The Impact of AI Use in Learning and Digital Material Accessibility on Students' Academic Achievement through Technology Engagement as a Mediating Variable

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Abstract: In the rapidly evolving digital era, the use of Artificial Intelligence (AI) in learning and the accessibility of digital materials have increased, offering opportunities to enhance students' academic achievement. However, the effectiveness of AI usage depends on the technology itself and how students engage with it. This study aims to understand how AI and digital material accessibility contribute to academic achievement through students' engagement with technology. The research employs a quantitative approach with a survey method using SEM-PLS data analysis to explore the relationships between the relevant variables. A purposive sampling technique is used to select samples that meet specific criteria. The research sample consists of 162 students in Malang, Indonesia, with data collected via an online questionnaire. This study shows that the use of AI in learning among students in Malang, when combined with effective digital material accessibility, has been proven to have a positive and significant impact on their academic performance, with technology engagement serving as an important mediating variable. AI, by enhancing competence, autonomy, and intrinsic motivation, helps students achieve their academic goals, increases their efforts, and provides higher self-satisfaction.

Article History

Key Words:
AI Use;
Digital Material Accessibility;
Academic Achievement;
Technology Engagement;
TPB Theory;
UTAUT Theory.

Introduction

In the rapidly evolving digital era, the use of Artificial Intelligence (AI) across various aspects of life has become a necessity. In the education sector, AI is utilized to streamline administrative processes, support learning, and enhance access to digital materials. AI enables personalized learning, where students can learn at their own pace and according to their own learning styles, potentially improving academic performance (Bhutoria, 2022). However, the effectiveness of AI in education depends on both the technology itself and how students engage with it, often referred to as technology engagement. This engagement includes how actively students use and leverage the technology provided and how they adapt to it in the learning context.

Globally, the integration of AI in education has become a major focus in many developed countries, where AI is used to personalize learning experiences, identify individual student needs, and provide more interactive and adaptive learning materials. In the United States, for instance, universities such as Stanford and MIT have developed AI-powered learning platforms that allow students to learn according to their preferences and needs (Kamalov et al., 2023). In the UK, the University of Edinburgh has implemented AI to provide real-time feedback to students during the learning process (Edinburg, 2023). Meanwhile, in Singapore, the government has launched the Smart Nation initiative, which aims to improve the quality of education through the use of AI (Sipahi & Saayi, 2024). Studies conducted in these countries indicate that AI application in education can enhance learning efficiency, enabling students to learn faster and more effectively. However, a major challenge is ensuring that students are truly engaged and making optimal use of the technology. Student engagement with AI technology remains a key factor in determining the success of AI implementation in education.

In Indonesia, the use of AI in education is still in its early stages of development. Although some leading universities, such as Universitas Indonesia and Institut Teknologi Bandung, have started adopting AI technology, its implementation is still limited to a few areas, such as academic guidance chatbots and data analysis for measuring student performance. Data from the Ministry of Education and Culture shows that only about 10% of universities in Indonesia have adopted AI technology in their educational processes (Pers, 2024). One of the

biggest challenges is the lack of adequate infrastructure, particularly outside major cities. Limited access to digital materials, especially in remote areas, poses a significant barrier to the digitization of education in Indonesia. Additionally, technology engagement among students also needs improvement. Many students are not yet accustomed to using AI technology in learning, which leads to suboptimal use of the technology and, ultimately, no significant improvement in their academic performance (Hakim, 2022).

In Malang, efforts to increase AI use and digitalization of learning materials have been made by several higher education institutions, such as Universitas Brawijaya and Universitas Negeri Malang (Maulina, 2024; Prasetya, 2024). Both universities have begun implementing various AI technologies, including chatbots for academic consultations and AI-based learning systems aimed at facilitating students' access to educational materials. However, the effectiveness of these implementations remains uncertain. Despite the availability of technology and increasing access to digital materials, technology engagement among students remains relatively low. According to an internal survey conducted by Universitas Brawijaya, about 40% of students rarely use the provided AI technology, citing lack of understanding, inadequate training, and resistance to new technology as the main reasons.

Students in Malang, particularly at Universitas Brawijaya and Universitas Negeri Malang, still face challenges in adapting to this technology. Limited digital literacy, a lack of confidence in using new technology, and minimal support from the university are major barriers to their engagement with AI. Consequently, despite the significant potential to enhance academic performance through the use of AI, the anticipated outcomes have not yet been fully achieved. This observation suggests that higher education institutions in Malang need to develop more effective strategies to improve technology engagement among students. This could be achieved through more intensive training programs, more interactive learning approaches, and enhanced digital literacy, to ensure that AI implementation in education truly impacts students' academic performance positively.

