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MEASURING THE EFFECTIVENESS OF AI-SUPPORTED DIGITAL LEARNING PLATFORMS: EVIDENCE FROM CYBERLEARN HUB IMPLEMENTATION

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Abstract:

This study examines the effectiveness of CyberLearn Hub, an AI-supported e-learning platform integrated with CyberBuddy chatbot assistance, in enhancing students' learning experience in cybersecurity education. A quantitative research design was employed, and data were collected from respondents using a structured questionnaire. The analysis was conducted using SPSS, including descriptive statistics, reliability analyses, Pearson correlations, and multiple regression. The findings demonstrate that the overall regression model is statistically robust and possesses substantial explanatory power in explaining variations in learning efficiency. System use performance was identified as the most significant factor, followed by AI chatbot effectiveness, indicating the importance of usability and intelligent support in digital learning environments. While user engagement demonstrated a moderate effect, usage acceptance showed no statistically meaningful impact on learning effectiveness. The study demonstrates the importance of integrating AI technologies with user-centered design in improving e-learning outcomes. The findings provide practical implications for educators and developers in designing effective AI-enhanced learning systems, particularly in technical domains such as cybersecurity.

Keywords:

AI Chatbot, Cybersecurity, Digital Learning, Self-Learning

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Introduction

The rapid growth of digital technology has greatly influenced the way education is delivered and experienced today. In recent years, especially following the COVID-19 pandemic, digital learning has shifted from being a supplementary approach to becoming a core component of education systems worldwide. Web-based learning platforms now play a crucial role in ensuring that teaching and learning can continue without disruption, while also offering greater flexibility and accessibility to students (Dhawan, 2021; Alqahtani & Rajkhan, 2022).

Platforms such as Moodle, Google Classroom, and Microsoft Teams have become widely used in higher education due to their ability to support content delivery, communication, and assessment in an online environment. These platforms allow students to access learning materials at any time and from any location, encouraging more independent and self-paced learning (Almaiah et al., 2022). However, despite these benefits, several challenges remain. Issues such as low student engagement, unequal access to digital resources, and concerns about the effectiveness of online assessments continue to limit the full potential of digital learning (Bond et al., 2021).

To address these challenges, recent developments have focused on integrating Artificial Intelligence (AI) into digital learning platforms. AI has the potential to transform the learning experience by making it more personalized and interactive. For instance, AI can adapt learning content based on individual student performance, provide instant feedback, and support more efficient learning processes. Studies have shown that AI-powered systems can enhance student engagement and improve learning outcomes by creating more responsive and adaptive learning environments (Zawacki-Richter et al., 2021; Chen et al., 2023).

The integration of chatbot technology in e-learning has gained significant attention in recent years, particularly with advancements in Artificial Intelligence in Education. Chatbots, powered by artificial intelligence (AI), function as virtual assistants that provide instant responses, personalized support, and interactive learning experiences. These capabilities have positioned chatbots as an important tool in enhancing digital learning environments.

According to Labadze et al. (2023), AI chatbots serve as virtual teaching assistants that can respond to students' queries, provide explanations, and offer additional learning resources in real time. This reduces dependency on instructors while promoting self-directed learning. The study highlights that chatbot integration improves accessibility and flexibility, allowing students to engage with learning materials anytime and anywhere.

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In the context of online learning, Rahman et al. (2025) reported that students' acceptance of AI chatbots is significantly associated with learning effectiveness. Chatbots provide immediate feedback, continuous support, and adaptive responses, which enhance students' understanding and overall learning experience. This finding aligns with the growing emphasis on personalized learning in digital education.

Furthermore, Kaiss et al. (2024) demonstrated that chatbot integration in online courses significantly improves students' learning experiences through interactive engagement. The study emphasizes that two-way interaction between learners and chatbots supports better comprehension of complex concepts, making learning more effective and meaningful.

