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Exploring the Role of AI-based Tools in Enhancing Student Learning Outcomes

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***Abstract*—Beyond chatbots, AI's application extends to serving as virtual assistants to educators, enhancing their capacity to support student learning in diverse ways. In the context of this study, we delve into the extensive advantages AI tools offer in boosting the learning outcomes of students. Our research specifically targets the effectiveness of AI in elevating the academic performance of first-year undergraduates within the Electrical and Electronics Department at the Faculty of Engineering, Universiti Malaysia Sarawak (UNIMAS). The empirical data from our study presents a compelling argument for AI's positive influence on educational outcomes. It reveals a consensus among participants that AI not only facilitates easier access to learning materials and enhances understanding but also promotes a sense of independence among learners. Our findings underscore a rising inclination towards adopting tech-driven innovations within the educational sphere of the university. Nonetheless, it also brings to light the critical need for an integrated approach that marries AI technologies with conventional pedagogical techniques, aiming for a curriculum that fosters comprehensive development of students. One of the standout observations from the research is the perceived potential of AI to democratize educational opportunities, suggesting its pivotal role in creating an equitable learning environment that accommodates students from varied backgrounds. Conclusively, the survey highlights a broad endorsement of AI's role in achieving educational goals, while also stressing the importance of its thoughtful integration to enhance various facets of student growth.**

***Index Terms*—AI-based Tools, Student Learning Outcomes, Engineering Education**

I. Introduction

The conventional education system encounters multiple challenges, such as classrooms filled beyond capacity, insufficient individualized attention for learners, diverse rates and methods of learning, and the difficulty in staying abreast with the rapidly changing technology and information landscape. With the ongoing evolution of the educational sector, the emergence of AI-based tools offers a hopeful means to tackle these existing challenges. A growing number of educational institutions are beginning to embrace these AI tools, acknowledging their significance, while others approach their adoption with caution in contemporary educational environments. This has led to a significant increase in academic research focused on exploring the role of AI tools in education, examining both their potential advantages and possible risks. Chatbots, leveraging AI technology, are now utilized in various fields, including education. The most advanced of these AI tools are typically web-based and designed to adapt to the behaviors of both educators and learners, thereby enriching the educational process. This has been documented in several studies [1]–[4]. In the realm of education, AI chatbots are employed for a range of purposes, including teaching, learning assistance, and administrative tasks. These AI tools are particularly adept at providing personalized tutoring, assisting with homework, facilitating the understanding of concepts, preparing students for standardized tests, and supporting discussions, collaboration, and mental health. Large language models offer various benefits to students in their educational journey. These advanced tools aid in developing and crafting learning materials. Notably, they have been employed by scholars to produce engaging educational tools like quizzes and flashcards. Such resources have shown to enhance student engagement and learning effectiveness [5], [6].

In their 2022 study, Dijkstra et al. specifically utilized GPT-3 to create multiple-choice questions and answers for reading comprehension exercises. They suggest that the automation of quiz creation not only eases the workload of teachers in crafting quizzes manually but, more importantly, offers a valuable resource for students. This tool assists learners in practicing and assessing their knowledge, particularly when studying from textbooks or preparing for exams [5]. In a recent study, GPT-4 was used as an educational tool to encourage children's curiosity and improve their ability to ask questions [7]. The researchers developed a method to automatically generate prompts that spur curiosity, motivating children to ask more in-depth questions. Their findings suggest that large language models are not only effective in promoting curiosity-driven learning but also act as a valuable resource for enhancing curiosity expression [7]. In the field of computer science education, a study by MacNeil and colleagues in 2022 utilized GPT-3 for the purpose of creating explanations for code. While there are still numerous research and teaching questions that remain unanswered,

this research has effectively shown how GPT-3 can be used to enhance learning by providing detailed explanations for specific sections of code [8]. Bhat et al. (2022) introduced a methodology for creating assessment questions in a data science course using a GPT3 model that was fine-tuned on text-based educational materials. This approach involved evaluating the relevance of these questions to learning outcomes, utilizing both automatic labeling with a trained GPT-3 model and manual assessments by human experts. The study found that the questions produced were well-received by the experts, thereby supporting the integration of large language models in data science education [9].

