal access to the tool and the potential perpetuation of biased content, are identified in 6.9% (5 articles) of the studies, respectively. Concerns about privacy violations and the model's inaccurate calculations in STEM problems occupy 5.6% (4 articles) of the research, respectively. In 4.2% (3 articles) of cases, researchers focus on each of the risks of malicious use of the tool, inaccurate student assessments, and its inability to analyze and produce images and graphical representations. Finally, two studies, each representing 2.8% (2 articles) of the total articles, address issues of reliability in personalized exercises and ChatGPT's omissions in curriculum design. Table 7 presents a comprehensive overview of the challenges identified in the SLR regarding the utilization of ChatGPT across various educational levels.

Table 7. Limitations and ethical considerations in the use of ChatGPT in education

Limitations and ethical considerations	Educational level	References
Inaccurate, incomplete, irrelevant, outdated, superficial responses, and unreliable or fabricated citations (17 articles)	Preschool education	(Luo et al., 2024)
	Secondary education	(Chen et al., 2023; Javier & Moorhouse, 2024)
	Higher education	(Akiba & Fraboni, 2023; Albert & Li, 2023; Essel et al., 2024; Farazouli et al., 2023; Guo & Lee, 2023; Han et al., 2023; Ho et al., 2023; Michalon & Camacho-Zuñiga, 2023; Nguyen, 2023; Sánchez-Ruiz et al., 2023; Xiao & Zhi, 2023)
	General education	(Li et al., 2023; Tlili et al., 2023; Wardat et al., 2023)
Deficiencies in emotional intelligence, creative and deep thinking, critical reasoning, and problem-solving (9 articles)	Preschool education	(Luo et al., 2024)
	Secondary education	(Chen et al., 2023)
	Higher education	(Al-Garaady & Mahyoob, 2023; Guo & Lee, 2023; Han et al., 2023; Meron & Tekmen Araci, 2023; Tirado-Olivares et al., 2023)
	General education	(Daher et al., 2023; Tlili et al., 2023)
Threat to academic integrity (8 articles)	Preschool education	(Luo et al., 2024)
	Primary education	(Yan, 2023)
	Secondary education	(Chen et al., 2023; Waltzer et al., 2023)
	Higher education	(Al-Obaydi et al., 2023; Nguyen, 2023; Xiao & Zhi, 2023)
	General education	(Tlili et al., 2023)

Limitations and ethical considerations	Educational level	References
Lack of citations for the provided information (copyright infringement) (7 articles)	Preschool education	(Luo et al., 2024)
	Secondary education	(Chen et al., 2023)
	Higher education	(Albert & Li, 2023; Al-Garaady & Mahyoob, 2023; Farazouli et al., 2023; Ho et al., 2023; Roy & Putatunda, 2023)
Risk of excessive dependence - Negative impact on students' critical thinking (5 articles)	Secondary education	(Chen et al., 2023)
	Higher education	(Nguyen, 2023; Roy & Putatunda, 2023; Swargiary, 2023)
	General education	(Li et al., 2023)
Ethical issues: The digital divide and biased AI content perpetuating social inequalities (5 articles)	Preschool education	(Luo et al., 2024)
	Primary education	(Yan, 2023)
	Secondary education	(Waltzer et al., 2023)
	Higher education	(Roy & Putatunda, 2023)
	General education	(Tlili et al., 2023)
Risk of violation of users' privacy (4 articles)	Preschool education	(Luo et al., 2024)
	Higher education	(Ho et al., 2023; Roy & Putatunda, 2023)
	General education	(Tlili et al., 2023)
Errors in computations within STEM disciplines (math, geometry, chemistry, engineering) (4 articles)	Higher education	(Matzakos et al., 2023; Sánchez-Ruiz et al., 2023)
	General education	(Daher et al., 2023; Wardat et al., 2023)
Malicious use (3 articles)	Primary education	(Jeon & Lee, 2023)
	Secondary education	(Chen et al., 2023)
	Higher education	(Irfan et al., 2023)
Inaccurate student evaluations (3 articles)	Higher education	(Albdrani & Al-Shargabi, 2023; Albert & Li, 2023; Al-Garaady & Mahyoob, 2023)
Inability to analyze images and graphic representations (3 articles)	Higher education	(Han et al., 2023)
	General education	(Daher et al., 2023; Wardat et al., 2023)
Questionable reliability of personalized exercises and quizzes due to limited content variety, high predictability of answers, and superficial depth (2 articles)	Higher education	(Niu & Xue, 2023)
	General education	(Tlili et al., 2023)
Limitations in curriculum design, including deficiencies in overall content, errors, and omissions (2 articles)	Higher education	(Han et al., 2023; Meron & Tekmen Araci, 2023)

RQ5: WHAT IS THE IMPACT OF USING CHATGPT ON STUDENT'S PERFORMANCE, HIGHER-ORDER SKILLS, AND MOTIVATION?

Nearly all articles in this SLR demonstrate that ChatGPT has a positive impact on students' learning outcomes and skills. As illustrated in Figure 4, a comprehensive analysis of 12 (twelve) studies reveals that the integration of ChatGPT into educational settings has the most pronounced effects on cognitive performance, with seven studies primarily conducted in higher education settings and five focusing on K-12 education. In addition, seven studies specifically highlight the positive influence of ChatGPT on the development of critical thinking abilities. However, only one of these studies focuses on K-12 education, while the majority are situated within higher education settings. Moreover, the tool is found to significantly enhance student motivation, engagement, and persistence, as evidenced by 6 (six) studies. Four of these articles originate from higher education, while one is found in both school and general education, respectively. Furthermore, 5 (five) studies indicate a significant positive impact of ChatGPT on the language skills of both school and university students, with one study focusing on general education. A further three studies highlight the positive impact of ChatGPT on AI literacy, two of which are focused on higher education and one on secondary education.

Based on subject areas, performance gains from using ChatGPT have been observed in K-12 education, particularly in History, where students' knowledge was enhanced (Jauhiainen & Guerra, 2023), and in Physics, where students benefited from improved conceptual understanding (Alneyadi & Wardat, 2023; Bitzenbauer, 2023), as well as across the broader spectrum of primary (Abdelghani et al., 2024) and secondary education (Forman et al., 2023). At the tertiary level, students in Mathematics developed problem-solving skills and learned new concepts (Sánchez-Ruiz et al., 2023), while those in Computer Programming built computational thinking skills (Yilmaz & Karaoglan Yilmaz, 2023). In the construction industry, students improved their ability to identify workplace hazards (Uddin et al., 2023). Additionally, ChatGPT had a positive impact on student performance in Data Science (Albdrani & Al-Shargabi, 2023), Research Methodology (Essel et al., 2024), Business Administration (Albert & Li, 2023), and English as a Foreign Language (Aydin Yildiz, 2023).

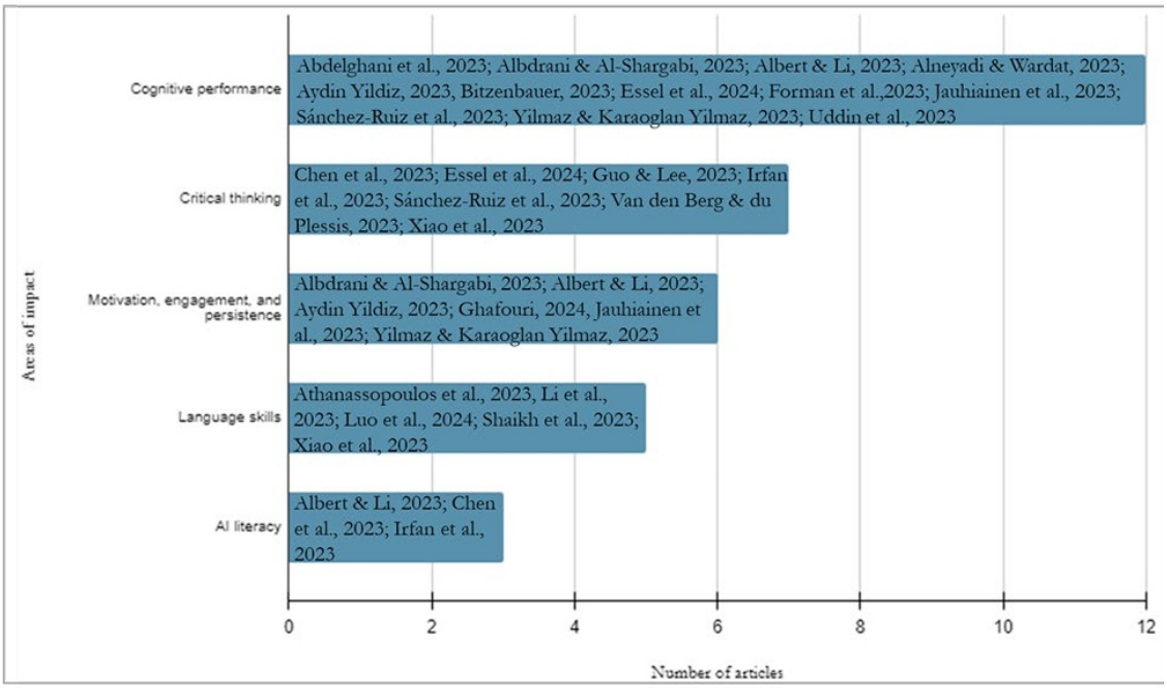

Figure 4. Areas of positive impact of ChatGPT based on SLR studies

Students' critical thinking was positively influenced by the tool in a course on world religions during knowledge construction (Chen et al., 2023), in Mathematics (Sánchez-Ruiz et al., 2023), and Chemistry (Guo & Lee, 2023) during problem-solving, in teacher education during lesson planning (van den Berg & du Plessis, 2023), as well as in Journalism (Irfan et al., 2023), Research Methodology (Essel et al., 2024), and English language learning (Xiao & Zhi, 2023).

Students demonstrate increased motivation, persistence, or enjoyment of the learning process when using ChatGPT in courses on History (Jauhiainen & Guerra, 2023), Data Science (Albdrani & AlShargabi, 2023), Programming (Yilmaz & Karaoglan Yilmaz, 2023), Business Administration (Albert & Li, 2023), and English (Aydin Yildiz, 2023; Ghafouri, 2024).

Improvements in students' language skills are observed in preschool education (Luo et al., 2024) and in the learning of English (Shaikh et al., 2023; Xiao & Zhi, 2023), German (Athanassopoulos et al., 2023), and Chinese (Li et al., 2023).

Additionally, ChatGPT has also facilitated the development of AI literacy in students. Its application in fields such as world religions (Chen et al., 2023), Business Administration (Albert & Li, 2023), and Jour nalism (Irfan et al., 2023) demonstrates its potential to foster digital competence.

In contrast to the generally positive findings regarding ChatGPT in university contexts, Swargiary (2023) found evidence of a negative correlation between the use of this tool and students' academic achievement, critical reasoning, and motivation.

DISCUSSION

In this section, a synthesis of the SLR findings is presented, followed by an in-depth comparative analysis that juxtaposes the current review's outcomes with those of previous studies. This critical evaluation enables a nuanced understanding of the research landscape and highlights the unique contributions of this study.

IDENTITY AND METHODOLOGICAL DESIGN OF THE STUDIES UNDER INVESTIGATION

While the United States accounted for a substantial portion (12%) of the studies reviewed, Asian countries exhibited a more pronounced presence, contributing 46% of the overall articles. China was particularly prominent within this group, a trend potentially attributable to demographic scale or the region's strong emphasis on technological innovation and AI in education (AIED). Most studies were published in 2023 and early 2024, coinciding with the initial deployment of ChatGPT. A gradual increase in publications was observed throughout 2023.

The primary focus of these studies was on higher education, a finding consistent with previous literature reviews (Zhang & Tur, 2023). However, this review expands on prior work by including a substantial proportion of studies (25%) dedicated to K-12 education, with one study even delving into preschool settings (Luo et al., 2024).

Regarding subject areas, foreign languages, particularly English, dominated the research. Studies exploring STEM fields, while present, were less frequent, aligning with the findings of AlBadarin et al. (2023). Moreover, previous systematic literature reviews often lacked detailed descriptions of the specific domains in which ChatGPT was applied.

In terms of research methodology, a mixed-methods approach was most prevalent, closely followed by qualitative methods. Quantitative methods were comparatively less frequently employed.

INDICATIVE BEST PRACTICES AND USE CASES OF CHATGPT IN SCHOOL AND UNIVERSITY EDUCATION

In primary education, teachers commonly used ChatGPT to create quizzes (Tlili et al., 2023). In history, it was utilized to generate personalized learning materials (Jauhiainen & Guerra, 2023), while in physics, it was employed to develop lesson plans based on the 5E model and create assessment rubrics (Cooper, 2023). In a high school world religions course, teachers integrated the tool into the curriculum, encouraging students to achieve more accurate results through prompt engineering and to verify the model's responses (Chen et al., 2023).

Primary school students, on the other hand, generally used ChatGPT as a tool to prepare for exams, find ideas for essay writing, and understand concepts (Forman et al., 2023). In physics, students found examples and supplementary explanations (Alneyadi & Wardat, 2023) and completed assignments more quickly (Bitzenbauer, 2023). Similarly, in mathematics, students used ChatGPT for immediate feedback, explanations of mathematical concepts, and problem-solving (Wardat et al., 2023).

Specific use cases were identified in two studies. Bitzenbauer (2023) implemented a scenario in a quantum physics course involving generative and critical use of the model based on the think-pairshare teaching method. Additionally, Chen et al. (2023) integrated ChatGPT into a knowledge-building instructional model in a world religions course. Systematic literature reviews by C. K. Lo (2023) and Vargas-Murillo et al. (2023), as well as the UNESCO guidelines (2023), confirm some of the practices identified in this review for higher education. However, the current study provides additional data from specific scientific fields.

