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AI-Supported Learning Among Higher Education Students: Role of Learning Engagement and Self-Regulated Learning Among Multi-Group Analysis Based on AI Literacy

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Abstract: The rapid integration of artificial intelligence (AI) technologies in higher education has created new opportunities to enhance student learning outcomes. This study examined the effects of perceived usefulness of AI, AI self-efficacy, and institutional AI support on AI enhanced learning outcomes among higher education students in Saudi Arabia. The study further investigated the mediating roles of AI learning engagement and self-regulated learning. Using a quantitative cross sectional design, data were collected from 547 university students with prior experience using AI technologies for academic purposes. The data were analyzed using Partial Least Squares Structural Equation Modeling (PLS SEM). The findings revealed that perceived usefulness of AI, AI self-efficacy, and institutional AI support significantly influenced both AI learning engagement and self-regulated learning. Furthermore, AI learning engagement and self-regulated learning significantly enhanced AI enhanced learning outcomes, with self-regulated learning emerging as the strongest predictor. The mediation analysis confirmed that both AI learning engagement and self-regulated learning significantly transmitted the effects of the antecedent variables to learning outcomes. The study demonstrates that the effectiveness of AI supported learning depends not only on technological resources but also on students' capabilities, perceptions, and learning behaviors.

Keywords: Artificial Intelligence, AI Learning Engagement, Self-Regulated Learning, AI Self Efficacy, Higher Education.

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1. Introduction

The unusual evolution of artificial intelligence (AI) has radically changed the area of higher education around the globe, affecting educational processes and students' educational experience (Yilmaz et al., 2026). AI using systems of smart tutoring, generative AI, and adaptive learning have become very popular in educational institutions since these technologies are helpful in the improvement of education quality and process. In Saudi Arabia, the national will to digital transformation and economy based on knowledge has encouraged the use of these new technologies in higher education institutions (Duncan, 2026). The implementation of the Vision 2030 program has led universities of Saudi Arabia to invest huge sums in the development of technological investment, smart learning space, and education connected with AI. Therefore, students gain unique experience in using technologies that change traditional learning environments (Cabero-Almenara et al., 2026). According to Liu et al. (2026), the use of AI technologies has raised big academic interest to the understanding of the conditions of the effective use of AI in learning and education. Even though AI is promising in terms of improvement of academic performance and critical thinking skills of students, the effectiveness of its usage is based on students' perceptions and their level of competence in using new technologies (Böhmer et al., 2026). Therefore, examining the determinants that facilitate effective AI supported learning has become an increasingly important area of educational research, particularly within rapidly transforming educational systems such as Saudi Arabia.

Among the various factors influencing students' adoption and utilization of AI technologies, perceived usefulness, AI self-efficacy, and institutional support have emerged as particularly significant (Jingwen & Jun, 2026). From the perspectives of technology adoption and educational psychology, students are more likely to adopt technology if they consider it useful in completing academic work and improving the learning process. Perceived usefulness is the belief that AI technologies can be used by students to enhance their academic performance and learning processes (Mohd Daud, 2026). This makes them more likely to use these technologies more frequently and in greater quantities. The self-efficacy for using AI refers to students' belief in their skills and capabilities to use such technologies effectively in the educational process (Sun & Liu, 2026). In general, students with greater self-efficacy are inclined to check new and innovative technologies, overcome technological barriers, and use AI applications in education. Besides support from the educational institutions is crucially important in creating a favorable environment for successful AI use (Fahmawee, 2026). The universities that provide their students with necessary technological support and methods of application, as well as those that assist in the organization of the educational process in an efficient manner, are more likely to develop students' interest in utilizing AI in their studying.

Scholars reported that despite being significant and making an impact on the learning outcomes, the ways the influence of technology-related reasons on the learning outcomes is formed need to be studied more (Tang & Wang, 2026). There are two significant educational processes: learning engagement and self-regulated learning. AI learning engagement is seen as the form of cognitive, emotional and behavioral involvement of a student in the academic activities based on AI (Meishar-Tal & Amzalag, 2026). Students that are engaged tend to invest more efforts in their studies and have more activity concerning academic resources, in addition, they show a high level of dedication to their education. Self-regulated learning is connected to the way students can set goals and judge the realization of their educational plans. Although there is evidence of the effectiveness and usefulness of AI tools that give students easy access to the information and provide personalized recommendations; it is worth noticing that the success depends on the ability of a student to control their learning process (Sharmin et al., 2026). This limitation is particularly evident in the context of developing AI ecosystems within higher education institutions across the Middle East, including Saudi Arabia.

Even though AI applications are becoming more widely used in various universities in Saudi Arabia, there is still a lack of knowledge concerning the factors affecting learning outcomes related to the implementation of AI technologies (Liu, 2026). Existing research has dedicated much of its time to investigating whether or not students accept AI technologies, while not paying that much attention to learning mechanisms through which this technology may affect the results of education (Zhao et al., 2026). More specifically, researchers have not combined students' perceptions of AI usefulness as well as AI self-efficacy and institutional support for AI in one model to assess how all of them may influence learning processes (Phung et al., 2026). Furthermore, there is little research exploring the role of AI learning engagement and self-regulation as mediating factors that help explain how the independent variables contribute to AI enhanced learning outcomes (Huang et al., 2026). This plays a major role in the case of higher educational institutions in Saudi Arabia, which is spending a lot of money on increasing educational transformation processes based on AI technologies.

Although the fact that AI literacy is regarded as an important skill in modern education is well established, nothing is known regarding whether the relationships mentioned above behave differently for students with different levels of AI literacy (Al-atrash et al., 2026). Thus, this research develops and tests a unified research model capable of studying the influence of three variables: AI perceived usefulness, AI self-efficacy, and the AI support offered by educational institutions, in relation to AI engagement and self-regulation, as well as the influence of these variables on learning results. Furthermore, the research examines how the above-mentioned factors influence students' learning indirectly through mediational variables and includes a multi-group analysis based on the students' AI literacy to learn about changes across different student groups. In this way, the research contributes to the knowledge of AI-supported education by providing a more elaborate understanding of how different variables related to AI help students achieve better learning results in Saudi Arabian higher education while offering some recommendations for the policymaking processes and studies in the field.

2. Review of Literature

Even though AI technologies are being increasingly incorporated into universities in Saudi Arabia, there is a limited and conceptually fragmented existing literature regarding the factors influencing AI-based educational outcomes (Duncan, 2026). Most research on AI has focused on students' acceptance and usage of AI technologies while paying relatively less attention to the learning processes involved by a given AI factor. In particular, previous work has not treated students' perceptions about usefulness of AI, AI efficacy and AI support by university in a single holistic framework that examines cognitive and behavioral approaches in learning (Nguyen & Nguyen, 2026). Additionally, there is a scant empirical evidence regarding the role of learning through AI engagement and self-regulation in demonstrating how these factors eventually lead to better learning outcomes from the use of AI technology (Sousa & Cardoso, 2025). This lack of research is especially relevant to Saudi education context due to huge investments made by Saudi universities in AI technology and therefore the necessity to carry out more studies on students' educational experience. Moreover, though AI literacy is acknowledged as a significant skill in education recently, it remains unknown whether the relationships between AI related antecedents, mediating learning processes, and learning outcomes vary based on level of AI literacy of the students (Chen & Anyanwu, 2025). Hence, the following hypothesis is proposed:

H1: Students perceived usefulness of AI have impact on students AI learning engagement.