In line with this, current trends in education emphasize the importance of personalized and learner-centered approaches. AI-driven platforms are increasingly being used to tailor learning experiences according to students' needs, abilities, and learning pace, which can lead to improved motivation and academic performance (Holmes & Tuomi, 2022). Additionally, emerging technologies such as virtual reality (VR) and intelligent tutoring systems are being explored to create more immersive and engaging learning environments (Radianti et al., 2023).

Despite these promising advancements, there are still notable gaps in existing digital learning platforms. Many systems do not fully integrate key elements such as interactive learning, cybersecurity awareness, and AI-based assistance within a single platform. Furthermore, educators often face difficulties in adopting these technologies due to limited digital skills and lack of proper training (Khalil & Ebner, 2022). These challenges highlight the need for more comprehensive, user-friendly, and inclusive digital learning solutions.

In response to these issues, CyberLearn Hub has been developed as a web-based digital learning platform that incorporates AI assistance to enhance the teaching and learning of cybersecurity. The platform is designed to provide an interactive, accessible, and intelligent learning environment that meets the needs of both educators and students. By integrating key features into a single platform, CyberLearn Hub aims to improve engagement, support personalized learning, and strengthen cybersecurity awareness.

In conclusion, recent literature from 2021 to 2026 shows that while digital learning platforms have significantly improved access to education, there is still room for improvement in terms of engagement, personalization, and integration of advanced technologies. The inclusion of AI is increasingly seen as a key factor in overcoming these challenges. Therefore, CyberLearn Hub represents a timely and relevant innovation that contributes to the ongoing development of digital learning, particularly in the field of cybersecurity education.

Research Methodology

This study adopts a quantitative research approach to examine the effectiveness of an AI-supported digital learning platform, namely CyberLearn Hub, in enhancing students' learning experience in cybersecurity education. The methodology is designed to systematically evaluate users' perceptions of the platform, particularly focusing on key dimensions such as learning effectiveness, system use performance, AI chatbot effectiveness-CyberBuddy, user engagement & motivation, and usage & acceptance. A quantitative survey-based approach was selected since it enables the collection of standardized numerical data from a high number of

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respondents that can be statistically analyzed for establishing differences in the level of awareness in the group with reliability and validity in the findings.

The population of the study is students of the Diploma in Information Technology and Communication Politeknik Muadzam Shah. Stratified random sampling was employed in order to get equal representation from the group. Based on Krejcie and Morgan's sampling table (Krejcie & Morgan, 1970), 200 respondents were determined as sufficient to provide meaningful comparison, in addition to statistical significance, whereby 212 participants were sampled from IT student programs.

The tool for this study was a structured questionnaire derived from validated studies on cybersecurity awareness, adapted to suit the local setting. The questionnaire had two sections: demographic information and 20 questions about the use of CyberLearn Hub. A five-point Likert scale ranging from Strongly Disagree to Strongly Agree was employed to note the degree of agreement of the respondents to each statement. The questionnaire was pre-tested on a small group of 20 students for clarity and reliability test, and modifications were made as needed before full administration. The result achieved Alpha Cronbach value 0.930, indicating high internal consistency. The outcome of this pilot study revealed that the reliability value, as indicated by Cronbach's Alpha is 0.930 as shown in Table 1. This means that the instrument is in very good and effective condition with a high level of consistency and therefore can be utilized in the actual study. Overall, the reliability of this questionnaire is acceptable to Cronbach's Alpha value of 0.930.

Table 1. Value of Alpha Cronbach for Questionnaire Items

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.930	0.928	20

Data collection was done online using Google Forms to reach out and ensure accessibility for students in the department. The participation was voluntary, and informed consent was given to all the respondents prior to completing the survey. Ethics were maintained by ensuring anonymity and confidentiality of the participants.