Peer assessments, where students review and critique each other's solutions, offer valuable learning opportunities. The effectiveness of this approach is enhanced when the feedback provided is thorough and of superior quality. For instance, in their study, Jia et al. demonstrated the application of BERT for analyzing peer evaluations, aiding students in refining the quality of their feedback [10]. In their latest analysis of conversational AI's role in language education, Ji et al. (2022) identified five primary uses of this technology in teaching [10]. The most prevalent application is employing large language models as conversational counterparts, either in writing or speaking. For instance, as El Shazly (2021) notes, these models are often used in task-oriented dialogues to offer language practice opportunities, including pronunciation enhancement [11]. Another use is assisting students who struggle with anxiety while learning foreign languages [12] or are less inclined to communicate [13]. [14] investigated how feedback, needs analysis, and evaluation can be applied when primary school students are learning vocabulary. [15] discovered that a chatbot directed by a mind map is more effective in offering support and scaffolding to students during language learning than a standard AI chatbot. A study by Kung et al. focused on assessing ChatGPT's capabilities in the context of the United States Medical Licensing Exam [16]. The findings indicated that ChatGPT's performance reached or closely approached the pass mark, even without specific adjustments for medical content. Kung et al. suggest that these outcomes demonstrate the potential of large language models to significantly aid in medical education and possibly in clinical decision-making processes. From an educational standpoint, numerous uncertainties and knowledge gaps remain regarding the effective and ethical incorporation of large language models in teaching and learning environments. Tailoring these models to particular needs, managing biases in certain applications, and navigating ethical and copyright challenges necessitate comprehensive, multidisciplinary research and assessment.

II. Methodology

A. Survey Instrument

The respondents (n = 69) were first-year undergraduates in the Electrical and Electronics Engineering program at the Faculty of Engineering, Universiti Malaysia Sarawak (UNIMAS). They were part of the cohort that enrolled in an object-oriented programming course in 2023. The students completed a survey questionnaire using Microsoft Forms. The survey consisted of five sections, with 10 questions in each section. Each section are designed to gather specific insights, contributing to a comprehensive understanding of the subject from various angles. The sections of the questionnaire focus on general experience, usage and accessibility, learning and development, engagement and motivation, and conclude with student learning outcomes. Each section of the questionnaire was designed to elicit either a positive ('yes') or negative ('no') response for every item. Participation in this survey was entirely voluntary for students.

III. Results and Discussion

In this section, we present the results of the reviewed articles, focusing on our research questions, particularly with regard to ChatGPT. ChatGPT, as one of the latest AI-based tools, has gained significant attention for its potential applications in education [17]. Data were recorded and tabulated by using the Microsoft Excel (Office version 2013) software. Percentages of yes and no responses were calculated. Results are analysed and presented using descriptive statistics.

A. Student General Experience

Table 1 displays survey results from respondents on their general experience with AI-based tools in education, with ten different items being assessed. The majority of respondents (93%) have engaged with AI tools in their educational journey, which indicates a widespread integration of AI technologies in educational settings. Similarly, a high percentage (94%) find AI tools to be user-friendly, suggesting that these tools are generally well-designed for ease of understanding and usability. Nearly all respondents (97%) believe that AI tools have made their learning process more efficient. This suggests that AI tools are considered to be effective aids in education, perhaps streamlining or enhancing the learning process. A majority (71%) see AI tools as a better learning avenue compared to traditional methods, though a significant minority (29%) may still find traditional methods to be effective or have concerns about AI-based learning. The responses are split regarding the safety and security provided by AI tools, with just over half (54%) in agreement. This could highlight issues around data protection, content quality, or digital safety that some users are experiencing or perceive. The majority of users (72%) have encountered technical problems while using AI tools, which could include software glitches, interface issues, or other technical barriers that might hinder the effective use of AI in education.