Previous research indicates that the adoption of AI in learning has significant potential to enhance learning effectiveness and academic outcomes. However, there are also studies suggesting that these outcomes are not always significant and depend on various contextual factors, including student technology engagement. Studies demonstrating significant effects generally argue that AI in learning can improve the educational experience through personalized content, real-time analysis of student performance, and providing quick and adaptive feedback. Students can learn in a more interactive way tailored to individual needs, which can, in turn, increase motivation and engagement in the learning process with AI (Seo et al., 2021). Higher engagement is often linked to improved academic performance because more engaged students tend to be more consistent in their studies, have a better understanding of the material, and are better able to achieve their academic goals. From a theoretical perspective, technology engagement as a mediator is an important element in explaining why the use of AI and digital material accessibility can lead to improved academic performance. Self-Determination Theory (SDT) emphasizes the importance of fulfilling basic psychological needs such as competence, autonomy, and relatedness, all of which can be facilitated through the use of technology in education. When students feel more competent and have control over their learning through AI and digital materials, they are more intrinsically motivated to learn, which ultimately can result in better academic performance (Chiu et al., 2023).

Conversely, some studies have found no significant impact of AI use and digital material accessibility on academic performance, especially when technology engagement is not strong or well-facilitated. One major reason proposed is that technology, no matter how advanced, cannot fully replace the role of human interaction, such as support from lecturers and peer learning. If students do not engage deeply with the technology or feel unsupported in its use, AI and digital materials may only serve as auxiliary tools without a significant impact on academic outcomes (Jaysone, 2024). Additionally, technical barriers, such as access difficulties or technology complexity, can also reduce the effectiveness of AI in supporting

learning (Ali et al., 2024), ultimately making its impact on academic performance insignificant. In this context, the Unified Theory of Acceptance and Use of Technology (UTAUT) highlights that the intention to use technology and expected outcomes are heavily influenced by perceptions of ease of use and available support. When students perceive technology as difficult to use or lack adequate support, they tend to engage less actively, which then diminishes the positive impact of the technology on their academic performance (Sampasa-Kanyinga et al., 2022). This indicates that the success of implementing AI and digital materials in improving academic performance heavily depends on the context and quality of technology application.

The research gap emerging from these findings lies in the need to gain a deeper understanding of the conditions and factors influencing the extent to which AI use and digital material accessibility can enhance academic performance. While there is evidence supporting positive effects, variables such as technology engagement are not yet fully understood in this context. Further research is needed to clarify where, when, and how AI and digital materials can significantly enhance academic performance and to identify barriers that may reduce their impact. Research should also explore the role of technology engagement as a mediator and the conditions that can strengthen or weaken this engagement in the learning process.

This study employs several relevant theories to support the accuracy of the results and impact of the research. The theory used for the variable of AI Use in Learning is the Theory of Planned Behavior (TPB). TPB is a social psychology theory introduced by Icek Ajzen in 1985 (Ajzen, 1985). TPB was developed as an extension of the Theory of Reasoned Action (TRA) by adding the concept of perceived behavioral control. TPB explains that an individual's behavior is influenced by the intention to perform that behavior, which is shaped by three main factors: attitude toward the behavior, subjective norm, and perceived behavioral control. In the context of learning, TPB helps understand how students decide to use AI in their learning process, considering their perceptions of the benefits and drawbacks of AI, social influences from their environment, and their self-efficacy in using the technology:

1. *Attitude toward technology use:* Students' perceptions of the benefits and drawbacks of using AI in learning, including positive impacts such as efficiency and personalization, as well as potential negative impacts like technology dependence.
2. *Subjective norm:* The influence of the social environment, such as peers, lecturers, or family, which can encourage or hinder students from utilizing AI in learning. This norm includes social expectations and pressure to adopt or reject the technology.
3. *Perceived behavioral control:* Students' beliefs about their ability to effectively use AI in learning, including access to technology, level of technological literacy, and support from educational institutions.