The data collected were statistically compared using Statistical Package for the Social Sciences (SPSS). Descriptive statistics such as mean, frequency, and percentage were utilized to generalize the effective use of the platform. The study utilizes several statistical techniques to analyze the data, including descriptive analysis to determine the overall level of effectiveness, reliability analysis using Cronbach's Alpha to assess the internal consistency of the constructs, and inferential analysis such as Pearson correlation and multiple regression (He, 2024). These analyses are conducted to identify relationships between variables and to determine the extent to which different factors influence learning effectiveness.

Overall, the methodology provides a systematic framework for evaluating the impact of AI-supported features, particularly the CyberBuddy chatbot, on students' learning outcomes within the CyberLearn Hub platform.

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Research Findings

This section presents the findings of the study on the effectiveness of the CyberLearn Hub platform as an AI-supported digital learning system for cybersecurity education. The analysis is conducted based on the data collected from 212 respondents who have experienced using the platform. The results are organized systematically to provide a clear understanding of the data and to address the research objectives of the study. Initially, reliability analysis is performed to assess the internal consistency of the measurement items. This is followed by descriptive analysis to determine the overall level of each construct, including content quality, usability, AI chatbot effectiveness, user engagement, and usage and acceptance.

Subsequently, inferential statistical analyses are conducted to explore the relationships and influences among the variables. Pearson correlation analysis is used to examine the strength and direction of relationships between the constructs, while multiple regression analysis is applied to identify the significant factors influencing learning effectiveness. This approach is widely used in educational research to examine relationships between teaching factors and student performance (He, 2024; Gao et al., 2024).

Table 2 displays the demographic profile of the respondents. In terms of gender, the sample was comprised of 101 males (47.6%) and 111 females (52.4%), with an even distribution and a small majority of females. In semester distribution, the largest group of students came from Semester 2 (44.3%) and Semester 3 (27.8%), trailed by Semester 4 (19.3%) and Semester 5 (8.5%).

Table 2. Demography Data

Item	Category	Frequency	Percentage
Gender	Male	101	47.6
	Female	111	52.4
Semester	Semester 2	94	44.3
	Semester 3	59	27.8
	Semester 4	41	19.3
	Semester 5	18	8.5

The second section of the research instrument comprises a questionnaire designed to evaluate the effectiveness of the CyberLearnHub platform as an AI-supported digital learning system. The questionnaire utilizes a 5-point Likert scale (1 – Strongly Disagree, 2 – Disagree, 3 – Neutral, 4 – Agree, 5 – Strongly Agree) to measure respondents' perceptions. This study focuses on several key constructs, namely learning effectiveness, system use performance, AI chatbot effectiveness (CyberBuddy), user engagement and motivation, as well as usage and acceptance.

Table 3. Mean Score and Standard Deviation (Learning Effectiveness)

Item	Leaning Effectiveness	Mean	S.D
Q1	The content provided on the CyberLearn Hub webpage is comprehensive and relevant to the cybersecurity course.	4.75	0.52

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Q2	The multimedia elements (videos, diagrams) on the webpage effectively support the learning material.	4.72	0.52
Q3	CyberLearn Hub helps me to better understand key concepts in cybersecurity.	4.77	0.495
Q4	I am able to apply what I learned from CyberLearn Hub to solve cybersecurity-related problems.	4.61	0.552
	Overall Mean and Standard Deviation	4.71	0.466

The findings in Table 3, indicate that students perceive CyberLearn Hub as highly effective in supporting their cybersecurity learning, with an overall mean score of 4.71. The highest mean value of 4.77 was recorded for understanding key concepts, followed by content quality at 4.75 and multimedia support at 4.72. Although slightly lower, the ability to apply knowledge recorded a mean of 4.61, which still reflects a high level. Overall, the results demonstrate that the platform effectively enhances both understanding and application of cybersecurity knowledge.