The research revealed intriguing practices to address ChatGPT's limitations in providing accurate mathematical calculations. Specifically, the model was leveraged to generate the steps or instructions for solving problems, and subsequently, calculations were performed using software like Mathematica or Maxima. Alternatively, the Wolfram Alpha plugin was employed for more precise mathematical computations (Matzakos et al., 2023; Sánchez-Ruiz et al., 2023). In Physics, educators seemed to utilize it for creating high-quality assessment tasks (Küchemann et al., 2023). In Computer Science, it was used to generate personalized exercises in conjunction with the Rasch model (Niu & Xue, 2023). In Medicine, it was found to assist in creating lesson plans and assessment tests (Han et al., 2023). Business Administration, it was employed as a co-grader for assignments (Albert & Li, 2023).

Students, on the other hand, used it as an aid to explain mathematical concepts and provide steps for

problem-solving (Sánchez-Ruiz et al., 2023). In Chemistry, it assisted in solving problems, primarily those involving memorization (Daher et al., 2023). Future teachers employed it to create lesson plans, learning materials, and practice and assessment tasks (van den Berg & du Plessis, 2023). In journalism, it contributed to improving writing skills and generating ideas quickly (Irfan et al., 2023). In the field of programming, it was utilized to generate code snippets and assist in identifying and correcting code errors (Yilmaz & Karaoglan Yilmaz, 2023). In Medicine, students used it as a medical writing tool (Ho et al., 2023).

Regarding use cases, Kong et al. (2023) detailed a process for utilizing the model in a mass transfer course within a Chemical Engineering curriculum. In Chemistry, Guo and Lee (2023) presented steps for effectively employing the model in creating an essay. Ho et al. (2023) implemented a scenario for drafting medical reports. Finally, Michalon and Camacho-Zuñiga (2023) described a series of preparatory activities to train students in the field of international relations, enabling them to provide suitable prompts and have more effective conversations with ChatGPT.

In language learning, educators have employed ChatGPT to create dialogues and short stories, generate exercises and assessments, produce personalized learning materials and tasks, and automate written assessment and error detection (Al-Garaady & Mahyoob, 2023; Aydin Yildiz, 2023; Escalante et al., 2023; Jeon & Lee, 2023; Nguyen, 2023; Young & Shishido, 2023). Learners have utilized ChatGPT as a conversational partner, aiding in language practice and contributing to the improve ment of vocabulary and grammar (Javier & Moorhouse, 2024; Li et al., 2023; Roy & Putatunda, 2023), as well as a personal tutor for receiving personalized feedback and checking written work before final submission (Athanassopoulos et al., 2023; Li et al., 2023; Xiao & Zhi, 2023).

Use cases of the model in language learning involve the implementation of the Relationship Building Protocol by Ghafouri (2024), the structured pedagogical approach combining laboratory sessions and collaborative practices by Yan (2023), the method of assigning the role of a grader to GPT-4 by Escalante et al. (2023), the stages of integrating ChatGPT as an assessment tool to support German writing by Athanassopoulos et al. (2023), the process of creating high-level critical thinking on English literature by Roy and Putatunda (2023), and the practice of Li et al. (2023) to support autonomous learning in academic Chinese writing.

Focusing on the potential key differences in ChatGPT use across educational levels it is observed a) differences in the complexity of use: the cases of use evolve from simple interaction and personalized assistance in elementary education (e.g. conversational agent and personal assistant for assignments and

exam preparation or as a tool for understanding complex concepts and solving problems) to more structured, collaborative, and advanced problem-solving roles in higher education (e.g. assistant for advanced concepts comprehension in mathematics, data science, and programming, including code generation and debugging b) differences in the level of autonomy: In higher education, ChatGPT is often used for facilitating autonomy in learning (e.g. mentor for assignment improvement and grader or an advisor in academic writing), whereas in lower levels, it is more teacher-directed (e.g. assistant in mathematics and essay writing and examples generator) c) differences in teacher's role: While teachers at all levels can benefit from using ChatGPT to create materials and assess students, the focus of their use shifts from creating basic materials (creating personalized learning materials and quizzes) to designing more complex learning experiences (developing prompts for students to use ChatGPT effectively, using ChatGPT as a grading assistant).

The above differences demonstrate that ChatGPT's role adapts to the developmental and academic demands of each educational stage, fostering both teaching efficiency and student independence.

PERFORMANCE OF CHATGPT IN VARIOUS SUBJECT AREAS

Within the context of English as a Foreign Language (EFL) course, the tool demonstrated the capacityto produce high-quality essays (Waltzer et al., 2023) as well as reference dialogues that met high standards of readability, as measured by various metrics (Young & Shishido, 2023).]

In Chemistry, the model exhibited strong performance in conceptual understanding and problem-solving reasoning within the domain of Materials Science, although it encountered difficulties with depth and made errors in numerical calculations (Daher et al., 2023).

In History, it demonstrated superior performance in generating argumentative historical text compared to pre-service elementary school teachers, based on most dimensions of historical thinking (Tirado-Olivares et al., 2023).

In Mathematics, it was able to solve simple operations and mathematical problems quickly and easily, providing detailed steps; however, there were instances of errors in numerical calculations (Matzakos et al., 2023; Sánchez-Ruiz et al., 2023; Wardat et al., 2023).

In Medicine, it appeared to outperform medical students on complex questions related to vaccination (Baglivo et al., 2023).

Finally, ChatGPT achieved high scores in the context of take-home assignments in the humanities andsocial sciences (Farazouli et al., 2023).

Rudolph et al. (2023) confirm the model's good performance in simple mathematical problems and its adequacy in historical knowledge. However, while Lo (2023) corroborated the model's difficulties with mathematical calculations, they also found it to perform poorly in medical education, a finding that our study does not corroborate.

LIMITATIONS AND ETHICAL ISSUES

The most frequent limitation (cited in 17 studies) across a wide range of scientific fields in the SLR was the presence of inaccurate or outdated responses, as well as unreliable or fabricated references. Numerous SLRs, including those by Labadze et al. (2023), Lo (2023), and Zhang and Tur (2023), consistently indicate a high likelihood of models generating incorrect, unreliable, or even factually inaccurate responses, often referred to as 'model hallucinations' (AlBadarin et al., 2023; Montenegro-Rueda et al., 2023; Vargas-Murillo et al., 2023).

The model's deficiencies in expressing emotions and engaging in creative, deep, and critical thinking were also frequently cited (in 9 studies), a finding less common in previous reviews. Only Zhang and Tur (2023) corroborated ChatGPT's limitations in higher-order thinking, highlighting its inability to address complex application-level problems.

Subsequently, eight studies highlighted the risk of academic integrity violations. Consistently, the vast majority of previous reviews have pointed to the risk of compromising academic integrity through theuse of ChatGPT in educational settings (AlBadarin et al., 2023; İpek et al., 2023; Labadze et al., 2023; Lo, 2023; Vargas-Murillo et al., 2023; Zhang & Tur, 2023).

A novel finding emerged from seven articles, which noted the absence of references, indicating potential copyright infringement. This issue had not been a focal point in prior literature reviews.

Furthermore, findings from five studies revealed, on the one hand, the risk of excessive student reliance with a negative impact on a student's critical thinking and, on the other, the risk of social division due to unequal access to the tool and the potential for creating and reinforcing biased content. Concerns regarding the negative impact of over-reliance on ChatGPT on students' higher-order thinking skills are corroborated by Labadze et al. (2023), Vargas-Murillo et al. (2023), and Zhang and Tur (2023).

Additionally, İpek et al. (2023) highlighted the risk of reinforcing biased results due to algorithmic biases inherent in the model's training data.

Additionally, the risk of privacy violations (cited in 4 studies) and the possibility of malicious use of the tool (cited in 3 studies) were demonstrated. The ethical implications of using ChatGPT in education, including concerns about personal data privacy, model misuse, and student safety, are corroborated by the findings of İpek et al. (2023), Labadze et al. (2023), and Zhang and Tur (2023).

IMPACT OF CHATGPT ON STUDENT'S PERFORMANCE, SKILLS, AND MOTIVATION

While there are limited exceptions, most studies reviewed support the notion that ChatGPT can be a powerful tool for enhancing learning outcomes and developing critical thinking skills, a finding consistent with previous reviews (AlBadarin et al., 2023; İpek et al., 2023; Montenegro-Rueda et al., 2023).

Cognitive performance was most significantly impacted in various academic disciplines, including primary school History (Jauhiainen & Guerra, 2023), secondary school Physics (Alneyadi & Wardat, 2023; Bitzenbauer, 2023), and generally in primary and secondary education (Abdelghani et al., 2024; Forman et al., 2023). In higher education, student performance improved in Mathematics (Sánchez-Ruiz et al., 2023), Programming (Yilmaz & Karaoglan Yilmaz, 2023), Data Science (Albdrani & Al-Shargabi, 2023), Research Methodology (Essel et al., 2024), Business Administration (Albert & Li, 2023), Construction (Uddin et al., 2023), and English (Aydin Yildiz, 2023).

Furthermore, critical thinking was enhanced when students used the model in a secondary-level world religions course as well as in the university fields of Journalism (Irfan et al., 2023), Research Methodology (Essel et al., 2024), STEM (Guo & Lee, 2023; Sánchez-Ruiz et al., 2023), teacher education programs (van den Berg & du Plessis, 2023), and English language learning (Xiao & Zhi, 2023).

Furthermore, ChatGPT positively influenced student motivation and engagement, a finding corrobo rated by previous reviews (AlBadarin et al., 2023; Montenegro-Rueda et al., 2023). For instance, in English language learning, the tool increased motivation and sustained student persistence (Aydin Yildiz, 2023; Ghafouri, 2024). Similarly, in academic fields such as data science, programming, and business administration, ChatGPT appeared to positively impact student engagement.

Numerous studies in this review confirm the enhancement of language skills in the areas of vocabulary, grammar, discussion, and written expression among students who utilize ChatGPT while learning foreign languages (Athanassopoulos et al., 2023; Li et al., 2023; Shaikh et al., 2023; Xiao & Zhi, 2023).

Additionally, ChatGPT had a positive effect on students' digital literacy (Albert & Li, 2023; Chen et al., 2023; Irfan et al., 2023).

An exception to the positive impact of ChatGPT is the research of Swargiary (2023), which found a negative effect on student performance, critical thinking, and motivation. The literature review by Vargas-Murillo et al. (2023) confirms that excessive reliance on ChatGPT can hinder students' critical thinking skills.

Overall, emerging technologies like ChatGPT, with numerous applications for educators and learners, as revealed by the present SLR, have the potential to be a powerful tool for enhancing education. How ever, concerns about privacy, academic integrity, and the potential for misuse and bias linked to AI ethi cal principles of transparency and security, justice and equality, as well as the avoidance of harm (Holmes et al., 2022; Tzimas, 2021; Waelen, 2022) necessitate a cautious and responsible approach from educational stakeholders. Educational institutions must prioritize teaching critical thinking, digital liter acy, and the ethical use of AI to ensure that these technologies are used for good.

CONCLUSION

This study employed the stages of a Systematic Literature Review and adhered to the PRISMA protocol to collect and analyze data from 50 empirical studies focused on the application of the advanced conversational AI model, ChatGPT, in K-12 and higher education.

The findings revealed a diverse range of practices and use cases for the model among educators and students, primarily in higher education, which accounted for 62% of the articles. Also, in K-12 education, where 25% of the evidence was found, the research gap was addressed to some extent, given the rarity of research in the K-12 domain.

Numerous applications of the model were identified in language learning within formal education settings. These include creating dialogues, generating exercises, automated grading of written work for educators, language practice, and personalized feedback through its use as a conversational partner and personal tutor by students.

While these findings align with the results of previous reviews, this SLR enriches the literature with additional use cases of the model in K-12 and higher education, as well as in language learning. The results of this research demonstrate that ChatGPT exhibited strong performance in various academic domains, including English literature essay writing, conceptual understanding and problem-solving in Chemistry, and Mathematics, historical argumentation, answering complex medical queries, and humanities and social sciences homework assignments. Rudolph et al. (2023) reached similar conclusions regarding ChatGPT's performance.

Significant concerns regarding ChatGPT's limitations and the ethical implications of its use in education, as identified in the literature (Books, 2023; UNESCO, 2023) and previous reviews, are corroborated by the findings of this study. The results reveal a high prevalence of inaccurate or outdated information, as well as unreliable citations. Additionally, the model demonstrated notable deficiencies in expressing emotions, engaging in creative and deep thinking, and critical reasoning. This finding, less common in previous reviews, may be attributed to the demand for creativity and critical thinking in the theoretical cognitive fields examined and the focus of previous studies on lower educational levels where emotional interaction is more pronounced.

Consistent with previous reviews, this research demonstrated a positive impact of ChatGPT on student performance and skills, particularly in knowledge acquisition, critical thinking, motivation, engagement, language proficiency, and digital literacy across various academic disciplines at both the school and university levels.

Significant constraints arose from the application of the rigorous PRISMA protocol criteria, including limiting the time frame of publications to the first year of the model's application (January 2023-January 2024), focusing the search on data within the context of school and university education, restricting the search to English-language articles, and limiting the scope to articles accessible through open or academic access. Another limitation was the exclusive focus on ChatGPT, given the proliferation of other GPT-based CAI models (Rudolph et al., 2023) that could yield valuable data for educational research. Additionally, while studies focusing on ChatGPT in school education were included, primary education was underrepresented in the target groups of this study.

Finally, research examining the use of ChatGPT in special education was not included.

This SLR identified several limitations that underpinned the formulation of recommendations for future research in the field of Conversational Artificial Intelligence (CAI) in education. Considering the

potential benefits and ethical considerations associated with using conversational AI like ChatGPT in education, as evidenced by this SLR and previous research, a strategic and cautious approach is essential to maximize the positive impact of this technology on students and educators in both school and university settings. To address the challenges and limitations identified in this study, educational institutions should establish clear ethical guidelines for AI use, emphasizing transparency, fairness, and accountability. Furthermore, comprehensive training on AI- ethics, responsible use, and critical thinking skills should be provided to both educators and students.