AI self-efficacy refers to students' confidence in their ability to comprehend, implement, and handle AI technology effectively for school purposes (Okulich-Kazarin et al., 2024). There is a close relationship between self-efficacy and the Social Cognitive Theory. The theory suggests that self-efficacy impacts people's motivation, behaviour, persistence, and performance. Students with high levels of AI self-efficacy view AI-related tasks as feasible, while students with a lack of confidence experience anxiety and do not wish to use sophisticated technologies (Zembylas, 2023). AI self-efficacy is important for educational contexts, as students in such contexts need to deal with various applications, assess AI-generated assignments, and implement technological resources in their academic experience (Wang et al., 2023). Students endowed with a high level of AI self-efficacy tend to try new tools out, be able to find the solutions themselves, and tackle the technology issues faced during learning. Self-efficacy is also associated with active involvement in AI processes which contributes positively to learning engagement (Sharmin et al., 2026). Moreover, self-efficacious students are more curious and intrinsically motivated while using technology, which leads to higher cognitive engagement provided by their participation in learning. Studies focusing on technology enhanced learning established that there is a positive correlation between technological self-efficacy and student engagement, which means that confidence in technology applications leads to active participation and persistence in learning (Wang & Zhang, 2026). As AI systems gain prevalence in higher education, students' beliefs about their capacity to handle them properly are likely to shape their engagement in AI supported learning processes (Liu et al., 2022). Therefore, students demonstrating advanced levels of AI self-efficacy are expected to demonstrate positive cognitive, behavioral, and emotional engagement. Hence the following hypothesis is formulated:

H2: Students AI self-efficacy have impact on students AI learning engagement.

Institutional AI support indicates the degree to which institutions of higher education are equipped with resources, infrastructure, training facilities, assistance with technology and policies that allow students to use AI technologies efficiently (Wang & Wang, 2026). Organizational support is an important aspect influencing adoption and use of technologies by students, as educational institutions are vital in the creation of digital learning environments. Higher education institutions that invest in AI technologies infrastructure and provide all-inclusive support allow students to use AI technologies in a confident and effective way (Cabero-Almenara et al., 2026). Institutional assistance minimizes hurdles in implementing technology by guaranteeing access to the necessary tools, technological resources, and training. When learners think that their institutions advocate for AI inclusion and provide considerable assistance, they will likely form an optimistic attitude towards AI-assisted instruction (Jeilani & Abubakar, 2025). This support is crucial as it provides a feeling of safety and readiness for undertaking activities in a technology-mediated learning environment. Additionally, various initiatives such as workshops, AI literacy programs, faculty assistance, and learning platforms may increase students' involvement by creating possibilities for fruitful interaction with the AI technologies. Previous research shows that supportive learning environment contributes to enhanced engagement through the increase of motivation, accessibility, and confidence in using technology (Shi et al., 2025). In AI-related educational context, institutional support acts as an external facilitating factor positively impacting students' engagement (Chang & Li, 2026). Therefore, the higher the level of perceived institutional support, the better students' engagement in AI learning.

H3: Students institutional AI support have impact on students AI learning engagement.

Students' self-regulated learning is defined as students' ability to plan, track, assess, and modify their learning approaches (Chen & Anyanwu, 2025). In the modern educational context of higher education, Artificial Intelligence technologies have appeared to be excellent educational tools that help learners manage their educational processes (Liu, 2026). According to expectancy value theory students are more likely to use available resources in their learning processes if they have a strong belief in their importance. Therefore, students who find AI technologies effective are likely to use them wisely in their learning processes. The use of artificial intelligence in education provides students with prompt feedback, tailored recommendations, personalized learning paths, and access to vast educational resources (Tang & Wang, 2026). This allows students to check how well they are doing in their studies and what needs more effort. If students understand how AI technologies can help them in practice, they will want to integrate the use of these tools into their study lives and take responsibility for their education (Liu et al., 2022). Moreover, students' value of technology encourages them to engage in reflective learning behavior. Several studies in educational technology demonstrate that perceived usefulness contributes significantly to the autonomous learning of students (Essel et al., 2026). Moreover, self-regulated learning requires special efforts and deliberate use of the available resources, which calls for students' perception of the benefits of AI technologies. Therefore, the following hypothesis is developed:

H4: Students perceived usefulness of AI have impact on students self-regulated learning.

The confidence of students in their capacity to do effective application of AI technologies serves as a significant personal asset, which influences their learning behavior (Finkelstein & Soffer-Vital, 2025). The belief in its self-efficacy, according to Social Cognitive Theory, determines the tendency of the individual to set ambitious goals, overcome challenges, and exert control on one's actions. In the context of educational environments involving AI, self-efficacy goes beyond technical skills and incorporates the belief that students can utilize AI tools in their studies, solve educational tasks, and reach academic goals (Fošner & Aver, 2025). Learners who exhibit a high degree of AI self-efficacy exhibit proactive tendencies while managing their academics. Instead of relying on their instructors or external sources, they prefer to utilize AI resources on their own to find information, assess progress, and judge their academic performance (Zhou et al., 2025). They are open to trying different technologies and alternative learning methods whenever they face obstacles in learning. On the other hand, learners with low self-efficacy regarding AI usage are likely to avoid difficult applications and practice passive learning techniques, which limits their effective self-regulation (Okulich-Kazarin et al., 2024). According to previous studies, self-efficacy is an important precursor of autonomous behavior as self-efficacious individuals are more motivated and resilient during the learning process (Stone, 2025). Given that the use of AI in higher education is on the rise, the hypothesis that learners who believe they can successfully use AI will demonstrate high planning, monitoring, and self-evaluation skills. Therefore, the following hypothesis is proposed:

H5: Students AI self-efficacy have impact on students self-regulated learning.

The growth of self-regulated learning is not determined only by the characteristics of learners but also by the surroundings of the learning process (Huang et al., 2026). Institutional AI assistance involves the provision of the necessary means such as infrastructure, educational programs, academic regulations, technical support, and educational material. According to the principles of resource-based learning environment, students are more likely to engage in self-learning when the institutions offer the necessary instruments and support systems for effective learning (Shafiq et al., 2026). The universities that promote the utilization of artificial intelligence in education offer students opportunities to take regretful ownership of their educational endeavors. By providing students with access to platforms for AI in educational work, educational technology workshops, digital education tools, and advisory services, universities can help students learn to use AI effectively while managing their studies (Zembylas, 2023). Such assistance will enable students to organize their work more effectively in terms of learning planning and controlling their education. Additionally, schools' actions aimed at enhancing students' AI literacy and their responsible technology use can assist students in feeling more self-performed while managing their learning processes (Jeilani & Abubakar, 2025). The supportive atmosphere of the school creates the environment of less uncertainty regarding technologies so that students can concentrate on learning, rather than overcoming technological difficulties (Zhou et al., 2025). Therefore, if students see the great level of institutional support in regard to artificial intelligence, they will act in a self-regulated way allowing themselves to succeed in their learning endeavors. The following hypothesis is proposed:

H6: Students institutional AI support have impact on students self-regulated learning.