Table 4. Mean Score and Standard Deviation (System Use Performance)

Item	System Use Performance	Mean	S.D
Q5	The navigation and layout of the CyberLearn Hub webpage are user-friendly and intuitive.	4.75	0.505
Q6	I find the resources provided on CyberLearn Hub easy to access when I need them.	4.67	0.539
Q7	The loading speed and performance of the Google Site platform are satisfactory.	4.67	0.536
Q8	The overall design and aesthetics of the webpage are engaging and professional.	4.64	0.555
Overall Mean and Standard Deviation		4.67	0.478

The findings shown in Table 4 indicate that students perceive the system use performance of CyberLearn Hub at a high level, with an overall mean score of 4.67. The highest mean value of 4.75 was recorded for the navigation and layout, indicating that the platform is highly user-friendly and intuitive. The accessibility of resources and system performance both recorded mean values of 4.67, showing that students are satisfied with ease of access and platform performance. Meanwhile, the design and aesthetics recorded a mean of 4.64, which also reflects a high level. Overall, the results suggest that the platform provides a smooth and user-friendly experience for learners.

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Table 5. Mean Score and Standard Deviation (AI Chatbot Effectiveness-CyberBuddy)

Item	AI Chatbot Effectiveness CyberBuddy	Mean	S.D
Q9	The CyberBuddy AI agent provides accurate and helpful responses to my queries about the cybersecurity course.	4.69	0.531
Q10	The interaction with CyberBuddy enhances my understanding of complex cybersecurity concepts.	4.76	0.497
Q11	CyberBuddy provides responses in a timely manner.	4.76	0.478
Q12	CyberBuddy is able to understand my questions accurately.	4.88	0.390
Overall Mean and Standard Deviation		4.76	0.374

The findings shown in Table 5 indicate that students perceive the effectiveness of the CyberBuddy AI chatbot at a very high level, with an overall mean score of 4.76. The highest mean value of 4.88 was recorded for CyberBuddy's ability to understand questions accurately, followed by timely responses and enhanced understanding, both with mean values of 4.76. The accuracy and helpfulness of responses recorded a mean of 4.69, which also reflects a high level. Overall, the results show that CyberBuddy is highly effective in supporting students' learning in cybersecurity.

Table 6. Mean Score and Standard Deviation (User Engagement & Motivation)

Item	User Engagement & Motivation	Mean	S.D
Q13	Using the CyberLearnHub and CyberBuddy encourages me to study the cybersecurity course material more frequently.	4.79	0.519
Q14	I feel more engaged when learning using CyberLearn Hub compared to traditional methods.	4.78	0.470
Q15	CyberLearn Hub encourages me to explore cybersecurity topics beyond the syllabus.	4.74	0.450
Q16	CyberLearn Hub improves my confidence in learning cybersecurity topics.	4.60	0.500
Overall Mean and Standard Deviation		4.69	0.360

The findings shown in Table 6 indicate that students show a high level of engagement and motivation when using CyberLearn Hub, with an overall mean score of 4.69. The highest mean value of 4.79 was recorded for increased study frequency, followed closely by engagement at 4.78 and exploration beyond the syllabus at 4.74. Although slightly lower, confidence in learning recorded a mean of 4.60, which still reflects a high level. Overall, the results suggest that the platform effectively enhances students' engagement and motivation in learning cybersecurity.

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Table 7. Mean Score and Standard Deviation (Usage & Acceptance)

Item	Usage & Acceptance	Mean	S.D
Q17	I rely on CyberLearn Hub as one of my main learning resources for this course.	4.56	0.507
Q18	I frequently use CyberBuddy when I encounter difficulties in my learning.	4.70	0.58
Q19	I would recommend CyberLearn Hub to other students taking the cybersecurity course.	4.71	0.456
Q20	The explanations provided by CyberBuddy are clear and easy to understand.	4.79	0.410
Overall Mean and Standard Deviation		4.697	0.322

The findings shown in Table 7 indicate that students demonstrate a high level of usage and acceptance of CyberLearn Hub, with an overall mean score of 4.697. The highest mean value of 4.79 was recorded for the clarity of explanations provided by CyberBuddy, followed by recommendations to others at 4.71 and frequent use of the chatbot at 4.70. Although slightly lower, reliance on the platform as a main learning resource recorded a mean of 4.56, which still reflects a high level. Overall, the results suggest that the platform is well accepted and widely utilized by students in their learning process.