Next, the theory used for the variable of Digital Material Accessibility is the Unified Theory of Acceptance and Use of Technology (UTAUT). UTAUT, developed by (Venkatesh et al., 2003), integrates eight different theories and models related to technology adoption to explain technology use behavior. UTAUT states that the intention to use technology is influenced by four main constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions. In the context of digital material accessibility, UTAUT can be used to understand the factors affecting students' access to and use of digital resources in their learning:

1. *Performance expectancy:* The belief that using digital materials will enhance academic performance, such as by facilitating information retrieval, speeding up the learning process, or improving understanding of the material.
2. *Effort expectancy:* The ease of accessing and using digital materials, including user interface, device accessibility, and technology simplicity.
3. *Social influence:* The impact of others, such as friends, lecturers, or institutions, which encourages or hinders the use of digital materials. This also includes the technology culture among students and expectations for technology use in the academic environment.

4. *Facilitating conditions:* The availability of infrastructure and resources that enable students to access digital materials, such as stable internet connections, adequate devices, and technology training.

Third, for the variable of Technology Engagement, Self-Determination Theory (SDT) is used. SDT is a motivation theory developed by Edward Deci and Richard Ryan in 1985 (Watt & Richardson, 2015). SDT focuses on basic human psychological needs: competence, autonomy, and relatedness. The theory posits that individuals are motivated to engage in an activity when these needs are fulfilled. In the context of technology engagement, SDT explains how students engage with technology for learning, considering how capable they feel using the technology, their control over how they use it, and their sense of connection with others through technology:

1. *Competence:* The feeling of being capable and confident in using technology, including the ability to troubleshoot technical issues, navigate learning applications, and effectively use technology to support learning.
2. *Autonomy:* The degree of perceived freedom in using technology according to personal needs and preferences, such as choosing tools or platforms that best suit their learning style.
3. *Relatedness:* The sense of connection with others, such as lecturers or fellow students, through the use of technology. This includes social interactions, collaboration on tasks, and emotional support received through digital media.
4. *Intrinsic motivation:* The internal drive that motivates students to use technology without external coercion. This motivation can stem from curiosity, enjoyment of learning, or the desire to develop technological skills.

Based on the theories used in this study, the research hypotheses assume that AI use in learning is expected to enhance students' academic performance through increased personalization and adaptation of learning materials. AI provides students with opportunities to receive real-time feedback and access a broader and more relevant range of resources (Darvishi et al., 2024). According to the Theory of Planned Behavior (TPB) by Ajzen, positive attitudes towards AI, supportive subjective norms, and perceived behavioral control can encourage students to use AI more frequently in their studies, which in turn may improve their academic performance. Therefore, it is hypothesized that the use of AI in learning will have a positive and significant impact on students' academic performance.

Hypothesis$_1$: The use of AI in learning has a positive and significant effect on students' academic performance.

Digital material accessibility allows students to learn anytime and anywhere, providing greater flexibility in the learning process. Students can review lessons, deepen their understanding, and catch up more efficiently with easy access to digital materials (Riyadi & Sudiyatno, 2023). The Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al. supports that performance expectancy, effort expectancy, and adequate facilitating conditions can motivate students to effectively use digital materials, which then contributes to improved academic performance. Therefore, it is hypothesized that digital material accessibility has a positive and significant effect on students' academic performance.

Hypothesis$_2$: Digital material accessibility has a positive and significant effect on students' academic performance.

Technology engagement, reflecting students' active involvement in using technology during the learning process, is considered a key factor in academic achievement. According to Self-Determination Theory (SDT) by Deci and Ryan, the fulfillment of needs for competence, autonomy, and relatedness through technology use can enhance students' intrinsic motivation. Students who are deeply engaged with technology in learning are likely to be more motivated to study and achieve their academic goals (Balalle, 2024). Therefore, it is hypothesized that technology engagement has a positive and significant effect on students' academic performance.

Hypothesis$_3$: Technology engagement has a positive and significant effect on students' academic performance.

The use of AI in learning directly influences academic performance and can enhance students' technology engagement, which in turn strengthens the positive impact of AI on academic outcomes. AI, by providing interactive and adaptive learning experiences, can make students more engaged in the learning process, thereby increasing their motivation to study more intensively (Kaledio et al., 2024). Students are likely to achieve higher academic results with this increased engagement. Therefore, it is hypothesized that the use of AI in learning has a positive and significant effect on students' academic performance through technology engagement.

Hypothesis$_4$: The use of AI in learning has a positive and significant effect on students' academic performance through technology engagement.