Engagement in learning is already considered one of the key factors contributing to academic achievement since it consists of a student's level of engagement in the learning processes (Fošner & Aver, 2025). In educational settings enhanced by AI, engagement involves cognitive and emotional components of learning, and also includes physical participation in learning with the help of AI devices. Engagement is seen as a critical determinant of the effectiveness of AI technologies in education since it is important to understand that the impact of AI applications is dependent on the extent to which students actively engage in learning with the help of these technologies (Nguyen & Nguyen, 2026). The utilization of AI systems and tools enables educators to provide customized feedback to students, adapt the content and processes of learning to every learner in the classroom, offer ongoing support and provide access to various educational materials (Colclasure et al., 2025). The important point is that the potential of new technologies cannot be utilized until students are directly involved in the learning process and are actively involved in the learning activities. Students who demonstrate an increased level of engagement with AI technology in studies tend to considerably invest their efforts in mastering the tools, critically look at the information provided by technology, and continuously interact with AI systems (Sousa & Cardoso, 2025). Such engagement in studies leads to a more thorough acquisition of knowledge, better problem solving capabilities, and higher academic performance in comparison to less engaged students. In addition to this, engaged students show a higher level of perseverance in studies by being able to focus on the material being studied and thereby take full advantage of the benefits provided by AI technologies (Campillo-Ferrer et al., 2025). Different studies conducted show that cognitively and behaviorally engaged students have better results in the studies than those who engaged less in this process. Hence, the following hypothesis is proposed:

H7: Students AI learning engagement have impact on AI enhanced learning outcomes.

The phrase self-regulation refers to the learner's capability to manage their learning independently (Wang et al., 2023). In other words, learner-controlled education entails self-management actions through which learners plan their studies, select methods, assess their progress, evaluate their outcomes, and modify their actions so as to improve their results. Furthermore, regarding educational approaches based on AI technologies, self-regulated education has gained more importance due to learners' increasing autonomy concerning studies (Finkelstein & Soffer-Vital, 2025). Students who are skilled in self-management in learning employ artificial intelligence tools in a structured and purposeful manner. They are able to fully use the feedback offered by AI systems, provided advice, and adaptive instructional materials to determine their weaknesses, improve their study methods, and enhance their academic performance with the help of AI (Chick et al., 2026). These students keep on tracking their own progress and making the necessary adjustments to achieve their educational objectives. Conversely, students lacking sufficient self-regulatory skills may not be able to benefit fully from using AI solutions even with access to the same resources (Liu et al., 2026). Previous studies in education indicate that self-regulated learning contributes to academic performance, retention of information, development of cognitive abilities, and self-study effectiveness. In the milieu characterized by the integration of AI into learning self-regulation appears to be the key factor that allows learners to get the most out of digital technology (Colclasure et al., 2025). In this way, learners who are well developed in terms of self-regulated learning will show better results when using AI in education (Fahmawee, 2026). Hence, the following hypothesis is proposed:

H8: Students self-regulated learning have impact on AI enhanced learning outcomes.

Although perceived utility of AI, self-efficacy regarding AI, and institutional backing for AI are anticipated to affect results from learning enhanced by AI, the specific pathway by which these elements create educational advantages needs more detailed clarification (Stone, 2025). Theories concerning learning indicate that tools technology provides and personal skills do not instantly convert into achievement within academia. Instead, learners need to participate actively in instructional tasks prior to seeing any real improvement in education. Within settings where learning is aided by

AI, engagement with AI learning signifies how deeply students involve their minds, feelings, and actions when using AI tools for school goals (Jingwen & Jun, 2026). Thus, this engagement acts as a key explanatory step linking causes related to AI with final outcomes in learning. Learners viewing artificial intelligence systems as beneficial show increased frequency in tool usage, commit more energy to AI-assisted study sessions, and exhibit stronger excitement regarding tech-integrated education. Likewise, those possessing high AI self-efficacy tackle AI-linked assignments with assurance, stamina, and interest, leading to elevated engagement scores (Hamamra, 2026). School-based AI backing may further boost learner involvement through offering entry to hardware assets, skill-building chances, expert help, and a nurturing classroom setting promoting AI adoption. Such settings enable substantial involvement within AI-driven teaching moments (Sun & Liu, 2026). Consequently, learners who participate actively stand to gain more from artificial intelligence tools since they proactively investigate materials, request responses, dedicate energy to schoolwork, and keep continuous participation within the instructional flow. These actions lead to greater information uptake, ability growth, issue resolution powers, and general scholastic results (Dai et al., 2026). Earlier research has repeatedly pinpointed involvement as a vital connector between teaching resources and education outputs. Thus, one can logically anticipate that engagement regarding artificial intelligence conveys the beneficial impacts of seeing utility in such systems, belief in personal capability to use them, and backing provided by the organization on results achieved through augmented instruction (Liu, 2026). Guided by this reasoning, following hypotheses are developed:

H9a: Students AI learning engagement mediates the relationship between students perceived usefulness of AI and AI-enhanced learning outcomes.
H9b: Students AI learning engagement mediates the relationship between students AI self-efficacy and AI-enhanced learning outcomes.
H9c: Students AI learning engagement mediates the relationship between institutional AI support and AI-enhanced learning outcomes.

Self-regulated learning is broadly acknowledged as a core process by which learners convert existing assets and individual skills into academic success (Al-atrash et al., 2026). Within AI-supported educational settings, pupils gain vast chances to retrieve data, obtain tailored responses, track progress, and request scholarly help. Nevertheless, how well these technical features work relies heavily on learners' capacity to manage their study tasks (Vivas-Urias et al., 2026). Thus, self-regulated learning could act as a key route via which perceived utility of AI, AI self-efficacy, and organizational AI backing influence results from AI-enhanced learning. When learners view artificial intelligence systems as beneficial, they adopt these digital aids more often to organize, track, and assess their study outcomes. Similarly, those possessing strong belief in their own capacity regarding AI show higher assurance when using such tools alone, which allows them to assume more control over how they manage their education paths (Bilgiç & Sever, 2026). Support from schools through AI boosts this skill set by offering required hardware, educational courses, and direction needed for successful independent study work. Together, these elements push learners toward defining targets, checking results, changing methods, and practicing reflection on what they have learned (Phung et al., 2026). The importance of self-regulated learning stands out clearly within AI-assisted education settings since these technologies provide vast amounts of material needing

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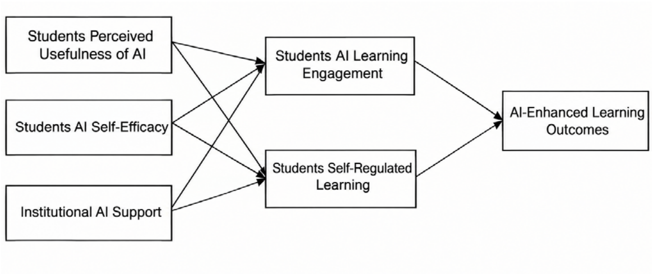
active student oversight. Students managing their own processes well can better use AI suggestions, spot gaps, modify tactics, and boost performance (Zhao et al., 2026). Thus, those regulating themselves tend to get better results compared to peers relying mostly outside help. Current studies show self-regulation predicts school success and how well people learn. Hence, benefits from seeing AI as useful, feeling confident using it, and getting school backing should happen via student self-control actions (Shafiq et al., 2026). From this view, we proposed these hypotheses:.

H10a: Students self-regulated learning mediates the relationship between students perceived usefulness of AI and AI-enhanced learning outcomes.
H10b: Students self-regulated learning mediates the relationship between students AI self-efficacy and AI-enhanced learning outcomes.
H10c: Students self-regulated learning mediates the relationship between institutional AI support and AI-enhanced learning outcomes.

The model of this research is reported in Figure 1.

Figure 1: Model of the Research.



3. Methodology

This study adopted a quantitative research approach using a cross sectional survey design to examine the relationships among perceived usefulness of AI, AI self efficacy, institutional AI support, AI learning engagement, self regulated learning, and AI enhanced learning outcomes among higher education students. The quantitative design was seen as an appropriate option as it helps to systematically analyze how multiple constructs are related to each other, and the influence of one variable on another can be assessed with the help of statistical analysis (Bougie & Sekaran, 2019). The study makes use of deductive reasoning because its hypotheses were derived from theoretical frameworks and established literature and evaluated using data collected from students of universities. The research design enables the establishment of both direct and indirect relations and makes the survey-based quantitative approach appropriate for conducting the research.