Additionally, equipping educators with the skills necessary to effectively integrate AI tools into their teaching practices is crucial. Governments and relevant stakeholders, like local, regional, and national educational authorities, must prioritize promoting AI literacy among members of the educational community to empower them to critically assess AI-generated content, identify biases, and use AI tools sponsibly. Finally, fostering continuous collaboration among researchers, AI developers, and educators is vital to creating innovative and appropriate applications that address emerging challenges. By implementing these recommendations and regularly evaluating the impact of AI tools on student learning outcomes, educational systems can harness the potential of AI to deliver more engaging and effective learning experiences.

REFERENCES

Abdelghani, R., Wang, Y.-H., Yuan, X., Wang, T., Lucas, P., Sauzéon, H., & Oudeyer, P.-Y. (2024). GPT-3 driven pedagogical agents to train children's curious question-asking skills. International Journal of Artificial Intelligence in Education, 34, 483-518. https://doi.org/10.1007/s40593-023-00340-7

Akiba, D., & Fraboni, M. C. (2023). AI-Supported academic advising: Exploring ChatGPT's current state and future potential toward student empowerment. Education Sciences, 13(9), 885.https://doi.org/10.3390/educsci13090885

AlBadarin, Y., Tukiainen, M., Saqr, M., & Pope, N. (2023). A systematic literature review of empirical research on ChatGPT in education (SSRN Scholarly Paper No. 4562771). https://doi.org/10.2139/ssrn.4562771

Albdrani, R. N., & Al-Shargabi, A. A. (2023). Investigating the effectiveness of ChatGPT for providing personalized learning experience: A case study. International Journal of Advanced Computer Science and Applications, 14(11), 1208-1213. https://doi.org/10.14569/IJACSA.2023.01411122

Albert, D., & Li, T. (2023). Insights from teaching with AI: How ChatGPT can enhance experiential learning and assist instructors (SSRN Scholarly Paper No. 4516801). https://doi.org/10.2139/ssrn.4516801

Al-Garaady, J., & Mahyoob, M. (2023). ChatGPT's capabilities in spotting and analyzing writing errors experienced by EFL learners. Arab World English Journals, 9, 3-17. https://doi.org/10.24093/awej/call9.1

Alneyadi, S., & Wardat, Y. (2023). ChatGPT: Revolutionizing student achievement in the electronic magnetism unit for eleventh-grade students in Emirates schools. Contemporary Educational Technology, 15(4), ep448. https://doi.org/10.30935/cedtech/13417

Al-Obaydi, L. H., Pikhart, M., & Klimova, B. (2023). ChatGPT and the general concepts of education: Can artificial intelligence-driven chatbots support the process of language learning? International Journal of Emerging Technologies in Learning, 18(21), 39-50. https://doi.org/10.3991/ijet.v18i21.42593

Athanassopoulos, S., Manoli, P., Gouvi, M., Lavidas, K., & Komis, V. (2023). The use of ChatGPT as a learning tool to improve foreign language writing in a multilingual and multicultural classroom. Advances in Mobile Learning Educational Research, 3(2), 818-824. https://doi.org/10.25082/amler.2023.02.009

Aydin Yildiz, T. (2023). The impact of ChatGPT on language learners' motivation. Journal of Teacher Education and Lifelong Learning, 5(2), 582-897. https://doi.org/10.51535/tell.1314355

Baglivo, F., Angelis, L. D., Casigliani, V., Arzilli, G., Privitera, G. P., & Rizzo, C. (2023). Exploring the possible use of AI chatbots in public health education: Feasibility study. JMIR Medical Education, 9, e51421. https://doi.org/10.2196/51421

Bitzenbauer, P. (2023). ChatGPT in physics education: A pilot study on easy-to-implement activities. Contemporary Educational Technology, 15(3), ep430. https://doi.org/10.30935/cedtech/13176

Books, T. J. (2023). Mastering ChatGPT: Create highly effective prompts, strategies, and best practices to go from novice to expert. TJ Books.

Bozkurt, A., Karadeniz, A., Baneres, D., Guerrero-Roldán, A. E., & Rodríguez, M. E. (2021). Artificial intelligence and reflections from educational landscape: A review of AI studies in half a century. Sustainability, 13(2), 800. https://doi.org/10.3390/su13020800

Chen, B., Zhu, X., & Díaz del Castillo, H. F. (2023). Integrating generative AI in knowledge building. Computers and Education: Artificial Intelligence, 5, 100184. https://doi.org/10.1016/j.caeai.2023.100184

Churi, P. P., Joshi, S., Elhoseny, M., & Omrane, A. (Eds.). (2022). Artificial intelligence in higher education: A practical approach (1st ed.). CRC Press. https://doi.org/10.1201/9781003184157

Cooper, G. (2023). Examining science education in ChatGPT: An exploratory study of generative artificial intelligence. Journal of Science Education and Technology, 32(3), 444-452. https://doi.org/10.1007/s10956-02310039-y

Crompton, H., Burke, D., Jordan, K., & Wilson, S. (2021). Learning with technology during

emergencies: A systematic review of K-12 education. British Journal of Educational Technology, 52(4), 1554-1575. https://doi.org/10.1111/bjet.13114

Daher, W., Diab, H., & Rayan, A. (2023). Artificial intelligence generative tools and conceptual knowledge in problem solving in chemistry. Information, 14(7), 409. https://doi.org/10.3390/info14070409

Elkhatat, A. M. (2023). Evaluating the authenticity of ChatGPT responses: A study on text-matching capabilities. International Journal for Educational Integrity, 19, Article 15. https://doi.org/10.1007/s40979-023-00137-0

Escalante, J., Pack, A., & Barrett, A. (2023). AI-generated feedback on writing: Insights into efficacy and ENL student preference. International Journal of Educational Technology in Higher Education, 20, Article 57. https://doi.org/10.1186/s41239-023-00425-2

Essel, H. B., Vlachopoulos, D., Essuman, A. B., & Amankwa, J. O. (2024). ChatGPT effects on cognitive skills of undergraduate students: Receiving instant responses from AI-based conversational large language models (LLMs). Computers and Education: Artificial Intelligence, 6, 100198. https://doi.org/10.1016/j.caeai.2023.100198

European Commission. (2018, March 9). Statement on artificial intelligence, robotics and 'autonomous' systems. https://data.europa.eu/doi/10.2777/531856

European Commission. (2022). Ethical guidelines on the use of artificial intelligence (AI) and data in teaching and learning for educators. https://data.europa.eu/doi/10.2766/153756

European Parliament. (2023). What is artificial intelligence and how is it used? https://www.europarl.europa.eu/news/en/headlines/society/20200827STO85804/what-is-artificial-intelligence-and-how-is-it-used

Farazouli, A., Cerratto-Pargman, T., Bolander-Laksov, K., & McGrath, C. (2023). Hello GPT! Goodbye home examination? An exploratory study of AI chatbots impact on university teachers' assessment practices. Assessment & Evaluation in Higher Education, 49(3), 363-375. https://doi.org/10.1080/02602938.2023.2241676

Fink, A. (2005). Conducting research literature reviews: From the internet to paper. Sage. Forman, N., Udvaros, J., & Avornicului, M. S. (2023). ChatGPT: A new study tool shaping the future for high school students. International Journal of Advanced Natural Sciences and Engineering Research, 7(4), 95-102. https://doi.org/10.59287/ijanser.562

Ghafouri, M. (2024). ChatGPT: The catalyst for teacher-student rapport and grit development in L2 class. System, 120, 103209. https://doi.org/10.1016/j.system.2023.103209

Guo, Y., & Lee, D. (2023). Leveraging ChatGPT for enhancing critical thinking skills. Journal of Chemical Education, 100(12), 4876–4883. https://doi.org/10.1021/acs.jchemed.3c00505

Haddaway, N. R., Page, M. J., Pritchard, C. C., & McGuinness, L. A. (2022). PRISMA2020: An R

package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and Open Synthesis. Campbell Systematic Reviews, 18(2), e1230. https://doi.org/10.1002/cl2.1230

Han, Z., Battaglia, F., Udaiyar, A., Fooks, A., & Terlecky, S. R. (2023). An explorative assessment of ChatGPT as an aid in medical education: Use it with caution. Medical Teacher, 46(5), 657-664. https://doi.org/10.1080/0142159X.2023.2271159

Ho, W. L. J., Koussayer, B., & Sujka, J. (2023). ChatGPT: Friend or foe in medical writing? An example of how ChatGPT can be utilized in writing case reports. Surgery in Practice and Science, 14, 100185.https://doi.org/10.1016/j.sipas.2023.100185

Holmes, W., & Porayska-Pomsta, K. (2022). The ethics of artificial intelligence in education: Practices, challenges, and debates. Routledge. https://doi.org/10.4324/9780429329067

Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Buckingham Shum, S., Santos, O. C., Rodrigo, M. T., Cukurova, M., Bittencourt, I. I., & Koedinger, K. R. (2022). Ethics of AI in education: Towards a community-wide framework. International Journal of Artificial Intelligence Education, 32, 504-526. https://doi.org/10.1007/s40593-021-00239-1

İpek, Z. H., Gözüm, A. İ. C., Papadakis, S., & Kallogiannakis, M. (2023). Educational applications of the ChatGPT AI System: Systematic review research. Educational Process International Journal, 12(3), 26-55. https://doi.org/10.22521/edupij.2023.123.2

Irfan, M., Murray, L., & Ali, S. (2023). Integration of Artificial intelligence in academia: A case study of critical teaching and learning in higher education. Global Social Sciences Review, VIII(I), 352-364.https://doi.org/10.31703/gssr.2023(viii-i).32

Jauhiainen, J. S., & Guerra, A. G. (2023). Generative AI and ChatGPT in school children's education: Evidence from a school lesson. Sustainability, 15(18), 14025. https://doi.org/10.3390/su151814025

Javaid, M., Haleem, A., Singh, R. P., Khan, S., & Khan, I. H. (2023). Unlocking the opportunities through ChatGPT Tool towards ameliorating the education system. BenchCouncil Transactions on Benchmarks, Standards and Evaluations, 3(2), 100115. https://doi.org/10.1016/j.tbench.2023.100115

Javier, D. R. C., & Moorhouse, B. L. (2024). Developing secondary school English language learners' productive and critical use of ChatGPT. TESOL Journal, 15(2), e755. https://doi.org/10.1002/tesj.755

Jeon, J., & Lee, S. (2023). Large language models in education: A focus on the complementary relationship between human teachers and ChatGPT. Education and Information Technologies, 28, 15873-15892. https://doi.org/10.1007/s10639-023-11834-1

Kong, Z. Y., Adi, V. S. K., Segovia-Hernández, J. G., & Sunarso, J. (2023). Complementary role of large language models in educating undergraduate design of distillation column: Methodology development. Digital Chemical Engineering, 9, 100126. https://doi.org/10.1016/j.dche.2023.100126

Kortemeyer, G. (2023). Could an artificial-intelligence agent pass an introductory physics course? Physical Review Physics Education Research, 19(1), 10132. https://doi.org/10.1103/PhysRevPhysEducRes.19.010132

Kostas, A., Paraschou, V., Spanos, D., & Sofos, A. (2023). Emergency remote teaching in K-12 education during COVID-19 pandemic: A systematic review of empirical research in Greece. In T. Bratitsis (Eds.), Research on E-Learning and ICT in Education (pp. 235-260). Springer. https://doi.org/10.1007/978-3-03134291-2_14

Küchemann, S., Steinert, S., Revenga, N., Schweinberger, M., Dinc, Y., Avila, K. E., & Kuhn, J. (2023). Can ChatGPT support prospective teachers in physics task development? Physical Review Physics Education Research, 19(2), 20128. https://doi.org/10.1103/PhysRevPhysEducRes.19.020128

Labadze, L., Grigolia, M., & Machaidze, L. (2023). Role of AI chatbots in education: Systematic literature review. International Journal of Educational Technology in Higher Education, 20, Article 56. https://doi.org/10.1186/s41239-023-00426-1

Lame, G. (2019). Systematic literature reviews: An introduction. Proceedings of the Design Society: International Conference on Engineering Design, 1(1), 1633-1642. https://doi.org/10.1017/dsi.2019.169

Lee, S. (2023). AI toolkit for educators. https://www.ai4t.eu/wp-content/uploads/2023/10/AI-Toolkit-for-Educators_v2_def_for_now.pdf

Li, J., Ren, X., Jiang, X., & Chen, C.-H. (2023). Exploring the use of ChatGPT in Chinese language classrooms. (2023). International Journal of Chinese Language Teaching, 4(3), 36-55. https://doi.org/10.46451/ijclt.20230303

Lo, C. K. (2023). What Is the Impact of ChatGPT on education? A rapid review of the literature. Education Sciences, 13(4), 410. https://doi.org/10.3390/educsci13040410

Lo, C. K., & Hew, K. F. (2023). A review of integrating AI-based chatbots into flipped learning: New possibilities and challenges. Frontiers in Education, 8, 1175715. https://doi.org/10.3389/feduc.2023.1175715

Luo, W., He, H., Liu, J., Berson, I. R., Berson, M. J., Zhou, Y., & Li, H. (2024). Aladdin's Genie or Pandora's Box for early childhood education? Experts chat on the roles, challenges, and developments of ChatGPT. Early Education and Development, 35(1), 96-113. https://doi.org/10.1080/10409289.2023.2214181

Matzakos, N., Doukakis, S., & Moundridou, M. (2023). Learning mathematics with large language models: A comparative study with computer algebra systems and other tools. International Journal of Emerging Technologies in Learning, 18(20), Article 20. https://doi.org/10.3991/ijet.v18i20.42979

Meo, S. A., Al-Masri, A. A., Alotaibi, M., Meo, M. Z. S., & Meo, M. O. S. (2023). ChatGPT knowledge evaluation in basic and clinical medical sciences: Multiple choice question examination-based

performance. Healthcare, 11(14), 2046. https://doi.org/10.3390/healthcare11142046