Digital material accessibility allows students to access information and learning resources more easily and quickly, which can enhance their engagement with technology during the learning process. When students are more engaged with the materials they access digitally, they tend to learn more effectively and achieve better academic results (Sappaile et al., 2023). Based on UTAUT and SDT, the combination of good material accessibility and active technology engagement is expected to result in a significant positive impact on students' academic performance. Therefore, it is hypothesized that digital material accessibility has a positive and significant effect on students' academic performance through technology engagement.

Hypothesis$_5$: Digital material accessibility has a positive and significant effect on students' academic performance through technology engagement.

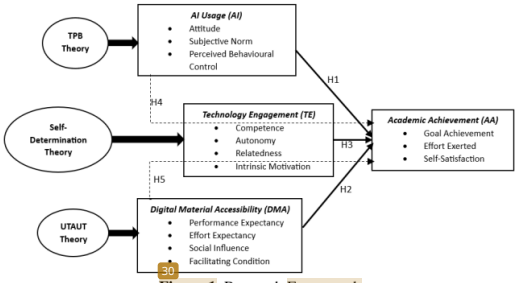

Figure 1. Research Framework

This study aims to investigate a model that integrates Theory of Planned Behaviour (TPB), Unified Theory of Acceptance and Use of Technology (UTAUT), and Self-Determination Theory (SDT) in the context of AI Use in Learning and Accessibility of Digital Materials on Student Academic Achievement, with a particular focus on the mediating role of Technology Engagement. Thus, this research is expected to contribute to the development of more effective learning strategies by leveraging AI technology and optimal digital accessibility.

Research Method

The research employs a quantitative approach, as it requires the collection of numerical and statistical data to meet scientific standards characterized by empirical, objective, measurable, rational, and scientific attributes (Igwenagu, 2016). In this study, AI use in learning and digital material accessibility are considered external factors (independent variables), while

students' academic performance is viewed as the dependent variable influenced by these external factors, with technology engagement acting as a mediating variable.

This study utilizes a survey design, with data collection conducted through an online questionnaire (Google Forms). The questionnaire is designed using a Likert scale to measure students' perceptions of AI use in learning, digital material accessibility, technology engagement, and academic performance from June to August 2024. The population for this research consists of undergraduate students in Malang who are enrolled from 2021 to 2024, have taken courses related to technology, are active in technology-related organizations both on and off campus, and possess proficiency in using technology for learning. Purposive sampling techniques are used to select a sample that meets specific criteria. The sample comprises 162 students chosen from an initial 177 respondents who completed the online questionnaire.

The collected data is analyzed using Structural Equation Modeling-Partial Least Squares (SEM-PLS), facilitated by SmartPLS 3.0 software. SEM-PLS analysis includes two main categories of relationships: the outer model which evaluates convergent validity, discriminant validity, and measurement reliability (Hair et al., 2011). Additionally, the inner model is assessed through R-square and Q-square analyses, and hypothesis testing to validate the proposed relationships.

Table 1. Characteristics of the Respondents

Demographic		Frequency	Percentage
Institution	Universitas Brawijaya	71	43.83%
	Universitas Negeri Malang	46	28.40%
	UIN Malang	4	2.47%
	UMM	11	6.79%
	Universitas Islam Malang	7	4.32%
	Universitas Merdeka Malang	11	6.79%
	Etc	12	7.41%
	Total	162	100%
Year Class	2021	19	11.73%
	2022	71	43.83%
	2023	52	32.10%
	2024	20	12.35%
	Total	162	100%
Gender	Male	77	47.53%
	Female	85	52.47%
	Total	162	100%
Age	17-23 years	138	85.19%
	24-30 years	19	11.73%
	31-37 years	5	3.09%
	>37 years	0	0%
	Total	162	100%
Subject	Economics	10	6.17%
	Accounting	12	7.41%
	Management	22	13.58%
	Computer Science	36	22.22%
	Business Administration	67	41.36%
	Education Technology	15	9.226%
	Total	162	100%
AI Usage & Digital Material Accessibility	Chatbots	162	100%
	Khan Academy	162	100%
	edX	162	100%
	Grammarly	162	100%
	Quillbot	162	100%
	IBM Watson	162	100%
	Moodle	162	100%
	Read&Write	162	100%
	Google Scholar	162	100%