The target audience was composed of students studying in public and private higher education institutions in Saudi Arabia who used AI-based technologies for educational and studying purposes. Among the technologies using AI were generative AI applications, intelligent tutoring systems and adaptive learning platforms. The unit of analysis for the project was students as they are the main beneficiaries of AI initiatives implemented at Saudi Arabian universities.

The research utilized purposive sampling as the primary method of sampling (Bougie & Sekaran, 2019). The use of purposive sampling was appropriate since the research required participants who had hands-on experience with the use of AI technologies in education. Prior to responding to the questionnaire, the participants had to be screened to make sure they had experience with the use of AI technologies for academic purposes like doing their assignments, research studies, presentations, problems, and general improvements in learning. This ensured that the only involved respondents could give useful assessments about AI-supported learning. Due to the spread of AI usage among university students in Saudi Arabia, purposive sampling was able to reach involved respondents meeting the requirements.

Data were collected by means of a predefined questionnaire that was conducted with the help of an online survey. The questionnaire consisted of two sections. The first section included demographic information of the respondents such as gender, age, educational level, specialization, and usage of AI technologies. The second section consisted of measurements of the constructs of the research that were measured using earlier validated scales.

Before the main data collection took place, a pilot study was carried out to establish the validity, reliability, and clarity of the survey tool. Minor refinements were made on the basis of feedback to ensure the clarity of items. The final questionnaire link was sent electronically via university communication channels, student groups, academic networks, and social media platforms. Participation in the study was voluntary and respondents were guaranteed that their responses would be kept anonymous. The data collection process lasted for about 8 weeks.

A total of 612 survey responses were received initially during the data collection process. After the application of data screening procedures, the responses with important missing values, straight lining situation, and incomplete questionnaire format were eliminated. Furthermore, the responses failing the screening procedures related to AI usage experience were also excluded from the final dataset. After the data cleansing process, 547 valid responses were used in further statistical analysis. The collected data were analyzed using SPSS 29 for demographics, and SmartPLS 4, which is widely utilized for Partial Least Squares Structural Equation Modeling (PLS SEM).

4. Results and Findings

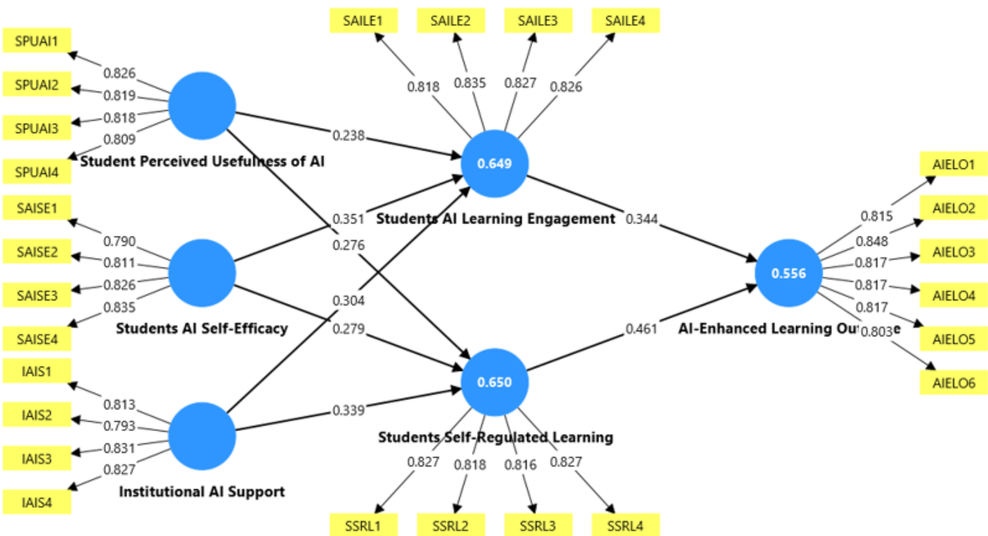
This study began with the demographic analysis of the data gathered through SPSS 29. Table 1 illustrates the demographic features of respondents. Among the 547 valid responses, the proportion of male (298) and female (249) respondents is almost equal (54.5% vs. 45.5%). In terms of age majority of respondents belonged to the group aged 20-24 years (51.4%), while the second largest group of respondents comprised students aged 25-29 years (23.4%). In terms of education level, undergraduate students representing 73.5% of the overall sample were the largest educational group, whereas the proportion of master's students making 20.5% of the sample was almost three times larger than that of doctoral degree holders (6.0%). In terms of academic majors, the largest proportion (25.4%) of respondents was comprised of students learning Engineering and Technology, then followed by Business and Management students (23.0%.), and Computer Science and Information Technology students who made 19% of the sample. Finally, in the context of using AI technologies, mean proportion of students who claimed that they use AI for their studies was 56.9% (either often or sometimes).

Table 1: Demographics.

Demographic Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	298	54.5
	Female	249	45.5
Age	Less than 20 years	72	13.2
	20-24 years	281	51.4
	25-29 years	128	23.4
	30 years and above	66	12.1
Level of Study	Undergraduate	402	73.5
	Master's	112	20.5
	PhD	33	6
Field of Study	Business and Management	126	23
	Engineering and Technology	139	25.4
	Computer Science and IT	104	19
	Social Sciences and Humanities	92	16.8
	Health Sciences	86	15.7
Frequency of AI Usage for Learning	Rarely	49	9
	Occasionally	103	18.8
	Sometimes	158	28.9
	Frequently	153	28
	Very Frequently	84	15.4

Measurement model assessment examines the reliability and convergent validity of the constructs included in the study. Reliability assesses the extent to which the measurement items are able to consistently capture their intended constructs, whereas convergent validity gauges the extent to which items belonging to the same construct exhibit some common variance. In PLS-SEM, for establishing a satisfactory reliability and convergent validity, the factor loadings should be greater than 0.70, the value of Cronbach's Alpha and composite reliability should be more than 0.70, and the average variance extracted (AVE) should be obtained at a value over 0.50 (Hair et al., 2021).

Figure 2: Measurement Model Assessment.



According to table 2 and figure 2, the item loadings ranged from 0.790 to 0.848, exceeding the required value of 0.70. These values indicate that the indicator reliability is excellent. The values of Cronbach's alpha have varied between 0.832 and 0.902, and the values of composite reliability have been between 0.888 and 0.925, which indicates the good internal consistency reliability of all the constructs. Moreover, the values of AVE ranged from 0.665 to 0.683 for all independent and mediating constructs, as for AI Enhanced Learning Outcome, its AVE was 0.671. Given that the AVE values are beyond the required value of 0.50, it is possible to conclude that convergent validity is achieved.

Table 2: Convergent Validitry.