Meron, Y., & Tekmen Araci, Y. (2023). Artificial intelligence in design education: Evaluating ChatGPT as a virtual colleague for post-graduate course development. Design Science, 9, e30. https://doi.org/10.1017/dsj.2023.28

Michalon, B., & Camacho-Zuñiga, C. (2023). ChatGPT, a brand-new tool to strengthen timeless competencies. Frontiers in Education, 8, 1251163. https://doi.org/10.3389/feduc.2023.1251163

Montenegro-Rueda, M., Fernández-Cerero, J., Fernández-Batanero, J. M., & López-Meneses, E. (2023). Impact of the implementation of ChatGPT in education: A systematic review. Computers, 12(8), Article 8. https://doi.org/10.3390/computers12080153

Nguyen, T. T. H. (2023). EFL Teachers' perspectives toward the Use of ChatGPT in writing classes: A case study at Van Lang University. International Journal of Language Instruction, 2(3), 1-47. https://doi.org/10.54855/ijli.23231

Niu, Y., & Xue, H. (2023). Exercise generation and student cognitive ability research based on ChatGPT and Rasch Model. IEEE Access, 11, 116695-116705. https://doi.org/10.1109/ACCESS.2023.3325741

OECD. (2020). Trustworthy AI in education: Promises and challenges. https://doi.org/10.1787/a6c90fa9-en

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. PLOS Medicine, 18(3), e1003583. https://doi.org/10.1371/journal.pmed.1003583

Petticrew, M., & Roberts, H. (2006). Systematic reviews in the social sciences: A practical guide. Blackwell. https://doi.org/10.1002/9780470754887

Roy, D., & Putatunda, T. (2023). From textbooks to chatbots: Integrating AI in English literature classrooms of India. Journal of E-Learning and Knowledge Society, 19(3), 65–73. https://doi.org/10.20368/19718829/1135860

Rudolph, J., Tan, S., & Tan, S. (2023). War of the chatbots: Bard, Bing Chat, ChatGPT, Ernie and beyond. The new AI gold rush and its impact on higher education. Journal of Applied Learning and Teaching, 6(1), 364-389. https://doi.org/10.37074/jalt.2023.6.1.23

Saldana, J. (2015). The coding manual for qualitative researchers. Sage.

Sánchez-Ruiz, L. M., Moll-López, S., Nuñez-Pérez, A., Moraño-Fernández, J. A., & Vega-Fleitas, E. (2023). ChatGPT challenges blended learning methodologies in engineering education: A case study in mathematics. Applied Sciences, 13(10), 6039. https://doi.org/10.3390/app13106039

Self, J. A. (1974). Student models in computer-aided instruction. International Journal of Man-Machine Studies, 6(2), 261-276. https://doi.org/10.1016/s0020-7373(74)80005-2

Shaikh, S., Yayilgan, S. Y., Klimova, B., & Pikhart, M. (2023). Assessing the usability of ChatGPT for formal English language learning. European Journal of Investigation in Health, Psychology and Education, 13(9), 1937-1960. https://doi.org/10.3390/ejihpe13090140

Skrabut, S. (2023). 80 ways to use ChatGPT in the classroom: Using AI to enhance teaching and learning. https://zoboko.com/book/2d2ngvje/80-ways-to-use-ChatGPT-in-the-classroom-using-ai-to-enhance-teaching-and learning

Swargiary, K. (2023). The impact of ChatGPT on student learning behavior: An experimental research study. SSRN. https://doi.org/10.2139/ssrn.4611213

Tirado-Olivares, S., Navío-Inglés, M., O'Connor-Jiménez, P., & Cózar-Gutiérrez, R. (2023). From human to machine: Investigating the effectiveness of the conversational AI ChatGPT in historical thinking. Education Sciences, 13(8), 803. https://doi.org/10.3390/educsci13080803

Tlili, A., Shehata, B., Adarkwah, M. A., Bozkurt, A., Hickey, D. T., Huang, R., & Agyemang, B. (2023). What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education. Smart Learning Environments, 10, Article 15. https://doi.org/10.1186/s40561-023-00237-x

Trinoskey, J., Brahmi, F. A., & Gall, C. (2009). Zotero: A product review. Journal of Electronic Resources in Medical Libraries, 6(3), 224-229. https://doi.org/10.1080/15424060903167229

Tzimas, T. (2021). Legal and ethical challenges of artificial intelligence from an international law perspective. Springer. https://doi.org/10.1007/978-3-030-78585-7_4

Uddin, S. M. J., Albert, A., Ovid, A., & Alsharef, A. (2023). Leveraging CHATGPT to aid construction hazard recognition and support safety education and training. Sustainability, 15(9), 7121. https://doi.org/10.3390/su15097121

UNESCO. (2021). AI and education: Guidance for policymakers. https://unesdoc.unesco.org/ark:/48223/pf0000376709

UNESCO. (2022). K-12 AI curricula: A mapping of government-endorsed AI curricula. https://unesdoc.unesco.org/ark:/48223/pf0000380602

UNESCO. (2023). ChatGPT and Artificial Intelligence in Higher Education: Quick start guide. https://unesdoc.unesco.org/ark:/48223/pf0000385146

van den Berg, G., & du Plessis, E. (2023). ChatGPT and Generative AI: Possibilities for its contribution to lesson planning, critical thinking and openness in teacher education. Education Sciences, 13(10), 998. https://doi.org/10.3390/educsci13100998

Vargas-Murillo, A. R., de la Asuncion Pari-Bedoya, I. N. M., & de Jesús Guevara-Soto, F. (2023). Challenges and opportunities of AI-assisted learning: A systematic literature review on the impact of ChatGPT usage in higher education. International Journal of Learning, Teaching and Educational Research, 22(7), 122-135. https://doi.org/10.26803/ijlter.22.7.7

Vázquez-Cano, E., Ramírez-Hurtado, J. M., Sáez-López, J. M., & López-Meneses, E. (2023). ChatGPT:

The brightest student in the class. Thinking Skills and Creativity, 49, 101380. https://doi.org/10.1016/j.tsc.2023.101380

Villan, F., & dos Santos, R. P. (2023). ChatGPT as co-advisor in scientific initiation: Action research with project-based learning in elementary education. Acta Scientiae, 25(6), 60-117. https://doi.org/10.17648/acta.scientiae.7474

Waelen, R. (2022). Why AI ethics is a critical theory. Philosophy and Technology, 35, Article 9. https://doi.org/10.1007/s13347-022-00507-5

Waltzer, T., Cox, R. L., & Heyman, G. D. (2023). Testing the ability of teachers and students to differentiate between essays generated by ChatGPT and high school students. Human Behavior and Emerging Technologies, 2023, Article 1923981. https://doi.org/10.1155/2023/1923981

Wardat, Y., Tashtoush, M. A., AlAli, R., & Jarrah, A. M. (2023). ChatGPT: A revolutionary tool for teaching and learning mathematics. Eurasia Journal of Mathematics, Science and Technology Education, 19(7), em2286. https://doi.org/10.29333/ejmste/13272

Wolfram, S. (2023). What is ChatGPT doing ... and why does it work? https://writings.stephenwolfram.com/2023/02/what-is-chatgpt-doing-and-why-does-it-work/

World Commission on the Ethics of Scientific Knowledge and Technology (COMEST). (2019). Preliminary study on the ethics of artificial intelligence. https://ircai.org/wp-content/uploads/2020/07/PRELIMINARY STUDY-ON-THE-ETHICS-OF-ARTIFICIAL-INTELLIGENCE.pdf

Xiao, Y., & Zhi, Y. (2023). An exploratory study of EFL learners' use of ChatGPT for language learning tasks: Experience and perceptions. Languages, 8(3), 212. https://doi.org/10.3390/languages8030212

Yan, D. (2023). Impact of ChatGPT on learners in an L2 writing practicum: An exploratory investigation. Education and Information Technologies, 28, 13943-13967. https://doi.org/10.1007/s10639-023-11742-4

Yilmaz, R., & Karaoglan Yilmaz, F. G. (2023). 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, 4, 100147. https://doi.org/10.1016/j.caeai.2023.100147

Young, J. C., & Shishido, M. (2023). Investigating OpenAI's ChatGPT potentials in generating Chatbot's dialogue for English as a foreign language learning. International Journal of Advanced Computer Science and Applications, 14(6), 65-72. https://doi.org/10.14569/IJACSA.2023.0140607

Yu, S., & Lu, Y. (2021). An introduction to artificial intelligence in education. Springer. https://doi.org/10.1007/978981-16-2770-5

Zhang, P., & Tur, G. (2023). A systematic review of ChatGPT use in K-12 education. European Journal of Education, 59(2), e12599. https://doi.org/10.1111/ejed.12599

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SUSTAINABLE LEARNING ENVIRONMENT AMIDST THE PANDEMIC: AN ADOPTION OF MOBILE LEARNING READINESS AMONG UNDERGRADUATE STUDENTS IN MALAYSIA'S HIGHER INSTITUTIONS

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ABSTRACT

Aim/Purpose *The present study explores the key determinants that influence the intention of public higher education institutions in Malaysia to utilize mobile learning. Furthermore, this study investigates the correlation between these attributes and the components that affect the sustainability viability of mobile learning.*

Background *The proliferation of mobile devices and the impact of COVID-19 have both played a role in the exponential growth of mobile learning. Mobile learning has emerged as an essential instrument and principal approach to student education within the higher education system amidst the pandemic. Nevertheless, research concerning the sustainability of mobile learning is still in its nascent phases in the post-pandemic period.*

Methodology *Structural equation modeling is utilized to analyze the gathered data and validate the hypotheses in this study, which comprises an online survey of 280 undergraduate students attending public higher education institutions in Malaysia.*

Contribution *This mobile learning research on the sustainability of learning environments during COVID-19 adds to the educational literature. This study reconstructs the antecedent factors of three fundamental constructs of the Theory of Planned Behavior (TPB) to explain the features of mobile learning sustainability. This research provides a theoretical framework for mobile learning sustainability.*

Findings *Based on the empirical evidence, the intention to adopt mobile learning in Malaysian higher education institutions is notably and directly influenced by attitude, subjective norms, and perceived behavioral control. Additionally, the core constructs of TPB are significantly impacted by perceived usefulness, instructor readiness, student readiness, perceived self-efficacy, and learning autonomy. Nevertheless, in Malaysian higher education institutions, the intention to adopt mobile learning is not*

significantly affected by the perceived ease of use.

Recommendations for Practitioners *Mobile learning providers should work on enhancing the performance of this technology to improve content appropriateness and support. Higher education administrators should improve faculty readiness to strengthen the sustainability and efficacy of mobile learning. Improving students' self-discipline in mobile learning and their perceived preparedness and self-efficacy is critical.*

Recommendations for Researchers *This study provides future researchers with a comprehensive perspective on mobile learning, which should be studied regarding technology acceptance, selfperception, and external influences, as well as a holistic research framework that combines internal and external aspects to explain mobile learning adoption behavior. Furthermore, future researchers should broaden their study horizons to include other educational institutions and populations and identify disparities to encourage broader use of mobile learning.*

Impact on Society *COVID-19 has profoundly impacted educational quality and the achievement of sustainable development goals (SDGs). This study demonstrates how mobile learning gives a unique chance for students to continue their learning journey from the comfort of their homes, lessening the disruption caused by pandemics and contributing to the progress of excellent education globally.*

Future Research *Based on the findings, future research should broaden the study's scope to include selecting students (undergraduate and postgraduate) and instructors from multiple universities in various states of Malaysia, collecting data and examining the differences between them, and providing an overall view of mobile learning adoption behaviors (intention to adopt and actual usage) from the perspective of both interactions.*

Keywords *Sustainability, mobile learning, intention, instructor readiness, student readiness, learning autonomy*

INTRODUCTION

Mobile learning is a developing online learning approach (Khalil-Ur-Rehman, 2019). It uses wireless devices like smartphones and tablets to offer learning materials that are neither time-sensitive nor location-sensitive. Mobile learning is learning where students can access material anytime and from any location while engaging in genuine learning activities using mobile technology (Martin & Ertzberger, 2013). Mobile learning is more contextualized and personalized, with more particular and portable material than e-learning (Traxler, 2009). COVID-19 has moved traditional learning and working techniques from in-person to online, owing to the requirement for robust solutions and technology's ability to enable virtual interactions (Dhawan, 2020).

During the pandemic, mobile learning was the predominant method of educating students (RomeroRodríguez et al., 2020). According to Norbutayevich's (2023) findings, mobile learning is an

innovative approach using mobile devices to efficiently complete coursework and access learning resources, regardless of time or space constraints. It is an essential component of making learning simple and adaptable. The pandemic encouraged the implementation of various techniques to prevent interruption in education, including flexible online learning and e-assessment. According to studies by Saikat et al. (2021), Alturki and Aldraiweesh (2022), Almaiah et al. (2022), and Sever Mališ et al. (2022), pandemic has highlighted the potential of mobile learning. Educational systems across the globe are investigating and integrating its novel functionalities. Mobile learning allows students to access learning resources whenever needed, utilizing mobile phones or tablets and an Internet connection (Lan & Sie, 2010; Yi et al., 2009). Mobile learning encourages students to acquire knowledge and apply their abilities in diverse contexts, fostering the development of their problem-solving capabilities beyond the confines of conventional classroom environments. Furthermore, mobile learning approaches enable instructors to tailor instruction while students self-regulate their learning (Naciri et al., 2020). As a result, engaging in additional activities outside of the classroom might boost children's enthusiasm for learning. Moving ahead to future educational problems, as Norbutayevich's (2023) research highlighted, mobile learning represents the cutting edge of technology in the twenty-first-century digital era, capturing students' eager attention. This development could suggest that mobile learning could potentially serve as an effective educational instrument in the post-pandemic period.