Following the descriptive analysis, correlation analysis was conducted to examine the relationships between the key constructs in this study. While the descriptive results provided insights into the overall levels of each variable, correlation analysis aims to determine the strength and direction of the relationships between factors such as content quality, usability, AI chatbot effectiveness, user engagement, and usage and acceptance. This analysis provides a deeper understanding of how these variables are associated with one another within the CyberLearn Hub platform.

Table 8. Correlation Matrix of Learning Effectiveness, System Use Performance, AI Chatbot Effectiveness-CyberBuddy, User Engagement & Motivation, and Usage & Acceptance)

		Learning Effectiveness	System Use Performance	AI Chatbot Performance-CyberBuddy	User Engagement & Motivation	Usage & Acceptance
Learning Effectiveness	Pearson Correlation	1	0.948	0.719	0.316	0.094
	Sig. (2-tailed)		0.000	0.000	0.000	0.171
	N	212	212	212	212	212
System Use Performance	Pearson Correlation	0.948	1	0.660	0.364	0.097

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	Sig. (2-tailed)	0.000		0.000	0.000	0.159
	N	212	212	212	212	212
AI Chatbot Performance-CyberBuddy	Pearson Correlation	0.719	0.660	1	0.511	0.267
	Sig. (2-tailed)	0.000	0.000		0.000	0.000
	N	212	212	212	212	212
User Engagement & Motivation	Pearson Correlation	0.316	0.364	0.511	1	0.389
	Sig. (2-tailed)	0.000	0.000	0.000		0.000
	N	212	212	212	212	212
Usage & Acceptance	Pearson Correlation	0.094	0.097	0.267	0.389	1
	Sig. (2-tailed)	0.171	0.159	0.000	0.000	
	N	212	212	212	212	212

The correlation in Table 8, the analysis shows several significant relationships among the key constructs. A very strong positive relationship is observed between learning effectiveness and system use performance, with a correlation value of 0.948. This indicates that better system usability and performance are strongly associated with higher learning effectiveness.

A strong positive relationship is also found between learning effectiveness and AI chatbot effectiveness at 0.719, suggesting that the CyberBuddy chatbot plays a major role in enhancing students' learning outcomes. In contrast, learning effectiveness has a weak but significant relationship with user engagement at 0.316, indicating that engagement contributes to learning effectiveness but to a lesser extent. However, the relationship between learning effectiveness and usage and acceptance is very weak and not significant, with a value of 0.094. This suggests that the frequency of use or general acceptance of the platform does not directly influence perceived learning effectiveness. In addition, AI chatbot effectiveness demonstrates a moderate positive relationship with system use performance and user engagement, as well as a weak relationship with usage and acceptance. User engagement also shows a moderate relationship with usage and acceptance, indicating that more engaged users tend to accept and use the platform more actively.

Overall, the findings indicate that system use performance and AI chatbot effectiveness are the strongest factors associated with learning effectiveness. While user engagement shows a supporting role, usage and acceptance do not significantly influence learning effectiveness. This highlights that the quality of system design and AI interaction is more critical than mere usage frequency in determining effective learning outcomes.

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Table 9. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.960[a]	0.921	0.919	0.132

The model summary in Table 9, indicates a very strong explanatory power of the regression model. The R value of 0.960 shows a very strong relationship between the independent variables and learning effectiveness. The R Square value of 0.921 suggests that 92.1 percent of the variance in learning effectiveness can be explained by system use performance, AI chatbot effectiveness, user engagement, and usage acceptance. This indicates that the model has a very high level of predictive accuracy.

Table 10. ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	42.155	4	10.539	601.848	0.000
	Residual	3.625	207	0.018		
	Total	45.779	211			

The ANOVA results show in Table 10 above mention that the regression model is statistically significant, with an F-value of 601.848 and a significance level of 0.000. This indicates that the overall model is likely valid and that the independent variables collectively may influence learning effectiveness (Zhang, 2024).