Variables	Items	Factor Loadings	Cronbach's Alpha	Composite Reliability	Average Variance Extracted
AI-Enhanced Learning Outcome	AIELO1	0.815	0.902	0.925	0.671
	AIELO2	0.848			
	AIELO3	0.817			
	AIELO4	0.817			
	AIELO5	0.817			
	AIELO6	0.803			
Institutional AI Support	IAIS1	0.813	0.833	0.888	0.666
	IAIS2	0.793			
	IAIS3	0.831			
	IAIS4	0.827			
Student Perceived Usefulness of AI	SAILE1	0.818	0.835	0.890	0.669
	SAILE2	0.835			
	SAILE3	0.827			
	SAILE4	0.826			
Students AI Learning Engagement	SAISE1	0.790	0.845	0.896	0.683
	SAISE2	0.811			
	SAISE3	0.826			
	SAISE4	0.835			
Students AI Self-Efficacy	SPUAI1	0.826	0.832	0.888	0.665
	SPUAI2	0.819			
	SPUAI3	0.818			
	SPUAI4	0.809			
Students Self-Regulated Learning	SSRL1	0.827	0.840	0.893	0.676
	SSRL2	0.818			
	SSRL3	0.816			
	SSRL4	0.827			

Discriminant validity assesses the extent to which a construct is empirically distinct from other constructs in the research model. The Fornell-Larcker criterion is a commonly used tool for evaluating discriminant validity in PLS-SEM. The criterion suggests that the square root of the average variance extracted (AVE) for each construct must be more than its correlations with the other constructs (Hair et al., 2021). If this condition holds true, it indicates that the construct shares more variance with its indicators than other constructs in the model, thereby demonstrating the presence of discriminant validity.

In Table 3, diagonal figures indicating the square roots of the AVE are shown to range from 0.816 to 0.826, and all are above the respective inter-construct correlations. AI Enhanced Learning Outcome exhibit a square root of AVE of 0.819 which is more than its correlations with Institutional AI Support (0.634), Student Perceived Usefulness of AI (0.638), Students AI Learning Engagement (0.671), Students AI Self-Efficacy

(0.657) and Students Self-Regulated Learning (0.705). Likewise, Institutional AI Support (0.816), Student Perceived Usefulness of AI (0.818), Students AI Learning Engagement (0.826), Students AI Self-Efficacy (0.816) and Students Self-Regulated Learning (0.822) each have values which exceed the respective correlations with other constructs. Therefore, the Fornell-Larcker criterion was fully satisfied, confirming adequate discriminant validity among all study constructs.

Table 3: Fornell and Larcker Criterion.

Variable	AI-Enhanced Learning Outcome	Institutional AI Support	Student Perceived Usefulness of AI	Students AI Learning Engagement	Students AI Self-Efficacy	Students Self-Regulated Learning
AI-Enhanced Learning Outcome	0.819					
Institutional AI Support	0.634	0.816				
Student Perceived Usefulness of AI	0.638	0.719	0.818			
Students AI Learning Engagement	0.671	0.729	0.705	0.826		
Students AI Self-Efficacy	0.657	0.724	0.710	0.740	0.816	
Students Self-Regulated Learning	0.705	0.74	0.718	0.71	0.721	0.822

The assessment of the structural model refers to the analysis of the importance of connections among the constructs included in the research model. The results shown in Table 4 and Figure 3 demonstrate that all direct associations are positive, as well as statistically important. The perceived usefulness of AI had a relevant influence on AI engagement in learning ($\beta = 0.238$, $t = 5.546$, $p < 0.001$), suggesting that students who consider AI technology to be useful for their studies tend to take an active part in AI-driven learning. The predictor of AI self efficacy also has a positive and statistically important impact on AI learning engagement ($\beta = 0.351$, $t = 7.763$, $p < 0.001$), indicating that students who feel more certain in their skills and knowledge regarding AI technologies are more engaged in the learning process. The institutional AI support had a positive relation to AI learning engagement ($\beta = 0.304$, $t = 6.646$, $p < 0.001$) as well. This factor indicates that the presence of support services, resources, and infrastructure for AI fosters participation in AI-driven learning. Among the discussed constructs, the most powerful predictor of AI learning engagement is AI self efficacy.

The results also indicated that AI perceived usefulness positively influences self-regulated learning ($\beta = 0.276$, $t = 6.207$, $p < 0.001$). This means that the students who see AI technologies as educational instruments are more likely to have self-regulated learning skills, such as the skills of planning, monitoring, and controlling learning sessions. AI self-efficacy also positively affected self-regulated learning ($\beta = 0.279$, $t = 6.302$, $p < 0.001$); this demonstrates that confidence in the usage of AI technologies enables students to have more self-regulated learning skills. Moreover, institutional AI support had a positive effect on self-regulated learning ($\beta = 0.339$, $t = 7.304$, $p < 0.001$). This means that institutions that provide support contribute to the advancement of students' self-management and learning autonomy. Among three factors, the strongest predictor of self-regulated learning is institutional AI support.

Findings also validated the significance of both mediating constructs in estimating AI enhanced learning outcomes. The relation between the AI learning engagement and AI enhanced learning outcomes turned out to be substantial and positive (β = 0.344, t = 8.346, p < 0.001), suggesting that students who took an active part in the learning activities supported by AI performed better academically. In the same vein, self regulated learning significantly impacted AI enhanced learning outcomes (β = 0.461, t = 11.624, p < 0.001) although this relation was stronger than that between AI learning engagement and AI enhanced learning outcomes, indicating that students' ability to plan and monitor their learning efforts was particularly important in improving outcomes in AI enhanced learning.

The mediation analysis validated the suggested model. AI learning engagement played an important mediating role in the relationship between the perceived effectiveness of AI and the results of learning successful with the help of AI (β = 0.082, t = 4.504, p < 0.001), self-efficacy in the usage of AI and the results of learning successful with the help of AI (β = 0.121, t = 5.542, p < 0.001), and institutional support in using AI and the results of learning successful with the help of AI (β = 0.105, t = 5.225, p < 0.001). The above-mentioned data prove that active engagement in AI-facilitated learning activities is the outcome of positive attitude towards AI, good self-efficacy in using AI and effective institutional support in the mentioned area.

The findings of the study indicated that self regulated learning greatly mediated perceptions of AI's usefulness in achieving AI driven educational results (β = 0.127, t = 5.545, p < 0.001), AI efficacy (β = 0.129, t = 5.292, p < 0.001), and institutional AI assistance (β = 0.156, t = 6.129, p < 0.001). The strongest indirect impact was shown between institutional AI assistance and AI driven educational results via self regulated learning. This confirmed the positive effects of such institutional efforts in creating students' changes in their independent learning behavior and, in turn, positive learning outcomes. Thus, the hypotheses were proved and the importance of perceived usefulness, self-efficacy, institutional support and self regulated learning in predicting educational outcomes of AI usage among higher education students was emphasized.

Figure 3: Structural Model Assessment.

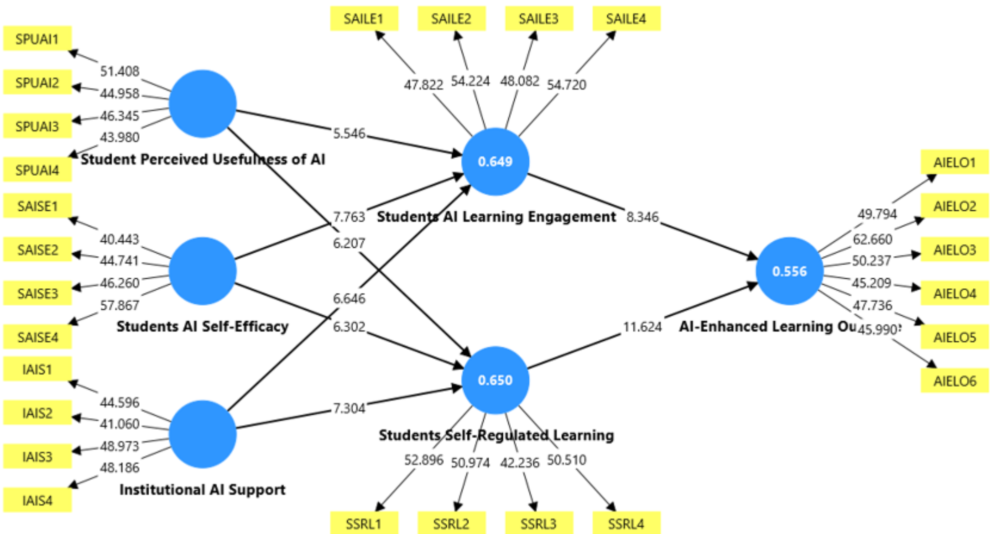


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Table 4: Structural Model Path Coefficients.