Notably, Malaysian education systems have implemented e-learning as a preventive measure against the pandemic's transmission (Adams, 2021), emphasizing the necessity of digital teaching training for educators (Chang et al., 2021). A survey of Malaysian university students conducted during the pandemic found that the vast majority possessed a mobile device, including tablets and cell phones. It was found that 97.7% believed mobile devices could facilitate their learning process, while 73.8% utilized them for online information retrieval and research (Karim et al., 2020). The policy orientation during the pandemic and the widespread popularity of hardware devices have resulted in the rapid advancement of mobile learning, which appears ready for widespread application. However, apparent readiness does not imply that everything is truly ready (Parkes et al., 2015). The investigation into the sustainability of mobile learning in education is presently in its nascent developmental phases (Medrano et al., 2023). Sustainability is defined as the enduring nature of the perpetual advancement of mobile learning, its ability to accommodate evolving user demands and align with its intended objectives, its capacity to adapt to potential changes, and its likelihood of achieving widespread user acceptance (A. M. Al-Rahmi et al., 2021). Prior to the pandemic, studies revealed that mobile learning might be an effective way of training, possibly superior to traditional face-to-face lectures (Shih et al., 2010). Consequently, additional study is required to investigate the post-pandemic educational sustainability of mobile learning, especially since the majority of higher education institutions have embraced mobile learning

as an indispensable pedagogical instrument.

This study demands the development of an explicit empirical feasibility model to analyze sustainability factors in mobile learning thoroughly. Mobile learning is an emerging technology. While investigating its acceptability or intention to use, it is clear to employ technology acceptance theory to explain user behavior. In order to explain whether mobile learning can meet current educational needs, this study incorporates perceived usefulness and perceived ease of use. Furthermore, Cheon et al. (2012) stated that when examining the determinants of mobile learning adoption among college students, it is crucial to commence by assessing their readiness for mobile learning. Ismail et al. (2016) and Mahat et al. (2012) found that Malaysian college students exhibit a moderate readiness for mobile learning. In contrast, instructors perceive a low level of readiness (Ibrahim et al., 2021), indicating that instructors and students in the Malaysian higher education system possess a certain degree of readiness regarding mobile learning. However, no previous studies have empirically examined learning readiness affecting usage behavior. Mobile learning readiness refers to students' preference and readiness to use technology, such as mobile devices, in the learning process (Mahat et al., 2012). However, the learning process is a two-way interactive process with the essential elements being the instructor and the student; thus, this study incorporates the variables of instructor readiness and student readiness into the research framework. Mobile learning places the student in the center of the entire learning activity, and the student-centered learning process allows students to choose when and how often they learn, making student self-directed learning a significant factor influencing mobile learning adoption (Kankok et al., 2020).

Considering all of those mentioned above, by employing the theory of planned behavior (TPB), this study attempts to reconstruct the conceptualization antecedents that explain the characteristics of sustainable mobile learning. The TPB states that individuals' intentions regarding attitudes, subject norms, and perceived behavioral control combine to shape their behavioral intentions and actions (Ajzen, 1991). Subjective norm is the manner in which an individual interprets the social pressures that they encounter. Attitude relates to the positive or negative sentiments that an individual holds regarding a particular behavior, and perceived behavioral control pertains to an individual's subjective assessment of their capability to exert influence over the resources and opportunities necessary to participate in a specific behavior; it is alternatively referred to as the subjective evaluation of the behavior's ease or difficulty to execute. Perceived behavioral control may be separated into two ries: self-efficacy (the perception of one's capacity to conduct behavior) and external resources (the availability of resources to individuals from external sources and obstacles encountered in these resources) (Ajzen, 2002). This study aims to investigate in depth the determinants that impact the adoption of mobile learning in

Malaysian higher education institutions, with a particular focus on the disturbing and complex period following the pandemic. To achieve this objective, the study constructs a holistic theoretical framework with comprehensive explanatory power. This framework is founded on the TPB theory and incorporates perceived usefulness and ease of use as antecedent variables of attitude, instructor readiness, and student readiness as antecedent variables of subjective norms and learning autonomy and self-efficacy as antecedent variables of perceived behavioral control.

LITERATURE REVIEW

MOBILE LEARNING IN HIGHER INSTITUTIONS

Mobile learning, as defined by Naismith et al. (2004), is an instructional approach that leverages mobile technology. Furthermore, research by Peters (2007) and Dahri et al. (2023) demonstrated that mobile learning's unique relevance is its adaptation to time and place. The sharing and exchange of information via mobile learning within academic institutions is an emerging subject of discourse (Salhab & Daher, 2023). According to the research by Lavidas et al. (2022), educating students regarding the advantages linked to mobile learning within higher education institutions is of the utmost importance. Advanced mobile devices have improved organizational, administration, and generation capabilities for teaching and learning due to superior hardware (such as cameras and accelerometers) and a multitude of software alternatives (such as applications) (Chen et al., 2008; Keskin & Metcalf, 2011). These capabilities facilitate individualized, contextual, collaborative, and informal learning by allowing students to build technological and communicative skills, communicate, exchange knowledge, and improve learning outcomes. Unquestionably, the proliferation of mobile devices has given rise to mobile learning as a feasible substitute for students desiring to attain fresh proficiencies or update pre-existing ones (Dahri et al., 2023). However, COVID-19 has prompted system adjustments at educational institutions, which raises concerns regarding the quality of education and the prospects of students. During the pandemic, colleges worldwide adopted online education dramatically, and many students study online using cell phones, desktop computers, or laptops (Voicu & Muntean, 2023). At the same time, Usak et al. (2020) and Naciri et al. (2020) discovered that the urgent scenario prompted a number of concerns, including students' futures and a reduction in educational quality.

The research conducted by Siron et al. (2020) in Indonesia amidst COVID-19 unveiled that students' utilization of e-learning was significantly impacted by experience, self-efficacy, perceived enjoyment, and computer fear. Additionally, perceived ease of use and usefulness influenced students' willingness to adopt e-learning. Unlike face-to-face encounters, mobile learning eliminates physical and temporal

barriers between instructors and learners while delivering a different perspective through digitalized content. Previous research has established a correlation between learners' perceived enhanced learning efficiency and the willingness to utilize mobile learning (Hao et al., 2017). The study by Wei and Chou (2020) investigated the relationship between students' online learning outcomes and their levels of online readiness and perception. The findings indicated that their satisfaction with online learning was significantly influenced by their self-efficacy with computers and the Internet. Moreover, it was noted that the relationship between course satisfaction and online learning perception was moderated by self-efficacy in utilizing computers and the Internet to facilitate online learning.

Given that knowledge acquisition is the fundamental objective of learning, users' favorable perceptions of learning outcomes are anticipated to impact their attitudes toward the system (Yuan et al., 2021). In light of the circumstances, directing attention toward mobile learning readiness is judicious. This entails assessing students' inclination to adopt or reject mobile learning according to their abilities and discernment in a mobile learning context, particularly considering alternative online platforms. Therefore, based on the TPB, the primary objective of this research is to provide an allencompassing comprehension of the factors that influence students' intentions concerning the adoption of mobile learning. SUSTAINABLE

MOBILE LEARNING

According to Naciri et al. (2020) and Alfalah (2023), mobile learning refers to the pedagogical practice of obtaining knowledge via mobile devices. Mobile learning is among the new millennium's learning techniques. In accordance with the findings of a recent study on the expansion of mobile learning (Alshurideh et al., 2023), educational and information systems scholars have examined approaches to integrate it into pedagogical practices. COVID-19 has increased people's reliance on bile learning as they seek alternate ways to complete their jobs (Alfalah, 2023). According to Lin et al.
(2016), individual readiness is among the most significant determinants impacting the tion and efficacy of mobile learning. Readiness includes psychomotor, cognitive, social, and emotional components of a person's ability to act (Borotis & Poulymenakou, 2004). Tang et al. (2021) found that students' readiness for live online learning influences their willingness, participation, and quality of online learning. However, in a separate study, Teo (2010) demonstrated that prior experiences with objects and actions have the most significant impact on an individual's readiness. This finding is consistent with Lin et al.'s (2016) research, which found a significant link between these experiences and the execution of actions or the use of objects.

As a result, Parasuraman (2000) emphasized that the technology itself may be the object when discussing adoption readiness. Moreover, the research by Liu et al. (2010) underlined that mobile learning enhances learning experiences by enhancing student-instructor contact and encouraging favorable attitudes towards learning and instructors. However, from a psychological standpoint, mobile learning readiness overlaps with technology acceptance and learning readiness (Lin et al., 2016). Meanwhile, Lin et al. (2016) discovered that mobile learning readiness is an individual's inclination to embrace and utilize mobile technology for educational purposes, including informal and formal learning. Motiwalla (2007) describes mobile learning as the application of mobile technologies in educational activities. Nonetheless, Ahmad (2019) stressed that the efficiency of mobile technology integration into learning would be determined by the readiness, communication, and commitment of teachers and university officials.

RESEARCH FRAMEWORK AND HYPOTHESIS DEVELOPMENT

THEORY OF PLANNED BEHAVIOR

The Theory of Planned Behavior (TPB) (Ajzen, 1991) is a psychological theory that establishes a link between thoughts and actions. TPB is also a well-known theory for predicting and understanding people's intentions and behaviors (Nie et al., 2020). As a result, limited research has employed the TPB model to elucidate the readiness of institutions of higher education for the adoption of mobile learning (Akour et al., 2021; Tagoe & Abakah, 2014) despite the profound impact that the Internet has had on distance education on a global scale. As a result of the platforms' requirement to sustain the learning environment, the worldwide pandemic has impacted online distance learning. The TPB is the paradigm for investigating the elements that impact students' adoption of mobile learning and its consequences. Therefore, this study constructs an extended research framework based on the TPB model as well as the readiness theory, as shown in Figure 1.

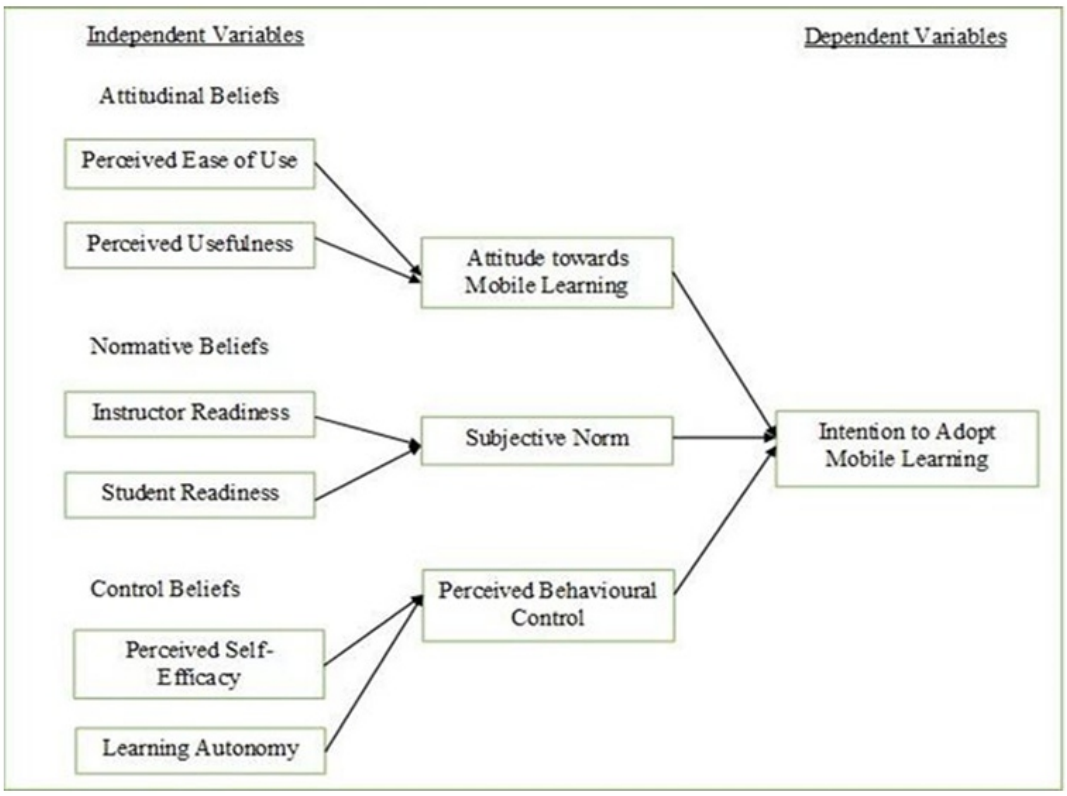

Figure 1. Research Framework

ATTITUDES TOWARDS MOBILE LEARNING

Given the technological limitations of mobile learning at this level and the multiple determinants of user behavior, this study employs two antecedent constructs (perceived ease of use and usefulness) from the technology adoption model to elucidate the attitude variable. Previous studies have also demonstrated significant relationships and high explanatory validity between these two antecedent constructs and attitude variables in various types of mobile applications, such as mobile health (Ramdani et al., 2020), mobile payments (Kavitha & Kannan, 2020), mobile banking (Normalini, 2019), and mobile learning (Cheon et al., 2012). Perceived usefulness relates specifically to the perception that mobile learning increases learners' performance in technological fields (W. M. Al-Rahmi et al., 2018; Davis, 1989). Furthermore, perceived ease of use pertains to an individual's belief that utilizing a specific item is effortless (Davis, 1989). Surveys show that pupils prefer mobile learning when the technology is straightforward. Indeed, as Avci and Askar (2012) showed, perceived usefulness significantly influences the intention to utilize technology applications in various scenarios. Hsu (2012), Joo et al. (2016), and Teo et al. (2019) revealed that students' behavioral intentions to utilize mobile learning management systems are significantly predicted by their perception of the systems' usefulness. Consequently, the subsequent hypotheses are presented:

H1: Perceived usefulness has a positive attitude-changing effect on students' inclination to use mobile

H2: Perceived ease of use positively influences students' attitudes and intentions about mobile learning adoption.