Opinions are divided on the quality of feedback from AI tools, with only 59% finding it accurate and constructive. This could reflect inconsistencies in the quality of AI tool outputs or varying expectations among users. A strong majority (88%) believe that AI tools are accessible to all students, suggesting that these tools are not limited by socioeconomic or other background factors. A high proportion of respondents (88%) acknowledge a significant role for AI tools in their learning, indicating that these tools are not only supplementary but potentially central to their educational experiences. Trust in the information provided by AI tools is comparatively lower, with 68% of respondents indicating trust. This might point to concerns about the accuracy or reliability of AI-generated content. In summary, the data suggests that while AI tools are widely used and generally well-regarded in

terms of usability and learning efficiency, there are areas of concern. These include the safety and security of AI tools, the occurrence of technical issues, the quality of AI-generated feedback, and a lower level of trust in the content provided by AI. These insights could be valuable for developers and educators to improve AI educational tools to address these concerns.

TABLE I
ITEMS AND SURVEY DATA OF FIRST SECTION QUESTIONNAIRE ON GENERAL EXPERIENCE

No.	Items in questionnaire	Yes (%)	No (%)
1	Have you used AI tools in your education before?	93	7
2	Do you find AI tools easy to understand and use?	94	6
3	Do AI tools make your learning process more efficient?	97	3
4	Do you think AI tools offer a better way to learn compared to traditional methods?	71	29
5	Do you feel AI tools provide a safe and secure learning environment?	54	46
6	Have you experienced any technical issues while using AI tools?	72	28
7	Do you find the feedback from AI tools to be accurate and constructive?	59	41
8	Do you think AI tools are accessible to all students regardless of their background?	88	12
9	Have AI tools played a significant role in your learning journey?	88	12
10	Do you trust the information and content provided by AI tools?	68	32

B. Student Usage and Accessibility

Table 2 shows the items and survey data of second section questionnaire on usage and accessibility. In examining the survey data pertaining to the utilization and accessibility of Artificial Intelligence (AI) tools for educational purposes, several key insights emerge. A substantial 94% of respondents affirm the ease of access to AI tools for their learning needs, indicating a successful integration of AI into the educational infrastructure. Although the majority, 62%, report the ability to use AI tools without technical hindrances, a notable 38% face challenges, highlighting an area where user experience could be enhanced. With 84% of participants indicating that AI tools accommodate their individual learning styles, it suggests that AI applications are perceived as diverse and adaptable educational aids. The data shows that 90% find AI tools compatible with personal devices, pointing towards a robust adaptability of AI tools across different technological platforms.

The high percentage (94%) of users with reliable internet access for AI tools suggests that connectivity is largely not a constraint for users. A critical finding is that only 45% of users report receiving adequate training to use AI tools, indicating a significant gap in user education and support. The fact that 90% of users can access AI tools anytime underscores the flexibility and on-demand nature of these tools, which is essential for modern learning environments. A strong majority (87%) find the AI tools' interfaces to be intuitive, which is indicative of the user-centric design of these technologies. Although the majority (83%) find the content understandable, there remains a 17% minority for whom the content complexity suggests a need for clearer explanations or instructional design improvements. The 88% positive response rate regarding location-agnostic access to AI tools reflects the portable and convenient nature of AI educational resources. Overall, the data reflects a positive reception towards AI tools in the educational sector, with high accessibility and a user-friendly interface. Nonetheless, the findings also point towards a pressing need for enhanced user training and support, as well as improvements in technical usability to ensure AI tools are leveraged to their fullest potential in diverse learning environments.