Table 11. Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	0.315	0.166		1.898	0.059		
	System Use Performance	0.806	0.025	0.842	32.046	0.000	0.554	1.804
	AI Chatbot	0.273	0.036	0.215	7.536	0.000	0.470	2.129
	User Engagement	-0.135	0.033	-0.097	-4.066	0.000	0.666	1.502
	Usage Acceptance	-0.010	0.031	-0.007	-0.314	0.754	0.828	1.208

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The coefficients result in Table 11, reveal the contribution of each independent variable toward learning effectiveness. System use performance has the strongest positive influence on learning effectiveness with a beta value of 0.842 and is statistically significant. This indicates that system usability and performance are the most dominant factors in enhancing students' learning effectiveness.

AI chatbot effectiveness also shows a significant positive effect with a beta value of 0.215, suggesting that CyberBuddy plays an important role in supporting learning outcomes. In contrast, user engagement shows a significant negative relationship with learning effectiveness, indicating that higher engagement does not necessarily translate into better perceived learning outcomes in this context. Finally, usage acceptance is not statistically significant, suggesting that it does not have a meaningful direct impact on learning effectiveness.

The multicollinearity diagnostic results indicate that all tolerance values are above 0.10 and all VIF values are below 5, suggesting that there is no multicollinearity issue among the independent variables. Overall, the findings indicate that system use performance and AI chatbot effectiveness are key determinants of learning effectiveness in the CyberLearn Hub platform. While AI integration contributes positively to learning outcomes, system usability remains the most critical factor. However, usage acceptance does not significantly influence learning effectiveness, suggesting that frequent usage alone is not sufficient to enhance learning outcomes without effective system design and interaction quality.

In summary, the results of this study demonstrate that the proposed regression model is statistically significant and exhibits strong explanatory power in predicting learning effectiveness within the CyberLearn Hub platform. The findings indicate that system use performance and AI chatbot effectiveness were identified as significant predictors, while user engagement showed a moderate effect and usage acceptance was not significant. The absence of multicollinearity provides support for the potential reliability of the model. The following section will discuss these findings in relation to existing literature and provide a more in-depth interpretation of the results.

Discussion

The findings of this study highlight the potential of CyberLearn Hub as an AI-supported digital learning environment for cybersecurity education. The integration of artificial intelligence, particularly through the CyberBuddy chatbot, together with a well-structured system interface, appears to enhance the overall learning experience. This aligns with recent advancements in Artificial Intelligence in Education, where AI-enabled platforms are increasingly recognized for their ability to support adaptive, personalized, and interactive learning environments (Zawacki-Richter et al., 2021; Chen et al., 2023). From an interpretive perspective, this suggests that the value of AI in education is not limited to automation but extends to enhancing learner interaction and cognitive support.

A key insight from the study is that system usability and performance play a central role in shaping learning effectiveness. The results imply that learners are more likely to benefit from platforms that are intuitive, accessible, and well-designed. This reinforces established perspectives in e-learning research which emphasize that system quality is a critical foundation for effective digital learning experiences (Almaiah et al., 2022; Alqahtani & Rajkhan, 2022). In practical terms, this indicates that institutions aiming to implement AI-based learning

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systems should prioritize interface design and usability as core development elements, rather than treating them as secondary considerations.

The role of the AI chatbot also emerges as an important supporting factor in enhancing learning outcomes. The findings suggest that AI-based assistance contributes to improved understanding by offering immediate responses, guidance, and scaffolding during learning activities. This supports the broader view that intelligent tutoring systems can strengthen learner autonomy and engagement with complex subject matter such as cybersecurity (Chen et al., 2023; Holmes & Tuomi, 2022). However, the contribution of AI should be interpreted as complementary rather than standalone, as its effectiveness is closely linked to the overall system design and learning context.