SUBJECTIVE NORMS ON MOBILE LEARNING

Subjective norms are defined as others' perceptions of social effects on conduct (Ajzen, 1991), which reflect teacher and student readiness. This readiness is crucial for adopting mobile learning throughout the pandemic and sustaining the learning environment. After reviewing the studies on the determinants of mobile learning adoption by students worldwide (Cheon et al., 2012; Iqbal & Ahmed Bhatti, 2015; Mahat et al., 2012), it is critical to emphasize that this concept is in a state of constant development, especially in the realm of remote and open education. As a result, Cheon et al. (2012) found that professors and instructors significantly impacted students' decisions to use mobile learning. Furthermore, as emphasized by Alrasheedi et al. (2015), it is vital to assess students' perceptions of the acceptability of mobile learning since its efficacy is intrinsically tied to student technological acceptance. Therefore, teacher readiness for mobile learning adoption and student readiness should be investigated in Malaysian higher education institutions, where online learning has been crucial to the learning environment throughout the pandemic. Instructors are students' primary source of advice; thus, the learning environment should be consistent with low failure risk. Furthermore, students' utilization of mobile learning was significantly impacted by the level of assistance provided by the university administration, according to Almaiah et al. (2022). Hence, these hypotheses are derived:

H3: Instructor readiness influences students' desire to use mobile learning positively.
H4: Student readiness has a favorable subjective norm-changing effect on the intention to adopt mobile learning.

PERCEIVED BEHAVIORAL CONTROL

Aguilera-Hermida's (2020) research defines perceived behavioral control as an individual's competence, effort, and enabling factors that impact their ability to engage with educational technology. Al-Emran et al. (2020) and Azizi and Khatony (2019) discovered a consistent positive link between learners' perceived behavioral control and their inclination to employ mobile learning. However, prior studies have demonstrated that attitude is a dependable indicator of intention. According to Armitage and Conner (2001), a person's desire to participate in an activity increases as their attitude towards it improves. In contrast, Davis' (1989) research highlights that mentality comes before aspirations to use computer technology. The study by Normalini et al. (2018) revealed that attitude is the strongest

predictor influencing undergraduate students' intention to use mobile applications in Malaysian public universities. The social cognitive theory by Bandura (1986) supposes that individuals' behavior is significantly impacted by perceived self-efficacy. Afful and Boateng (2023) discovered that students' self-efficacy influences their behaviors when engaging in practical mobile learning activities. Nowadays, most students have the confidence, organizational skills, and action-taking abilities to use mobile learning effectively. Holec (1981) defined learning autonomy as the ability to direct one's own learning, and it refers to the extent to which students are in command and accountable for their own actions while using mobile learning. Nonetheless, autonomy is a crucial predictor of behavioral control in mobile learning. Cheon et al. (2012) revealed that mobile learning requires self-motivated and self-disciplined learners, mobility, and flexibility. Thus, these hypotheses are constructed.

H5: Perceived self-efficacy impacts the perception of behavioral control in favor of the intention to adopt mobile learning.
H6: Learning autonomy has a favorable impact on how behavioral control is viewed and the propensity to use mobile learning.
H7: Attitude influences the intention to use mobile learning positively.
H8: Subjective norm has a favorable impact on the intention to adopt mobile learning.
H9: Perceived behavioral control influences the intention to use mobile learning favorably.

MATERIALS AND METHODS

DATA COLLECTION AND SAMPLING METHOD

The research sample comprises 280 undergraduate students currently enrolled in one of Malaysia's public higher education institutions. The purposive sampling approach was used to implement the non-probability sampling method. Data were collected over four weeks via an online Google Form survey from undergraduate students who used mobile devices for online courses owing to the outbreak. All measurements in this research were derived from prior studies (Cheon et al., 2012) and were assessed using a 7-point Likert scale that ranged from "strongly disagree" to "strongly agree." Three measurements were attached to each construct in this study. The 18th WMA General Assembly in Helsinki, Finland, adopted the ethical principles for this research in June 1964 (World Medical Association, 2013). Even though it may be necessary to communicate with family members or community leaders, it is strictly forbidden to participate in a research project without the voluntary consent of an individual competent to provide informed consent. The present study is conducted in accordance with the Helsinki Protocol.

DATA ANALYSIS AND RESULTS

DEMOGRAPHIC PROFILE AND TECHNOLOGY USAGE

The survey instrument was divided into three discrete stages. Following the collection of demographic information in the first section was a segment pertaining to technology usage. In the third section, the responses of the participants regarding the specific measurement items associated with each construct were extracted. The study used the deliberate sampling approach to target specific groups of people, especially mobile learning users, who best provided the necessary information for the study.

The respondents' technology usage and demographic profile are detailed in Table 1. Most respondents were female (73.5%), with a male proportion of only 26.8%. The age range of males and females who answered the questionnaire was 24-26 years (9.3%), followed by 21-23 years (86.1%), and the lowest was 18-20 years (4.6%). The percentage of individuals falling within the age range of 21-23 years is the highest of all age ranges documented.

Table 1. Profile of Demographic

Demographic	Categories	Frequency	Percentage (%)
Age	18-20	13	4.6
	21-23	241	86.1
	24-26	26	9.3
Gender	Male	75	26.8
	Female	205	73.2
Ethnicity	Malay	90	32.1
	Chinese	141	50.4
	Indian	43	15.4
	Others	6	2.1
School	Arts Course	212	75.7
	Science Course	68	24.3
Year	First Year	20	7.1
	Second Year	111	39.6
	Third Year	121	43.2
	Fourth Year	25	8.9
	Fifth Year	3	1.1
CGPA	3.00-3.50	129	46.1
	3.51-4.00	151	53.9
Smartphone Brand	Apple (iPhone)	88	31.4
	Samsung	47	16.8
	Nokia	1	0.4
	HTC	3	1.1
	Sony Xperia	3	1.1
	LG	3	1.1
	Vivo	40	14.3
	Xiaomi	18	6.4
	Huawei	44	15.7
	Others	33	11.8
Own Tablet PC	Yes	280	100
PC Brand	Apple (Ipad)	33	11.8
	Samsung	26	9.3
	Asus	74	26.4
	Acer	43	15.4
	Microsoft Surface	16	5.7
	Sony	15	5.4
	Lenovo	15	5.4
	HP	34	12.1
	Others	24	8.6

Years Using Internet	1-10	164	58.6
	11-20	114	40.7
	21-30	2	0.7
Hours	Almost Never	1	0.4
	Less than 1 hour	23	8.2
	1-5 hours	48	17.1
	6-10 hours	109	38.9
	11-15 hours	63	22.5
	16-20 hours	29	10.4
	More than 20 hours	7	2.5

Demographic	Categories	Frequency	Percentage (%)
Data Plan	Yes	260	92.9
	No	20	7.1

Most responders were Chinese, accounting for 50.4%, followed by Malays (32.1%). The Arts course cluster, which included social sciences, humanities, education, language, and communication courses, had the most responses (212, 75.7%). The remaining 24.3% comprised 68 Science course cluster students studying chemistry, pharmacy, physics, biology, industrial technology, computer science, mathematical science. The highest year of study reported was by third-year students, at 43.2%, followed by second-year students at 39.6%. First-year students scored just 7.1%, followed by fourthyear students at 8.9% and fifth-year students at 1.1%. The recorded cumulative grade point average (CGPA) of the 129 students varied from 3.00 to 3.50 (46.1%), with 151 individuals achieving a higher CGPA of 3.51 to 4.00 (53.9%). The Arts course cluster is far more extensively represented than the Science course cluster; nevertheless, variations in optional topics and grade levels do not influence mobile technology use for the Generation Z cohort. Among the 280 respondents, all the students had a smartphone, with 192 using Android (68.6%) and 88 using an iPhone (31.4%). On the other hand, all 280 respondents also have a tablet PC (Apple: 11.8%; Windows PC Operating Systems: 88.2%). This suggests that Malaysian university students are selective about mobile devices during mobile learning and can choose different devices depending on the scenario. Most students prefer Android phones and Windows systems, which may be associated with the compatibility of mobile learning programs. Of the respondents, 164 had used the Internet for ten years, while 114 had used it for up to 20 years. Most respondents (109, 38.9%) spent 6-10 hours daily on the Internet, with the lowest time spent at 0.4%. Most respondents (92.9%) had data subscriptions, while just 7.1% used a free Wi-Fi network.

ANALYSIS

This study's constructed models were analyzed using SmartPLS 3.3.3, a second-generation structural equation modeling software (Ringle et al., 2015). The present study utilized a two-step approach, commencing with an assessment of the measurement model, which was subsequently followed by an examination of the instrument's validity and reliability. Using the structural model, the hypothesis was examined during the second phase of the research.

MEASUREMENT MODEL

This study conforms to the analysis and evaluation by Hair et al. (2020), who employed outer loadings, average variance extracted (AVE), and composite reliability (CR) to assess quality indicators, including convergent validity, discriminant validity, and other external model indicators. The loading, AVE, and CR threshold values specified by Ramayah et al. (2018) are 0.7, 0.5, and 0.7, respectively. According to the results shown in Table 2, all loadings exceeded 0.7, AVE was less than 0.5, and CR exceeded 0.7. The findings indicate that the assessment has convergent validity and can be considered reliable. We then examined the discriminant validity employing the HTMT ratio proposed by Franke and Sarstedt (2019). When the HTMT value is less than 0.90, it indicates that the structures being evaluated are distinct. As seen in Appendix A, all but a few HTMT ratios were less than 0.90. Nonetheless, after doing the HTMT bootstrapping, we noticed that the UL between variables over the proposed threshold was less than 1.0, indicating that respondents were aware that the ten constructs tested were independent.

Table 2. Measurement Model

Construct	Item	Loadings	AVE	CR
Attitude	ATT1	0.896	0.836	0.938
	ATT2	0.921		
	ATT3	0.925		
Intention	INT1	0.949	0.872	0.953
	INT2	0.950		
	INT3	0.902		
Instructor Readiness	IR1	0.899	0.798	0.922
	IR2	0.907		
	IR3	0.874		
Learning Autonomy	LA1	0.957	0.919	0.958
	LA2	0.961		
Perceived Behavioral Control	PBC1	0.945	0.854	0.946
	PBC2	0.899		
	PBC3	0.929		
Perceived Ease of Use	PEOU1	0.829	0.724	0.887
	PEOU2	0.879		
	PEOU3	0.844		
Perceived Self-Efficacy	PSE1	0.963	0.869	0.952
	PSE2	0.925		
	PSE3	0.909		
Perceived Usefulness	PU1	0.865	0.775	0.912
	PU2	0.897		
	PU3	0.880		
Student Readiness	SR1	0.872	0.789	0.918
	SR2	0.888		
	SR3	0.906		
Subjective Norm	SN1	0.931	0.822	0.933
	SN2	0.893		
	SN3	0.895		

Note: LA3 was deleted due to low loadings

MEASUREMENT OF STRUCTURAL MODEL

This study employed 5,000 bootstrap resamples (Hair et al., 2020; Ramayah et al., 2018) to examine the structural model and test the hypotheses formulated. The outcomes of this analysis are presented in the form of confidence intervals, t-values, standard errors, p-values, beta values, and standard errors. According to the final results, the R2 was 0.458 (Q2 = 0.376) for Attitude, R2 was 0.7 (Q2 = 0.59) for Perceived Behavioral Control, R2 was 0.684 (Q2 = 0.555) for Subjective Norm and R2 was 0.805 (Q2 = 0.695) for Intention. The findings determined that the predictors could explain 45.8% of the variance in Attitude, 70% of the variance in Perceived Behavioral Control, 68.4% of the variance in Subjective Norm, and 80.5% of the variance in Intention. Based on the results of the analysis (see Figure 2), We found a positive correlation between Attitude and Perceived Usefulness ($\beta = 0.676$, $t = 9.674$, $p < 0.01$) but no significant relationship with Perceived Ease of Use ($\beta = 0.002$, $t = 0.027$, $p = 0.489$) when examining the factors influencing Attitude. Secondly, both Student Readiness ($\beta = 0.395$, $t = 6.088$, $p < 0.01$) and Instructor Readiness ($\beta = 0.492$, $t = 7.879$, $p < 0.01$) had a significant and positive impact on Subjective Norms. Moreover, significant positive correlations were observed in this study among Perceived Behavioral Control, Learning Autonomy ($\beta = 0.568$, $t = < 0.01$), and Perceived Self-efficacy ($\beta = 0.29$, $t = 3.768$, $p < 0.01$). In conclusion, the findings of this research demonstrated that Intention to Use was significantly and positively influenced by Attitude ($\beta = 0.292$, $t = 4.998$, $p < 0.01$), Subjective Norms ($\beta = 0.281$, $t = 4.944$, $p < 0.01$), and Perceived Behavioral Control ($\beta = 0.416$, $t = 7.510$, $p < 0.01$). Consequently, H2 was not supported in this investigation, while H1, H3, H4, H5, H6, H7, H8, and H9 were supported (see Appendix B).