Hypothesis	Statement	Original Sample	Sample Mean	Standard Deviation	T Statistics	P Values	Results
H1	Student Perceived Usefulness of AI -> Students AI Learning Engagement	0.238	0.238	0.043	5.546	0.000	Supported
H2	Students AI Self-Efficacy -> Students AI Learning Engagement	0.351	0.352	0.045	7.763	0.000	Supported
H3	Institutional AI Support -> Students AI Learning Engagement	0.304	0.303	0.046	6.646	0.000	Supported
H4	Student Perceived Usefulness of AI -> Students Self-Regulated Learning	0.276	0.276	0.044	6.207	0.000	Supported
H5	Students AI Self-Efficacy -> Students Self-Regulated Learning	0.279	0.279	0.044	6.302	0.000	Supported
H6	Institutional AI Support -> Students Self-Regulated Learning	0.339	0.340	0.046	7.304	0.000	Supported
H7	Students AI Learning Engagement -> AI-Enhanced Learning Outcome	0.344	0.344	0.041	8.346	0.000	Supported
H8	Students Self-Regulated Learning -> AI-Enhanced Learning Outcome	0.461	0.461	0.040	11.624	0.000	Supported
H9a	Student Perceived Usefulness of AI -> Students AI Learning Engagement -> AI-Enhanced Learning Outcome	0.082	0.082	0.018	4.504	0.000	Supported
H9b	Students AI Self-Efficacy -> Students AI Learning Engagement -> AI-Enhanced Learning Outcome	0.121	0.121	0.022	5.542	0.000	Supported
H9c	Institutional AI Support -> Students AI Learning Engagement -> AI-Enhanced Learning Outcome	0.105	0.104	0.020	5.225	0.000	Supported
H10a	Student Perceived Usefulness of AI -> Students Self-Regulated Learning -> AI-Enhanced Learning Outcome	0.127	0.127	0.023	5.545	0.000	Supported
H10b	Students AI Self-Efficacy -> Students Self-Regulated Learning -> AI-Enhanced Learning Outcome	0.129	0.129	0.024	5.292	0.000	Supported
H10c	Institutional AI Support -> Students Self-Regulated Learning -> AI-Enhanced Learning Outcome	0.156	0.157	0.026	6.129	0.000	Supported

Effect size (f^2) refers to the degree of impact of each exogenous construct on an endogenous construct such as the impact of removing a predictive variable from the model on the change in the explained variance of the endogenous construct. According to the existing criteria, values of 0.02, 0.15, and 0.35 reflect small, medium, and large effects, respectively (Hair et al., 2021) Hence effect size is useful in understanding the practical relevance of relationships apart from the statistical relevance of the relationships.

From Table 5, it can be seen that institutional support provided by artificial intelligence has a small effect on AI engaged learning (f^2=0.129), and self-regulated learning (f^2=0.103). Likewise, perceived usefulness of artificial intelligence has a small effect on both AI learning engagement (f^2=0.089) and self-regulated learning (f^2=0.066). The strongest effect among antecedents was produced by AI self-efficacy on AI learning engagement (f^2=0.141), while it has a small effect on self-regulated learning (f^2=0.089). With respect to the endogenous variable, AI learning engagement has a small to close to medium effect on AI enhanced learning outcomes (f^2=0.133), while self-regulated learning shows a medium effect (f^2=0.237). Thus, the results show that self regulated learning has the most significant impact on AI enhanced learning outcomes.

Table 5: Effect Size Assessment.

Variable	AI-Enhanced Learning Outcome	Students AI Learning Engagement	Students Self-Regulated Learning
Institutional AI Support		0.103	0.129
Student Perceived Usefulness of AI		0.066	0.089
Students AI Learning Engagement	0.133		
Students AI Self-Efficacy		0.141	0.089
Students Self-Regulated Learning	0.237		

R^2 is a coefficient of determination that conveys the percentage of variance in an endogenous item explained by the predictor variables. In partial least squares structural equation modeling (PLS-SEM), the R^2 values are used to determine the explanatory capability of the model and the R^2 values that are higher indicate that the research model can explain a higher amount of variability of the events (Hair et al., 2021).

As can be observed in Table 6, the model explained 55.6% variance in AI learning outcomes ($R^2 = 0.556$; Adjusted $R^2 = 0.554$). This implies that AI learning engagement and self regulated learning have played an important role in explaining students' AI learning outcomes. Also, the independent variables, particularly, perceived usefulness of AI, AI self efficacy, and institutional AI support made contribution equal to 64.9% of the variance in AI learning engagement ($R^2 = 0.649$; Adjusted $R^2 = 0.646$). The same happened with the self regulated learning, where the affected variables explained the amount of 65% of the variance ($R^2 = 0.650$; Adjusted $R^2 = 0.648$). The small gap between the given values further supports the reliability of the model. In general, it can be stated that the proposed model is significantly useful in explaining both AI learning engagement, self regulated learning, and AI learning outcomes of students.

Table 6: Coefficient of Determination.

Variable	R-square	R-square Adjusted
AI-Enhanced Learning Outcome	0.556	0.554
Students AI Learning Engagement	0.649	0.646
Students Self-Regulated Learning	0.650	0.648

The predictive capability of the structural model can be assessed using PLS Predict. The concept of predictive relevance is examined through Q^2predict values, which show positive values above zero when predictive relevance exists (Hair et al., 2021). Moreover, the predictive errors can also be approximated using Root Mean Square Error (RMSE) and Mean Absolute Error (MAE), where a smaller value leads to better accuracy of predictions.

According to the data provided in Table 7, the Q^2predict values were positive which confirms that the proposed model has the predictive relevance. More specifically, the Q^2predict value of the AI learning engagement was 0.643, while considering the RMSE of 0.600 and MAE of 0.479. The Q^2predict value of the self regulated learning was 0.644 with the RMSE of 0.600 and MAE of 0.478. In this case, it has to be noted that both the mediating variables show high predictive relevance. Furthermore, the AI driven learning outcome has the Q^2predict value of 0.502 indicating that the values of RMSE and MAE equated to 0.710 and 0.570 respectively. As the Q^2predict values are significantly more than zero, it can be summarized that the structural model has the relevant predictive power.

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Table 7: PLS Predict.

Variable	Q^2predict	RMSE	MAE
Students AI Learning Engagement	0.643	0.6	0.479
Students Self-Regulated Learning	0.644	0.6	0.478
AI-Enhanced Learning Outcome	0.502	0.71	0.57

5. Discussion

The findings showed that students perceived usefulness of AI really does matter a lot for their AI learning engagement, which also backs up H1 ($\beta = 0.238$, $p < 0.001$). In other words, learners who think AI technologies are useful for boosting academic performance, finishing learning tasks, and raising the overall educational effectiveness tend to get more involved in AI supported learning, in a cognitive, emotional, and behavioral sense. When students feel that these tools help them reach the right information, and give them quick feedback, plus make learning more efficient, they become more willing to keep interacting with the technology, not just once (Wang & Wang, 2026). Thus, the way usefulness is perceived basically becomes a kind of motivational lever that pushes learners to participate actively in AI enabled educational settings (Chang & Li, 2026).