TABLE II
ITEMS AND SURVEY DATA OF SECOND SECTION QUESTIONNAIRE ON USAGE AND ACCESIBILITY

No.	Items in questionnaire	Yes (%)	No (%)
1	Do you find AI tools easy to access for your learning needs?	94	6
2	Have you been able to use AI tools without technical difficulties?	62	38
3	Do AI tools accommodate your individual learning style?	84	16
4	Are the AI tools available to you compatible with your personal devices?	90	10
5	Do you have reliable internet access to use AI tools effectively?	94	6
6	Have you received adequate training or instructions on how to use the AI tools?	45	55
7	Are you able to access AI tools at any time you need for your studies?	90	10
8	Do you find the user interface of the AI tools intuitive and user-friendly?	87	13
9	Is the content provided by AI tools easily understandable?	83	17
10	Do you find the AI tools accessible regardless of your location (home, university, elsewhere)?	88	12

C. Student Learning Experience

In the evaluation of AI tools' efficacy in student learning outcomes, the surveyed data reveals a predominantly affirmative reception. Table 3 shows the items and survey data of third section questionnaire on learning experience. A detailed analysis yields the following insights.

A substantial majority, 87%, attest to AI tools elevating the engagement level in learning, indicating the potential of these tools to introduce compelling interactive elements surpassing conventional educational methodologies. An equivalent majority of 88% recognize the efficiency gains in assignment completion afforded by AI tools, suggesting their role in streamlining the information retrieval process and task execution. The feedback from AI tools, while still seen as beneficial by 71% of participants, indicates a relative dissatisfaction, marking the lowest positive response and highlighting an area for potential enhancement in AI tool functionality. With 81% in agreement, the interactive nature of AI learning tools is significantly valued over traditional learning approaches, emphasizing the importance of user engagement in

the learning process. Notably, 91% of respondents endorse the effectiveness of AI tools in providing supplementary learning support outside of regular classroom hours, illustrating their critical role in facilitating continuous and accessible learning opportunities. The contribution of AI tools to creating more inclusive learning environments is acknowledged by 84% of respondents, reflecting the capacity of AI to cater to a diverse array of educational needs and preferences. The efficiency of AI tools is further underscored by 81% of learners reporting a reduction in the time investment required for studying, suggesting that AI tools may enhance learning productivity.

AI tools appear to mitigate academic stress, as indicated by 78% of respondents, pointing to the potential of these tools in rendering the learning experience more manageable. The affirmation by 84% of participants that AI-delivered content is current and relevant highlights the capability of AI tools to keep pace with the evolving educational content landscape. Lastly, 72% of learners express a bolstered confidence in their academic abilities post the incorporation of AI tools into their learning regime, signifying the empowering impact of these tools, though also suggesting an opportunity for further improvement. In summary, the survey indicates a strong approval of AI tools in education, particularly praising their capacity to support learning beyond traditional settings, to foster inclusivity, and to enhance interactivity. Nevertheless, the data also points to areas where AI tools could be refined to better meet educational needs, specifically in improving the precision of feedback and in further fostering learner confidence.

TABLE III
ITEMS AND SURVEY DATA OF THIRD SECTION QUESTIONNAIRE ON LEARNING EXPERIENCE

No.	Items in questionnaire	Yes (%)	No (%)
1	Has the use of AI tools made learning more engaging for you?	87	13
2	Have AI tools helped you in completing assignments more efficiently?	88	12
3	Do you find the feedback from AI tools to be accurate and helpful?	71	29
4	Do you feel AI tools offer an interactive way of learning compared to traditional methods?	81	19
5	Are AI tools effective in providing additional learning support outside of classroom hours?	91	9
6	Do you think AI tools contribute to a more inclusive learning environment?	84	16
7	Has the use of AI tools reduced the time you spend on studying?	81	19
8	Have you experienced a reduction in learning-related stress due to the use of AI tools?	78	22
9	Do you find the learning content delivered by AI tools to be up-to-date and relevant?	84	16
10	Do you feel more confident in your academic abilities since using AI tools?	72	28