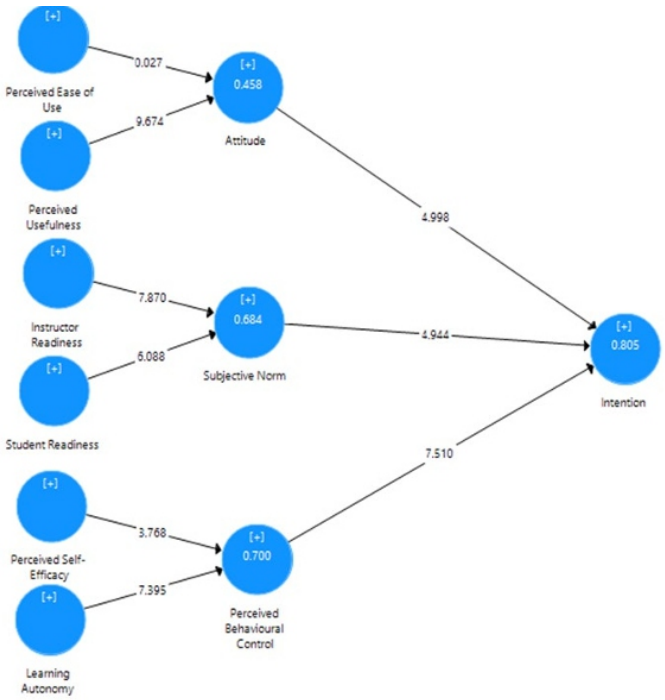

Figure 2. Hypothesis Testing Results

DISCUSSION AND IMPLICATIONS

DISCUSSION

This study employed the TPB theory to examine the determinants that impact the intentions of university students to adopt mobile learning, and the findings presented insightful conclusions about the dynamics of technology adoption in higher education. This study developed predicted beliefs for each of the three essential components of the TPB hypothesis. According to the findings of this study, perceived behavioral control (β = 0.416) had the most substantial influence on the intentions of university students to utilize mobile learning. The abovementioned results corroborated those of Cheon et al. (2012). Meanwhile, two predictive beliefs, learning autonomy and perceived self-efficacy, had the most explanatory power for perceived behavioral control (R2 = 0.700). Perceived behavioral control was more significantly impacted by learning autonomy (β = 0.568) than perceived self-efficacy (β = 0.290). This finding suggested that students' self-regulation responsibility and control of the learning process (Liu, 2008) had a more substantial effect on perceived behavioral control than self-referential judgments of competence for adopting mobile learning. Importantly, this study confirmed that learning autonomy is a prerequisite for mobile learning-related perceived behavioral control. This implies that learners with autonomous and self-directed learning abilities are more inclined to use mobile learning. In contrast, learners with more excellent self-directed learning skills and potential are more effective at using mobile learning.

Attitude (β = 0.292) significantly increased adoption intention. Nevertheless, concerning the two antecedent variables of Attitude, the impact of perceived ease of use on Attitude was insignificant. This nuanced finding suggested that undergraduates' perceptions of the mobile learning platform's ease of use in Malaysian higher education institutions may not substantially influence their intention to use mobile learning. This insight highlighted the present students' growing familiarity with digital technologies, which may reduce perceived obstacles to ease of use. The perceived usefulness (β = 0.676) strongly affected attitudes towards embracing mobile learning. The findings indicated that the better college students viewed mobile learning performance, the more beneficial they thought this technology to be, and the more favorable their attitudes towards adopting mobile learning were, resulting in more excellent mobile learning adoption intentions. In this study, the effect of the two antecedent variables of Attitude on Attitude is consistent with the findings of Normalini and Ramayah (2015).

Subjective norms (β = 0.281) positively and directly influenced adoption intentions, according to this study. The influence of instructor readiness (β = 0.395) on subjective norms was found to be more

substantial in comparison to student readiness (β = 0.290). These two variables together explained 68.4% of the variation in perceived norms (R2 = 0.684). This finding indicates that enhancing teacher readiness is likely to increase the propensity of college students to utilize mobile learning. The observed result is in accordance with the conclusions posited in the research conducted by Cheon et al. (2012). The results of this study support previous research that found low teacher readiness in Malaysia's higher education system due to traditional teacher-centered educational philosophy and a lack of holistic understanding of pedagogical integration in mobile learning (Ibrahim et al., 2021). This means that sustained performance attainment and effective deployment of mobile learning in higher education need a thorough understanding of mobile learning's potential, limits, and successes by instructors and students (Azizi & Khatony, 2019).

In conclusion, to confirm the substantial determinants that significantly impact the intention of Malaysian university students to adopt mobile learning and thereby ensure its long-term sustainability and prosperity, an exhaustive investigation was conducted to validate these factors. The finding of this study demonstrated that the combined influence of attitude, subjective norms, and perceived behavioral control explained 80.5% of the variance (R2 = 0.805) of the adoption intention for mobile learning. This finding indicates that the model constructed specifically for this study possesses a greater capacity to explain the intention of undergraduate students in Malaysian higher education institutions to implement mobile learning. Simultaneously, the reconstructed core constructs' antecedent variables provided a transparent empirical sustainability model. These variables effectively interpreted the different components of mobile learning sustainability.

PRACTICAL IMPLICATIONS

This study investigated the factors influencing undergraduates' intention to utilize mobile learning to provide a comprehensive perspective on initiatives to enhance sustainability and support students'intention for mobile learning. Based on the results, we can provide stakeholders in the mobile learning domain with actionable recommendations. First, mobile learning providers must work on increasing the performance of mobile learning technology, which may be accomplished through content, efficiency, and resource integration, in order to support student learning successfully. Higher education administrators may improve faculty readiness for mobile learning by capitalizing on faculty influence and reputation among students, increasing the durability and efficiency of mobile learning readiness. Simultaneously, each educational institution should provide diverse opportunities for training in mobile learning functions to promote students' self-efficacy perspectives. Initially, students should concentrate on improving their self-control and self-discipline when using mobile devices for

educational reasons. Based on this assumption, students ought to make an effort to enhance their readiness for learning, proactively acquire proficiency in utilizing mobile learning technologies, and engage in diverse training and guidance offered by tertiary educational establishments to augment their self-efficacy and performance perceptions of mobile learning. Furthermore, COVID-19 has tremendously influenced global progress toward sustainable development objectives and educational excellence. This study illustrates how mobile learning gives students a tough chance to continue their learning journey from the comfort of their homes, alleviating the interruptions caused by the pandemic's early beneficial impacts and helping the growth of excellent education globally.

CONCLUSION

The present study employed the TPB theory as a conceptual model to comprehensively examine the principal determinants impacting mobile learning adoption in Malaysian higher education institutions by reconstructing the antecedent variables of the critical components that explain the attributes of sustainable mobile learning. The study's findings indicated that attitude, subjective norms, and perceived behavioral control significantly influenced the adoption of mobile learning in Malaysian higher education institutions. Nonetheless, perceived usefulness significantly affects the attitude variable, and increasing perceived usefulness aids mobile learning in meeting the sustainability element of responding to current educational needs. Instructor readiness significantly impacts subjective norms more than student readiness, directly affecting the sustainability element of increased user acceptance. Learning autonomy and self-efficacy significantly influence perceived behavioral control and the long-term potential of mobile learning to adapt and develop. The findings effectively aid stakeholders in better understanding the integrated perspective of mobile learning and contribute to developing mobile learning's sustainability in education by bridging the research of pre-pandemic and post-pandemic mobile learning system acceptance factors.

LIMITATIONS AND DIRECTIONS FOR FUTURE STUDIES

This study provides an original viewpoint regarding the sustainable implementation of mobile learning in Malaysian higher education institutions. Nevertheless, this investigation did not examine the practical implementation of mobile learning. Meanwhile, increased data collection will facilitate comparative analyses, reveal differences, and provide a comprehensive understanding of mobile learning adoption behaviors from the perspectives of all stakeholders, both in terms of intentions and actual usage. Given these findings, further research should aim to broaden the scope of this investigation by incorporating academic staff and undergraduate and graduate students from multiple colleges and

regions within Malaysia.

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REFERENCES

Adams, D. (2021). Innovative practices of technology-enhanced learning. Universiti Pendidikan Sultan Idris.

Afful, D., & Boateng, J. K. (2023). Mobile learning behavior of university students in Ghana. Cogent Social Sciences, 9(1), Article 2204712. https://doi.org/10.1080/23311886.2023.2204712

Aguilera-Hermida, A. P. (2020). College students' use and acceptance of emergency online learning due to COVID-19. International Journal of Educational Research Open, 1, 100011. https://doi.org/10.1016/j.ijedro.2020.100011

Ahmad, T. (2019). Undergraduate mobile phone use in the Caribbean: Implications for teaching and learning in an academic setting. Journal of Research in Innovative Teaching & Learning. 13(2), 191-210. https://doi.org/10.1108/JRIT-01-2019-0001

Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50(2), 179211. https://doi.org/10.1016/0749-5978(91)90020-T

Ajzen, I. (2002). Residual effects of past on later behavior: Habituation and reasoned action perspectives. Personality and Social Psychology Review, 6(2), 107-122. https://doi.org/10.1207/S15327957PSPR0602_02

Akour, I., Alshurideh, M., Al Kurdi, B., Al Ali, A., & Salloum, S. (2021). Using machine learning algorithms to predict people's intention to use mobile learning platforms during the COVID-19 pandemic: Machine learning approach. JMIR Medical Education, 7(1), e24032. https://doi.org/10.2196/24032

Al-Emran, M., Arpaci, I., & Salloum, S. (2020). An empirical examination of continuous intention to use mlearning: An integrated model. Education and Information Technologies, 25(4), 2899-2918. https://doi.org/10.1007/s10639-019-10094-2

Alfalah, A. A. (2023). Factors influencing students' adoption and use of mobile learning management systems (m-LMSs): A quantitative study of Saudi Arabia. International Journal of Information Management Data Insights, 3(1), 100143. https://doi.org/10.1016/j.jjimei.2022.100143

Almaiah, M. A., Al-Otaibi, S., Lutfi, A., Almomani, O., Awajan, A., Alsaaidah, A., Alrawad, M., & Awad, A. B. (2022). Employing the TAM model to investigate the readiness of m-learning system usage using SEM technique. Electronics, 11(8), 1259. https://doi.org/10.3390/electronics11081259

Al-Rahmi, A. M., Al-Rahmi, W. M., Alturki, U., Aldraiweesh, A., Almutairy, S., & Al-Adwan, A. S. (2021). Exploring the factors affecting mobile learning for sustainability in higher education. Sustainability, 13(14), 7893. https://doi.org/10.3390/su13147893

Al-Rahmi, W. M., Yahaya, N., Alamri, M. M., Aljarboa, N. A., Kamin, Y. B., & Moafa, F. A. (2018). A model of factors affecting cyber bullying behaviors among university students. IEEE Access, 7, 2978–2985. https://doi.org/10.1109/ACCESS.2018.2881292

Alrasheedi, M., Capretz, L. F., & Raza, A. (2015). A systematic review of the critical factors for success of mobile learning in higher education (university students' perspective). Journal of Educational Computing Research, 25(2), 257-276. https://doi.org/10.1177/0735633115571928

Alshurideh, M., Al Kurdi, B., Salloum, S. A., Arpaci, I., & Al-Emran, M. (2023). Predicting the actual use of mlearning systems: A comparative approach using PLS-SEM and machine learning algorithms. Interactive Learning Environments, 31(3), 1214-1228. https://doi.org/10.1080/10494820.2020.1826982

Alturki, U., & Aldraiweesh, A. (2022). Students' perceptions of the actual use of mobile learning during COVID-19 pandemic in higher education. Sustainability, 14(3), 1125. https://doi.org/10.3390/su14031125

Armitage, C. J., & Conner, M. (2001). Efficacy of the theory of planned behaviour: A meta-analytic review. British Journal of Social Psychology, 40(4), 471-499. https://doi.org/10.1348/014466601164939

Avci, U., & Askar, P. (2012). The comparison of the opinions of the university students on the usage of blog and wiki for their courses. Journal of Educational Technology & Society, 15(2), 194-205. https://www.jstor.org/stable/jeductechsoci.15.2.194

Azizi, S. M., & Khatony, A. (2019). Investigating factors affecting on medical sciences students' intention to adopt mobile learning. BMC Medical Education, 19, Article 381. https://doi.org/10.1186/s12909-019-18314

Bandura, A. (1986). Social foundations of thought and action. Englewood Cliffs.

Borotis, S., & Poulymenakou, A. (2004). E-learning readiness components: Key issues to consider before adopting e-learning interventions. In J. Nall & R. Robson (Eds.), Proceedings of E-Learn: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education (pp. 1622-1629). Association for the Advancement of Computing in Education. https://www.learntechlib.org/primary/p/11555/

Chang, C.-C., Tsai, L.-T., Chang, C.-H., Chang, K.-C., & Su, C.-F. (2021). Effects of science reader

belief and reading comprehension on high school students' science learning via mobile devices. Sustainability, 13(8), 4319. https://doi.org/10.3390/su13084319

Chen, W., Tan, N., Looi, C., Zhang, B., & Seow, P. (2008). Handheld computers as cognitive tools: Technology enhanced environmental learning. Research & Practice in Technology Enhanced Learning, 3(3), 231–252. https://doi.org/10.1142/S1793206808000513

Cheon, J., Lee, S., Crooks, S. M., & Song, J. (2012). An investigation of mobile learning readiness in higher education based on the theory of planned behavior. Computers & Education, 59(3), 1054-1064. https://doi.org/10.1016/j.compedu.2012.04.015

Dahri, N. A., Al-Rahmi, W. M., Almogren, A. S., Yahaya, N., Vighio, M. S., Al-maatuok, Q., Al-Rahmi, A. M., & Al-Adwan, A. S. (2023). Acceptance of mobile learning technology by teachers: Influencing mobile selfefficacy and 21st-century skills-based training. Sustainability, 15(11), 8514. https://doi.org/10.3390/su15118514

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319-340. https://doi.org/10.2307/249008

Dhawan, S. (2020). Online learning: A panacea in the time of COVID-19 crisis. Journal of Educational Technology Systems, 49(1), 5-22. https://doi.org/10.1177/0047239520934018

Franke, G., & Sarstedt, M. (2019). Heuristics versus statistics in discriminant validity testing: A comparison of four procedures. Internet Research, 29(3), 430–447. https://doi.org/10.1108/IntR-12-2017-0515

Hair, J. F., Jr., Howard, M. C., & Nitzl, C. (2020). Assessing measurement model quality in PLS-SEM using confirmatory composite analysis. Journal of Business Research, 109, 101–110. https://doi.org/10.1016/j.jbusres.2019.11.069

Hao, S., Dennen, V. P., & Mei, L. (2017). Influential factors for mobile learning acceptance among Chinese users. Education Technology Research and Development, 65, 101–123. https://doi.org/10.1007/s11423-016-9465-2

Holec, H. (1981). Autonomy and foreign language learning. Pergamon Press.