Also, this outcome looks consistent with wider technology adoption studies, where perceived usefulness is repeatedly described as one of the most powerful drivers behind technology acceptance, and long term engagement (Mohd Daud, 2026). Earlier education based research has said something similar too, that learners often put in more effort, and pay more attention, to technologies that show clear academic benefits. In that sense, this study builds on the existing understanding by looking at AI supported learning in Saudi higher education, and confirming that students views about the practical value of AI technologies are strongly tied to whether they stay engaged (Dai et al., 2026). The result suggests that universities should demonstrate the educational advantages of AI applications to strengthen student involvement and maximize the benefits associated with AI enhanced learning environments.

The results revealed that AI self efficacy exerted a rather significant positive effect on AI learning engagement, supporting H2 ($\beta = 0.351$, $p < 0.001$). It is remarkable that AI self-efficacy is the strongest predictor of learning engagement of the three antecedents. It suggests that students who are sure in their abilities to use AI technologies effectively will be more engaged in AI learning. When the students are confident in their learning process, they would show greater motivation to do the tasks. As a result, they are able to work with AI more comprehensively (Liu et al., 2026).

The observations in this study can be explained from both educational and psychological points of view. It is well-known that self-efficacy plays an important role in a person's learning behavior (Vivas-Urias et al., 2026). Previous studies show that self-efficacious learners are likely to show greater motivation and to know how to deal with technical problems (Yilmaz et al., 2026). This research confirms the correlation between self-efficacy and the learning process in the era of AI technologies. Students with a high level of self-efficacy will probably be free from technological anxiety when using AI learning. This finding demonstrates that boosting students' skills in AI by means of training may have considerable influence on engagement as compared to simply relying on having the technology at disposal. Therefore, self-assurance becomes very important personal asset for utilization of AI technologies to the full.

The results supported the idea that AI support from educational institutions had a significant impact on students' engagement in AI learning and thus confirmed hypothesis H3 ($\beta = 0.304$, $p < 0.001$). It means that satisfaction with the level of technical support influences the level of engagement in the process of learning supported by AI technologies, as students learn that with sufficient technological support from their universities they can be much more actively involved in learning with the use of innovative technologies. Consequently, with such support in place, those problems usually associated with the adoption of AI technologies become much less serious, and students at universities are provided with enough possibilities to use AI technologies for studying (Sun & Liu, 2026).

The results of this study also confirmed the conclusions from many previous studies, showing how the supportive learning environments have encouraged technology use (Shafiq et al., 2026). The existing body of knowledge suggests that schools play an essential role in making students engaged in learning because of what they do concerning resources and the provision of support (Cabero-Almenara et al., 2026). Our research results provide an additional layer to what has been known by showing that the actions of schools help in the context of AI learning environments. When students know that universities provide them with stable access to the platforms, knowledge, advice, and materials, they become more involved in the usage of AI tools.

Moreover, institutional commitment can also be interpreted as a proof of AI tools' credibility and learning validity (Noushad, 2026). This leads to the very important conclusion that students can utilize AI in their life processes instead of perceiving it as something unnecessary (Tang & Wang, 2026). Thus, in order for universities to boost student participation when it comes to the application of AI, it is insufficient for them to focus merely on these technologies. It is important to build a support infrastructure that allows for a successful implementation of these tools and ensures good educational participation and engagement.

The results backed up H4 since they showed that there is a statistically significant positive relationship between the perceived value of AI and self-regulated learning ($\beta = 0.276$, $p < 0.001$). This means that students who think that AI technologies serve a useful purpose are more inclined to exhibit autonomous learning behavior, i.e. planning, observing, and evaluating their academic performance (Meishar-Tal & Amzalag, 2026). Also, the more students understand the benefits of using AI technologies, the more willing they are to apply these technologies in their studying process so that they make their study process more productive (Sousa & Cardoso, 2025).

The outcomes are consistent with numerous educational technology findings, as it is assumed that a perception of usefulness is beneficial for independent and strategic learning behaviors. Students who find AI beneficial for learning are likely to use it for feedback, prioritization, progress tracking, and adjustment of learning strategies (Sharmin et al., 2026). The findings point out that perceptions of usefulness are not just a part of "tech acceptance," but they help students manage their learning processes (Wang & Zhang, 2026). In AI learning environments, students receive a large amount of information and multiple learning opportunities, but real learning gains will occur only if the resources are used in a purposeful manner (Al-atrash et al., 2026). Therefore, perceived usefulness seems to create a certain responsibility of students for learning effectiveness and motivate them to benefit from AI's possibilities for their academic improvement; however, it proves the need for students to have a clear idea of how AI works in order to make learning more effective.

The findings lent credibility to hypothesis 5 as AI self-efficacy was demonstrated to have a positive impact on self-regulated learning ($\beta = 0.279$, $p < 0.001$). The implication of this is that students, who master AI technology, are able to learn on their own independently. Those who have confidence in AI use, therefore, show sufficient skills and capabilities to set goals, keep track of their progress, adjust the strategies employed for learning, etc (Essel et al., 2026).

This corresponds well with the broader education literature according to which self-efficacy is considered to be an important predictor of self-directed learning behavior (Phung et al., 2026). Numerous studies confirm that more self-confident learners tend to be relatively more active, to persist, and to bounce back from academic challenges (Nguyen & Nguyen, 2026). Hence, this study shows that the process of gaining AI confidence is similar to that of increasing overall self-efficacy. Studying in AI-enhanced learning environment, more self-confident students are more likely to utilize advanced features of AI, analyze the information produced by AI, and to solve academic problems independently (Fahmawee, 2026). Lower the confidence lower the willingness to make the most of AI (and thus to develop self-regulation). This means that training students in using AI might be useful for promoting independent learning.

The results revealed that institutional support from AI did indeed positively influence self-regulated learning, providing evidence for H6 ($\beta = .339$, $p < .001$). Among the three antecedents, institutional AI support seemed to be the most salient predictor, effectively setting the tone for the entire self-regulated learning image. Hence, universities appear to play a significant role in assisting their students in a more independent way, by not only instructing them on what to do but also providing them with AI relevant support.

This finding is in accordance with what the previous literature has indicated, indicating that learning conditions are important to the development of more autonomous learning capabilities (Bilgiç & Sever, 2026). Namely, previous research has illustrated that self-regulated learning increases when students get the necessary resources, education, and somewhat straightforward guidance (Böhmer et al., 2026). In this study, the authors build on that literature by demonstrating that institutional support is essential for self-regulated learning, specifically in conditions of AI support in teaching. When the students can access the AI technologies, participate in the workshops, receive technical support, and engage in various initiatives aimed at raising the AI literacy among educators and learners, they gain the opportunities to control their learning more effectively. Moreover, by staying supportive, institutions lower the level of uncertainty that people experience with technology, thus allowing them to focus on improvements they can make rather than on technology issues which they might face (Chick et al., 2026). What is shown in the study basically proves that investments in the AI infrastructure and students support contribute to the self-regulated learning experience of students.

The results proved that AI engagement had a significant impact on AI enhanced learning outcomes, thus confirming H7 ($\beta = 0.344$, $p < 0.001$). This finding means that learners take part actively in AI assisted education to ensure effective learning outcomes. Engagement denotes careful cognitive effort, emotional involvement, and active participation, thus promoting the proper application of AI technologies while educating in schools (Colclasure et al., 2025).