D. Student Engagement and motivation

Table 4 shows the items and survey data of forth section questionnaire on engagement and motivation. The data presented in Table 4 of the survey results indicates a predominantly positive perception of artificial intelligence (AI) tools in educational settings among the participants. A comprehensive analysis reveals the following insights. A considerable majority of respondents (86% for Question 1 and 87% for Question 2) affirm that AI tools elevate the enjoyment and engagement aspects of learning. This suggests that AI tools are effectively enriching the educational experience by providing a more interactive and pleasurable learning environment. Questions 3 and 4 reveal that 86% and 78% of participants, respectively, report an increase in interest and motivation due to the use of AI tools. These findings imply that AI tools are beneficial in sparking learners' curiosity and enhancing their willingness to engage with the material. The response to Question 5, while still a majority at 70%, is notably lower than for other questions. It indicates that while many students find AI tools more captivating than traditional teaching methods, there remains a subset of learners who may prefer traditional educational approaches. According to the responses to Questions 6 and 7, 71% and 75% of students, respectively, feel that AI tools assist in maintaining focus during study sessions and encourage a more substantial investment of time in academic tasks. These responses suggest that AI tools play a constructive role in promoting concentration and diligence in learners' academic pursuits.

TABLE IV
ITEMS AND SURVEY DATA OF FORTH SECTION QUESTIONNAIRE ON ENGAGEMENT AND MOTIVATION

No.	Items in questionnaire	Yes (%)	No (%)
1	Does using AI tools make learning more enjoyable for you?	86	14
2	Do you feel more engaged in the subject matter when using AI tools?	87	13
3	Have AI tools increased your interest in learning new topics?	86	14
4	Do you find yourself more motivated to study when using AI tools?	78	22
5	Does the interactive nature of AI tools capture your attention better than traditional teaching methods?	70	30
6	Do you think AI tools help in maintaining your focus during study sessions?	71	29
7	Do AI tools encourage you to spend more time on academic tasks?	75	25
8	Do you feel more confident in your academic abilities when using AI tools?	78	22
9	Do AI tools make you feel more actively involved in your learning process?	83	17
10	Are you more likely to complete homework or assignments when using AI tools?	93	7

The responses to Questions 8 and 9 (78% and 83% affirmative, respectively) indicate that AI tools contribute positively to learners' confidence in their academic capabilities and their active participation in the learning process. This implies that AI tools are empowering students by fostering a sense of competence and engagement in their educational journey. The most significant positive response emerges from Question

10, with 93% of participants indicating that they are more likely to complete homework or assignments when utilizing AI tools. This robust endorsement highlights the practical efficacy of AI tools in aiding students to fulfill their academic responsibilities. In summary, the survey results underscore a strong endorsement of AI tools within the learning environment, characterized by heightened engagement, increased motivation, and a more effective completion of academic tasks. Nevertheless, it is essential to acknowledge that these findings are based on subjective self-reports and may not fully capture the multifaceted impact of AI on educational outcomes. Further empirical research would be beneficial to quantify the effects of AI on learning performance objectively and to understand the nuances of the minority dissenting views. Additionally, a more granular analysis considering demographic variables and specific learning contexts could offer deeper insights into the applicability and effectiveness of AI tools across diverse educational landscapes.

E. Student Learning Outcome

Table 5 shows the items and survey data of fifth section questionnaire on the learning outcome. The survey results encapsulate a predominantly favorable stance towards the integration of Artificial Intelligence (AI) in educational settings. The analysis of the responses reveals several insights. A resounding 94% of participants acknowledge the facilitation of assignment completion when assisted by AI, indicating its substantial role as a supportive tool in education. The majority, with an 83% affirmation rate, recognize AI as a significant aid in deciphering complex academic subjects, highlighting AI's role in simplifying intricate educational material. A notable 86% of respondents report an uplift in academic performance attributed to the use of AI tools, suggesting a correlation between AI usage and improved educational outcomes. Seventy percent of the survey participants report a reduced reliance on instructors for understanding new concepts, pointing towards a trend in autonomous learning facilitated by AI. Nevertheless, 30% still value the irreplaceable role of traditional teaching.