In contrast, learner engagement and motivation appear to have a more limited direct relationship with learning outcomes in this context. Although students reported high levels of engagement, this did not necessarily translate into improved performance. This suggests that engagement may sometimes reflect surface-level interaction rather than deep learning processes. It also indicates that engagement alone is insufficient unless it is directed toward meaningful, task-oriented learning activities. This finding contributes to ongoing discussions in digital learning research regarding the difference between behavioral engagement and cognitive engagement.

Similarly, the frequency of system usage and acceptance does not appear to be a strong determinant of learning success. This implies that simply using a platform more often does not guarantee improved learning outcomes. Instead, the quality of interaction and the depth of learning activities are likely more influential. This perspective aligns with prior research emphasizing that meaningful engagement with learning content is more important than usage intensity (Khalil & Ebner, 2022). Therefore, designers of e-learning systems should focus on enhancing interaction quality rather than encouraging usage frequency alone.

Overall, the model suggests that system-related factors, particularly usability and AI-supported functionality, play a more influential role in shaping learning effectiveness compared to behavioral factors such as usage or engagement. This implies that successful AI-based educational platforms require a balanced integration of technological design and pedagogical strategy. The relatively high explanatory capacity of the model further indicates that the selected variables collectively provide a meaningful framework for understanding learning effectiveness in AI-supported environments.

Despite these contributions, several limitations should be acknowledged. First, the study is based on a specific sample within a cybersecurity learning context, which may limit the applicability of the findings to other disciplines. Second, the cross-sectional design restricts the ability to infer long-term effects of AI integration on learning outcomes. Third, the study primarily relies on self-reported measures, which may be subject to response bias. Future research could address these limitations by employing longitudinal designs, larger and more diverse samples, and incorporating objective learning performance data.

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Conclusion

In conclusion, this study suggests that CyberLearn Hub is an effective AI-supported digital learning platform that enhances students' learning experience in cybersecurity education. The findings highlight that system use performance and AI chatbot effectiveness are the most influential factors in determining learning effectiveness. This is consistent with recent research emphasizing the importance of system quality and AI integration in improving learning outcomes (Almaiah et al., 2022; Chen et al., 2023).

The study also reveals that while user engagement and platform acceptance are important, they do not directly translate into improved learning outcomes without strong system design and meaningful interaction. This supports the argument that digital learning success depends more on the quality of learning experience rather than the quantity of usage (Khalil & Ebner, 2022). The CyberBuddy AI chatbot was found to be a significant component in facilitating personalized learning by providing accurate, timely, and understandable responses. This finding reinforces the growing role of AI in education, particularly in enhancing student support and enabling adaptive learning pathways (Holmes & Tuomi, 2022; Zawacki-Richter et al., 2021).

From a practical perspective, this study provides valuable inswasights for educators, system developers, and institutions in designing effective digital learning platforms. The integration of AI with user-centered design principles can significantly improve both learning effectiveness and student satisfaction. Moreover, the findings support the growing adoption of intelligent learning systems in higher education, particularly in technical fields such as cybersecurity (Radianti et al., 2023).

However, this study is limited by its reliance on self-reported data and a specific sample context, which may affect its applicability. Future research should consider longitudinal designs and diverse populations. Additionally, further studies could explore other influencing factors such as learning styles, instructor presence, and long-term learning outcomes.

In summary, CyberLearn Hub represents a significant innovation in digital education by demonstrating how AI-supported platforms can enhance learning effectiveness, support personalized learning, and improve overall educational experiences in the digital era.

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Author Contribution Statement: All authors contributed significantly to the development of this manuscript. Roziyaliney Muhammad was responsible for the conceptualization, methodology, and overall supervision of the study. Haris Fadillah Hasan handled data collection, analysis, and interpretation of results. Fatimah Zahra W Razali contributed to the literature review, drafting, and critical revision of the manuscript. All authors reviewed and approved the final version of the manuscript before submission and agreed to be accountable for all aspects of the work.

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