The conclusion of this study corresponds to findings, presented in many studies and academic papers where learner engagement is outlined as an influential factor contributing to the success of academic performance (Stone, 2025). According to previous studies, engaged learners are more likely to make an effort, stay focused, and participate in the learning process (Okulich-Kazarin et al., 2024). Similar trends are found in modern AI-assisted learning environments as students, who communicate with AI devices, learn how to use available resources effectively, analyze AI information critically, ask for clarifications, and apply this knowledge in their academic work. All of the above helps to achieve better learning results. Besides, this is indicative of the fact that the use of AI technologies does not guarantee positive results unless students actively interact with these instruments. Therefore, it is recommended that universities make use of strategies aimed at enhancing students' engagement in AI technologies learning.

The results confirmed H8 through the demonstration that self regulated learning has a positive impact on AI-aided learning results ($\beta = 0.461$, $p < 0.001$). In addition, self regulated learning was the most potent predictor of educational outcomes in the framework. This finding shows that students' capacity to plan, follow up, assess, and adjust their studying is of paramount importance for success in AI-assisted education.

The result obtained is quite identical with what was established in previous education studies, which had recognized self-regulation as one of the main determinants of educational success (Zembylas, 2023). Numerous researches proved that students reach better outcomes while regulating their learning process (Campillo-Ferrer et al., 2025). The given research is an affirmation of the idea that the facts described are true and essential for educational activities. AI technologies provide plenty of information, feedbacks and support, however, the student needs to manage these resources with the purpose of receiving appropriate educational benefits (Fošner & Aver, 2025). The fact that self-regulated learning proved to be of higher effect size than learning engagement confirms the significance of internal learning management process. Thus, it is evident from the results that successful AI educational practices depend on not only technological development but also on the students' ability manage their learning experience.

The mediating effect of AI learning engagement was revealed by the mediation analysis carried out through the study; this confirms hypothesis 9a, 9b, and 9c. The findings confirm that the positive views of AI, confidence in using AI, and institutional support worked to create good educational outcomes due to greater participation in the AI-supported learning activities.

The findings corroborate previous educational literature claiming that engagement plays a vital role in connecting educational inputs and learning outcomes (Huang et al., 2026). Prior research has highlighted that technological tools and personal skills don't cause academic achievement on their own unless learners are actively involved (Zhao et al., 2026). The current findings further confirm this hypothesis as they show that engagement serves as an essential path in which AI-related factors lead to teaching advantages. Thus, learners with a positive attitude towards AI, good confidence in using AI technologies, and sufficient support from educational institutions are likely to be more involved in AI-led learning (Bilgiç & Sever, 2026). Moreover, even though all three indirect effects are statistically significant, AI self-efficacy demonstrated the biggest effect on engagement. In this connection, confidence-building programs are crucial for establishing effective interaction with AI technologies.

The findings indicated that self regulated learning significantly mediated the relationships between perceived usefulness of AI, AI self efficacy, institutional support for AI, and AI learning outcomes in support of hypotheses H10a, H10b, and H10c. Importantly, the strongest indirect effect was established between institutional support for AI and learning outcomes with self regulated learning acting as a mediator. Therefore, it is obvious from the research findings that the antecedents associated with AI are useful for education through strengthening students' ability to self learn.

This result corroborates the conclusions made in previous educational studies, which underline the importance of self-regulated learning as a facilitator of the relationship between resources and abilities and academic success (Duncan, 2026). According to the research, existing literature emphasizes that successful implementation of educational technologies is only possible when students make use of the potential given by these technologies in a strategic way (Liu, 2026). The analysis shows that AI technologies follow the path of previous technologies. Students who see AI as helpful, believe in their ability to use AI, and get help from the institutions are able to plan, monitor, reflect, and adjust their strategies in the most effective way (Finkelstein & Soffer-Vital, 2025). All self-regulated learning behaviors mentioned lead to improved learning outcomes. The path of strong institutional support shows the importance of the role of universities in the development of students' self-regulated learning skills (Chen & Anyanwu, 2025).

6. Theoretical Implications

The research contributes several applicable findings in terms of literature on AI supported learning in higher education. First of all, the study offers an innovative framework comprising technological perceptions, individual capabilities, institutional factors and learning process variables that is validated throughout the study. Unlike previous studies examining these variables separately, this study provides evidence for their simultaneous work in the context of a single model. In addition to that, the study enhances the understanding of how AI-related variables can be utilized in the study of the educational outcomes due to combination of AI learning engagement and self-regulated learning as mediating variables. The evidence suggests that availability of technological advancements and positive perception of their use is not enough for achieving benefits of learning without active engagement in learning process and adequate management of learning process by students. Moreover, it is highlighted in the study that self-regulated learning plays a crucial role in achieving AI-enhanced educational outcomes. By providing empirical verification of the proposed relationships within this context, the study enriches the global understanding of AI enabled learning and offers a comprehensive theoretical foundation for future investigations examining educational outcomes associated with emerging AI technologies.

7. Practical Implications

These findings can be used in practice by higher education administrators, educators, and policymakers who are eager to make full use of the educational advantages that AI technologies can provide. To start with, educational organizations need to perform activities enhancing students' AI self efficacy via different training courses, seminars, and practical training opportunities. As self efficacy became the strongest predictor of AI learning engagement, it is important to note that aiming to increase students' self efficacy would lead to greater learning involvement. Secondly, institutions should further improve support for the use of AI technologies in education by investing in easy-to-use platforms, technical support, equipment, and AI literacy programs. Information derived from this study shows that providing support from institution is extremely important to self regulated learning development. Thirdly, teachers should focus on demonstrating the benefits of AI technologies by showing students how the provided tools can be useful for their studies and researches. Studying the usefulness of AI may result in its increased adoption. Fourthly, curriculum developers should include activities aimed at teaching students self regulated learning skills such as setting goals, monitoring the process, and evaluating learning strategies. Collectively, these actions can support the successful integration of AI technologies within higher education and contribute to improved student achievement and learning quality.

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Appendix A

Variable	Items	Statements
AI-Enhanced Learning Outcome	AIELO1	AI-based learning tools have improved my academic performance.
	AIELO2	I feel that AI-supported learning helps me retain information better.
	AIELO3	I can complete assignments and tasks more efficiently with AI assistance.
	AIELO4	AI tools have enhanced my critical thinking and problem-solving skills.
	AIELO5	My overall learning experience is enriched with the use of AI technology.
	AIELO6	AI-supported learning has improved my ability to achieve my learning objectives.
Institutional AI Support	IAIS1	My institution provides resources to support AI-based learning.
	IAIS2	Training on using AI tools for learning is available at my institution.
	IAIS3	The institution encourages the use of AI tools in educational activities.
	IAIS4	My institution has clear policies on AI use in education.
Student Perceived Usefulness of AI	SAILE1	AI technologies are useful for improving my academic performance.
	SAILE2	AI technologies help me complete my learning tasks more effectively.
	SAILE3	AI technologies help me access useful information for my studies.
	SAILE4	AI technologies make my learning more efficient.
Students AI Learning Engagement	SAISE1	I actively participate in learning activities that involve AI technologies.
	SAISE2	I devote considerable effort to learning when I use AI tools.
	SAISE3	I remain focused when using AI technologies for my studies.
	SAISE4	I regularly interact with AI tools to support my learning.
Students AI Self-Efficacy	SPUAI1	I am confident in my ability to learn and use AI tools for my studies.
	SPUAI2	I can troubleshoot minor problems when using AI technology for learning.
	SPUAI3	I feel capable of using AI tools effectively for my studies.
	SPUAI4	I believe I have the necessary skills to benefit from AI technology in education.
Students Self-Regulated Learning	SSRL1	I set goals for what I want to achieve in my learning.
	SSRL2	I monitor my progress while studying with AI-supported learning tools.
	SSRL3	I evaluate whether my learning strategies are helping me achieve my academic goals.
	SSRL4	I change my learning strategies when I find that they are not effective.