The positive influence of AI on overall academic success is affirmed by 83% of respondents, indicating a perceived link between AI engagement and scholastic achievement. Corresponding to the previous point, 70% feel more equipped for tests and exams due to the assistance of AI tools, identifying these tools as effective in bolstering study preparations. A robust 86% demonstrate optimism regarding AI's capacity to ameliorate learning outcomes, reflecting a confidence in AI's transformative potential in education. An 81% majority express confidence in their ability to adapt to changes in the educational landscape driven by AI, suggesting a readiness to embrace and evolve with technological progressions in education. A strong conviction is held by 83% of the participants that AI can contribute to diminishing educational disparities, indicating a belief in the democratizing power of AI in education. While still a majority, a lesser 75% of participants believe in AI's role in nurturing critical 21st-century skills, which might reflect some reservations about AI's effectiveness in developing skills traditionally associated with human interaction and innovation.

TABLE V
ITEMS AND SURVEY DATA OF FIFTH SECTION QUESTIONNAIRE ON THE LEARNING OUTCOME

No.	Items in questionnaire	Yes (%)	No (%)
1	Do you find it easier to complete assignments with the help of the AI tool?	94	6
2	Do you find it easier to understand complex topics with the AI tool?	83	17
3	Have you experienced an increase in your academic performance since using the AI tool?	86	14
4	Do you feel less dependent on teachers for understanding new concepts with the AI tool?	70	30
5	Do you think the AI tool has a positive impact on your overall academic achievement?	83	17
6	Do you feel more prepared for tests and exams due to the AI tool's assistance?	70	30
7	Are you optimistic about AI improving learning outcomes for students?	86	14
8	Do you feel confident about adapting to AI-driven changes in education?	81	19
9	Do you think AI can help in reducing educational inequalities?	83	17
10	Do you believe AI will help students develop critical 21st-century skills?	75	25

The data presents an optimistic view of AI's role in education, with respondents indicating that AI enhances learning accessibility and understanding, and promotes a degree of self-sufficiency in learners. The findings suggest a general trend towards the acceptance of technological advancements in education. However, they also point to a need for a harmonized approach that integrates AI tools with conventional educational practices and a curriculum focused on comprehensive student development. The perception that AI can aid in equalizing educational opportunities is particularly noteworthy, proposing that AI could be instrumental in creating a more inclusive educational environment for diverse populations. Overall, the survey highlights the positive reception of AI within educational spheres, while also noting the importance of its thoughtful incorporation to support various facets of student growth.

IV. CONCLUSION AND FUTURE WORK

The growing use of chatbots and their easy availability have elicited varied responses in various industries, creating notable ambiguity in the education sector. There's a distinct divide in attitudes among educators and students. Students are enthusiastic about incorporating chatbots, whereas educators tend to view them with skepticism. This scenario offers a distinctive chance but comes with novel obstacles. As a result, there's been a marked increase in studies focused on investigating how chatbots affect education. Integrating AI chatbots into the educational process brings numerous benefits, particularly from the viewpoint of students. These AI-driven assistants are instrumental in homework and study support, offering comprehensive feedback on assignments, helping navigate through intricate problems, and presenting step-by-step solutions. They serve as reliable study partners

by explaining and clarifying various topics. Chatbots are also useful for self-testing, aiding in knowledge consolidation and exam preparation. They support adaptive, personalized learning by adjusting their teaching approach to each student's distinct learning style. The interactive and conversational aspect of these chatbots boosts student engagement and motivation, making the learning process more enjoyable and tailored. Moreover, AI chatbots aid in skill enhancement by providing suggestions for syntax and grammar improvements, offering guidance in problem-solving, and promoting group discussions and debates with instant feedback. Students generally value the capabilities of AI chatbots, acknowledging their role in augmenting human intelligence and finding them beneficial for their academic and skill development. In summary, the integration of AI-based tools in education offers personalized learning experiences for students and time-saving advantages for educators. Students gain from flexible study support and skill enhancement opportunities. However, issues concerning the accuracy of the provided information, fairness in assessment methods, and ethical implications do arise. Finding a balance between these benefits and concerns is essential for a responsible and effective incorporation of AI-based tools in the educational domain.

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