Hsu, H. H. (2012). The acceptance of Moodle: An empirical study based on UTAUT. Creative Education, 3, 4446. https://doi.org/10.4236/ce.2012.38b010

Ibrahim, R., Abdullah, N., Razalli, A. R., Bitz, M., & Anal, A. binti. (2021). Teacher readiness towards the use of mobile learning for dyslexia student: A survey in Malaysia. International Journal of Asian Social Science, 11(6), 278-285. https://doi.org/10.18488/journal.1.2021.116.278.285

Iqbal, S., & Ahmed Bhatti, Z. (2015). An investigation of university student readiness towards m-learning using Technology Acceptance Model. The International Review of Research in Open and Distributed Learning, 16(4). https://doi.org/10.19173/irrodl.v16i4.2351

Ismail, I., Azizan, S. N., & Gunasegaran, T. (2016). Mobile learning in Malaysian universities: Are

students ready? International Journal of Interactive Mobile Technologies, 10(3), 17-23. https://doi.org/10.3991/ijim.v10i3.5316

Joo, Y. J., Kim, N., & Kim, N. H. (2016). Factors predicting online university students' use of a mobile learning management system (m-LMS). Educational Technology Research and Development, 64, 611-630. https://doi.org/10.1007/s11423-016-9436-7

Kankok, J., Ambotang, A. S., & Kariming, N. F. A. (2020). Mobile learning adoption: A perspective from a Form Six students in Sabah, Malaysia. Malaysian Journal of Social Sciences and Humanities, 5(12), 314–332. https://doi.org/10.47405/mjssh.v5i12.563

Karim, R. A., Adnan, A. H. M., Salim, M. S. A. M., Kamarudin, S., & Zaidi, A. (2020). Education innovations through mobile learning technologies for the Industry 4.0 readiness of tertiary students in Malaysia. Proceedings of the IOP Conference Series: Materials Science and Engineering, 917, 012022. https://doi.org/10.1088/1757899X/917/1/012022

Kavitha, K., & Kannan, D. (2020). Factors influencing consumers attitude towards mobile payment applications. International Journal of Management, 11(4), 140-150.

Keskin, N. O., & Metcalf, D. (2011). The current perspectives, theories and practice of mobile learning. The Turkish Online Journal of Educational Technology, 10(2), 202-208. https://eric.ed.gov/?id=EJ932239

Khalil-Ur-Rehman, F. (2019). Mobile learning in Malaysia: Deployment in higher education beneficial or disaster [Master's thesis, Limkokwing University of Creative Technology].

Lan, Y.-F., & Sie, Y.-S. (2010). Using RSS to support mobile learning based on media richness theory. Computers & Education, 55(2), 723-732. https://doi.org/10.1016/j.compedu.2010.03.005

Lavidas, K., Petropoulou, A., Papadakis, S., Apostolou, Z., Komis, V., Jimoyiannis, A., & Gialamas, V. (2022). Factors affecting response rates of the Web survey with teachers. Computers, 11(9), 127. https://doi.org/10.3390/computers11090127

Lin, H. H., Lin, S., Yeh, C. H., & Wang, Y. S. (2016). Measuring mobile learning readiness: Scale development and validation. Internet Research, 26(1), 265-287. https://doi.org/10.1108/IntR-10-2014-0241

Liu, Y. (2008, July). An adoption model for mobile learning. Proceedings of the IADIS Multi Conference on Computer Science and Information Systems, Amsterdam, Netherlands, 251-256. http://www.scopus.com/inward/record.url?eid=2-s2.0-58449083352&partnerID=MN8TOARS

Liu, Y., Li, H., & Carlsson, C. (2010). Factors driving the adoption of m-learning: An empirical study. Computers & Education, 55(3), 1211-1219. https://doi.org/10.1016/j.compedu.2010.05.018

Mahat, J., Ayub, A. F. M., & Luan, S. (2012). An assessment of students' mobile self-efficacy readiness and personal innovativeness towards mobile learning in higher education in Malaysia. Procedia - Social and Behavioral Sciences, 64, 284-290. https://doi.org/10.1016/j.sbspro.2012.11.033

Martin, F., & Ertzberger, J. (2013). Here and now mobile learning: An experimental study on the use of mobile technology. Computers & Education, 68, 76-85. https://doi.org/10.1016/j.compedu.2013.04.021

Medrano, M. M., Ostariz, P. L., Aranda, L. D. B., & Costa, R. S. (2023). Mobile learning and communication: Educational change? A systematic review. Education + Training, 65(2), 193-209. https://doi.org/10.1108/ET-03-2022-0110

Motiwalla, L. F. (2007). Mobile learning: A framework and evaluation. Computers & Education, 49(3), 581-596. https://doi.org/10.1016/j.compedu.2005.10.011

Naciri, A., Baba, M. A., Achbani, A., & Kharbach, A. (2020). Mobile learning in higher education: Unavoidable alternative during COVID-19. Aquademia, 4(1), ep20016. https://doi.org/10.29333/aquademia/8227

Naismith, L., Lonsdale, P., Vavoula, G., & Sharples, M. (2004). Literature review in mobile technologies and learning. Futurelab. http://www2.futurelab.org.uk/resources/documents/lit_reviews/Mobile_Review.pdf

Nie, J., Zheng, C., Zeng, P., Zhou, B., Lei, L., & Wang, P. (2020). Using the theory of planned behavior and the role of social image to understand mobile English learning check-in behavior. Computers & Education, 156, 103942. https://doi.org/10.1016/j.compedu.2020.103942

Norbutayevich, J. T. (2023). The use of mobile learning applications in higher education institutes. Advances in Mobile Learning Educational Research, 3(1), 610-620. https://doi.org/10.25082/AMLER.2023.01.010

Normalini, M. K. (2019). Revisiting the effects of quality dimensions, perceived usefulness and perceived ease of use on internet banking usage intention. Global Business & Management Research, 11(2), 252-261.

Normalini, M. K., Lurudusamy, S. N., & Arokiasamy, L. (2018). Factors that influence mobile application usage among undergraduates in Malaysian public university. International Academic Journal of Science and Engineering, 5(1), 120-133. https://doi.org/10.9756/IAJSE/V5I1/1810011

Normalini, M. K., & Ramayah, T. (2015). Perceived risk factors influence on intention to continue using Internet banking among Malaysians. Global Business Review, 16(3), 393-414. https://doi.org/10.1177/0972150915569928

Parasuraman, A. (2000). Technology Readiness Index (Tri): A multiple-item scale to measure readiness to embrace new technologies. Journal of Service Research, 2(4), 307-320. https://doi.org/10.1177/109467050024001

Parkes, M., Stein, S., & Reading, C. (2015). Student preparedness for university e-learning environments. The Internet and Higher Education, 25, 1-10. https://doi.org/10.1016/j.iheduc.2014.10.002

Peters, K. (2007). m-Learning: Positioning educators for a mobile, connected future. International Review of Research in Open and Distance Learning, 8(2). https://doi.org/10.19173/irrodl.v8i2.350

Ramayah, T., Cheah, J., Chuah, F., Ting, H., & Memon, M. A. (2018). Partial least squares structural equation modeling (PLS-SEM) using smartPLS 3.0. An updated guide and practical guide to statistical analysis.

Ramdani, B., Duan, B., & Berrou, I. (2020). Exploring the determinants of mobile health adoption by hospitals in China: Empirical study. JMIR Medical Informatics, 8(7), e14795. https://doi.org/10.2196/14795

Ringle, C. M. (2015). Partial least squares structural equation modelling (PLS-SEM) using SmartPLS 3. Computational Data Analysis and Numerical Methods VII WCDANM, Portugal.

Romero-Rodríguez, J.-M., Aznar-Díaz, I., Hinojo-Lucena, F.-J., & Gómez-García, G. (2020). Mobile learning in higher education: Structural equation model for good teaching practices. IEEE Access, 8, 91761-91769. https://doi.org/10.1109/access.2020.2994967

Saikat, S., Dhillon, J. S., Wan Ahmad, W. F., & Jamaluddin, R. A. (2021). A systematic review of the benefits and challenges of mobile learning during the COVID-19 pandemic. Education Sciences, 11(9), 459. https://doi.org/10.3390/educsci11090459

Salhab, R., & Daher, W. (2023). University students' engagement in mobile learning. European Journal of Investigation in Health, Psychology and Education, 13(1), 202-216. https://doi.org/10.3390/ejihpe13010016

Sever Mališ, S., Mamić Sačer, I., & Žager, K. (2022). Landscape of e-learning during Covid-19: Case study of economic disciplines in Croatia. Business Systems Research Journal, 13(2), 8-27. https://doi.org/10.2478/bsrj2022-0013

Shih, J.-L., Chuang, C.-W., & Hwang, G.-J. (2010). An inquiry-based mobile learning approach to enhancing social science learning effectiveness. Journal of Educational Technology & Society, 13(4), 50-62. https://www.jstor.org/stable/jeductechsoci.13.4.50

Siron, Y., Wibowo, A., & Narmaditya, B. S. (2020). Factors affecting the adoption of e-learning in Indonesia: Lesson from Covid-19. Journal of Technology and Science Education, 10(2), 282-295. https://doi.org/10.3926/jotse.1025

Tagoe, M., & Abakah, E. (2014). Determining distance education students' readiness for mobile learning at university of Ghana using the theory of planned behavior. International Journal of Education and Development Using Information and Communication Technology, 10(1), 91-106. https://eric.ed.gov/?id=EJ1071198

Tang, Y. M., Chen, P. C., Law, K. M. Y., Wu, C. H., Lau, Y., Guan, J., He, D., & Ho, G. T. S. (2021). Comparative analysis of student's live online learning readiness during the coronavirus (COVID-19) pandemic in the higher education sector. Computers & Education, 168, 104211

Teo, T. (2010). Development and validation of the E-learning Acceptance Measure (ElAM). The Internet and Higher Education, 13(3), 148-152. https://doi.org/10.1016/j.iheduc.2010.02.001

Teo, T., Zhou, M. M., Fan, C. W., & Huang, F. (2019). Factors that influence university students' intention to use Moodle: A study in Macau. Educational Technology Research and Development, 67, 749-766. https://doi.org/10.1007/s11423-019-09650-x

Traxler, J. (2009). Current state of mobile learning. Mobile learning: Transforming the delivery of education and training, 1, 9-24.

Usak, M., Masalimova, A. R., Cherdymova, E. I., & Shaidullina, A. R. (2020). New playmaker in science education: COVID19. Journal of Baltic Science Education, 19(2), 180-185. https://doi.org/10.33225/jbse/20.19.180

Voicu, M.-C., & Muntean, M. (2023). Factors that influence mobile learning among university students in Romania. Electronics, 12(4), 938. https://doi.org/10.3390/electronics12040938

Wei, H. C., & Chou, C. (2020). Online learning performance and satisfaction: Do perceptions and readiness matter? Distance Education, 41(1), 48-69. https://doi.org/10.1080/01587919.2020.1724768

World Medical Association. (2013). World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. JAMA, 310(20), 2191-2194. https://doi.org/10.1001/jama.2013.281053

Yi, C.-C., Liao, P.-W., Huang, C.-F., & Hwang, I.-H. (2010). Acceptance of mobile learning: A respecification and validation of information system success International Journal of Human and Social Sciences, 5(7), 477-481.

Yuan, Y. P., Tan, G. W. H., Ooi, K. B., & Lim, W. L. (2021). Can COVID-19 pandemic influence experience response in mobile learning? Telematics and Informatics, 64, 101676. https://doi.org/10.1016/j.tele.2021.101676

APPENDIX A

Discriminant Validity (HTMT)

	1	2	3	4	5	6	7	8	9	10
1. Attitude										
2. Instructor Readiness	0.896									
3. Intention	0.867	0.790								
4. Learning Autonomy	0.826	0.843	0.892							
5. Perceived Behavioral Control	0.774	0.735	0.899	0.902						
6. Perceived Ease of Use	0.535	0.570	0.511	0.479	0.468					
7. Perceived Self-Efficacy	0.846	0.836	0.895	0.974	0.865	0.503				
8. Perceived Usefulness	0.767	0.817	0.704	0.696	0.654	0.843	0.719			
9. Student Readiness	0.791	0.844	0.812	0.747	0.714	0.459	0.761	0.670		
10. Subjective Norm	0.826	0.885	0.888	0.864	0.822	0.607	0.840	0.759	0.860	

APPENDIX B

Hypothesis Testing

Hypo-thesis		Std. Beta	Std. Error	t-value	P values	f^2	Q^2	VIF	R^2	Decision
H1	Perceived Usefulness →Attitude	0.676	0.070	9.674	0	0.393		2.145	0.458	Supported
H2	Perceived Ease of Use→ Attitude	0.002	0.065	0.027	0.489	0	0.376	2.145		Not Supported
H3	Instructor Readiness → Subjective Norm	0.492	0.063	7.870	0	0.352	0.555	2.180	0.684	Supported
H4	Student Readiness → Subjective Norm	0.395	0.065	6.088	0	0.227		2.180		Supported
H5	Perceived Self-Efficacy → Perceived Behavioral Control	0.290	0.077	3.768	0	0.056	0.590	4.979	0.700	Supported
H6	Learning Autonomy → Perceived Behavioral Control	0.568	0.077	7.395	0	0.216		4.979		Supported
H7	Attitude → Intention	0.292	0.058	4.998	0	0.173	0.695	2.531	0.805	Supported
H8	Subjective Norm → Intention	0.281	0.057	4.944	0	0.142		2.890		Supported
H9	Perceived Behavioral Control → Intention	0.416	0.055	7.510	0	0.351		2.521		Supported

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