	ResearchGate	162	100%
	Google Drive	162	100%
	Dropbox	162	100%
	Zoom	162	100%
	Google Meet	162	100%
	Total	162	100%
Location	Malang	162	100%

In this survey, Universitas Brawijaya was the most represented institution, with 71 participants, accounting for approximately 43.83% of the total respondents. In terms of year class, students from the 2022 cohort were the most numerous, also with 71 participants, making up 43.83%. In the gen category, female participants outnumbered males, with 85 individuals representing 52.47% of the total respondents. The age group of 17-23 years was the largest, with 138 participants or 85.19% of the total. Regarding the field of study, Business Administration was the most popular subject, chosen by 67 participants, which represents 41.36% of the total respondents. All respondents, totaling 162 individuals, indicated yes for AI usage, reflecting a high level of technology adoption. Lastly, all participants were from Malang, covering 100% of the survey's total respondents.

Result and Discussion

Outer Model

In the initial phase of the Structural Equation Modeling-Partial Least Squares (SEM-PLS) analysis, the focus is on evaluating the outer model to ensure the constructs meet essential validity and reliability criteria. This stage is crucial for confirming that the data used is both accurate and consistent for further analysis.

Convergent Validity

Convergent validity examines whether indicators within a construct have strong correlations with each other. To establish this, each manifest variable should ideally have a loading factor greater than 0.70 when assessed using SmartPLS 3.2 software. This criterion ensures that indicators are effectively measuring the same underlying construct. In our analysis, as detailed in Table 2, all indicators associated with the constructs demonstrate loading factor values above 0.70. This confirms that the constructs achieve the necessary level of convergent validity, indicating that the measures are consistently reflecting the intended constructs.

Discriminant Validity

Evaluating discriminant validity involves comparing the square root of the Average Variance Extracted (AVE) for each construct with the correlations among constructs. Discriminant validity is confirmed if the square root of the AVE for a construct is greater than its correlations with other constructs. This comparison ensures that each construct is distinct and not overly correlated with others. According to the analysis shown in Table 3, the model meets the discriminant validity criteria, evidenced by the higher squared AVE values relative to the correlation values. This finding indicates that each construct is sufficiently distinct from the others.

Reliability Test

Reliability testing involves evaluating Cronbach's Alpha and Composite Reliability to ensure the consistency and dependability of the constructs. For constructs with reflexive indicators, acceptable reliability is indicated by values exceeding 0.60. This threshold ensures that the constructs reliably measure their respective variables. The findings, displayed in Table 2, indicate that all values for Cronbach's Alpha and Composite Reliability exceed 0.60. This confirms that the research constructs demonstrate satisfactory reliability, validating that the constructs are measured consistently across different indicators.

Table 2. Measurement Model Analysis

Variable	Item	Factor Loading	Cronbach's Alpha	Composite Reliability	AVE
AI Usage (AI)	AI.1	0,739	0,796	0,782	0,666
	AI.2	0,822			

	AI.3	0,810			
Digital Material Accessibility (DMA)	DMA.1	0,731	0,762	0,761	0,647
	DMA.2	0,749			
	DMA.3	0,755			
	DMA.4	0,771			
Technology Engagement (TE)	TE.1	0,782	0,719	0,730	0,642
	TE.2	0,784			
	TE.3	0,739			
	TE.4	0,725			
Academic Achievement (AA)	AA.1	0,720	0,722	0,726	0,639
	AA.2	0,776			
	AA.3	0,785			

Table 3. Discriminant Validity

Var/Ind	CH	EE	IB	SEI
AI.1	**0,739**	0,345	0,352	0,363
AI.2	**0,822**	0,413	0,319	0,342
AI.3	**0,810**	0,438	0,400	0,445
DMA.1	0,417	**0,731**	0,462	0,429
DMA.2	0,346	**0,749**	0,311	0,380
DMA.3	0,359	**0,755**	0,333	0,354
DMA.4	0,377	**0,771**	0,345	0,411
TE.1	0,314	0,413	**0,782**	0,318
TE.2	0,302	0,499	**0,784**	0,365
TE.3	0,327	0,467	**0,739**	0,349
TE.4	0,355	0,466	**0,725**	0,419
AA.1	0,344	0,397	0,496	**0,720**
AA.2	0,349	0,307	0,452	**0,776**
AA.3	0,382	0,350	0,404	**0,785**

Inner Model

The next phase of SEM-PLS analysis involves testing the inner model, which uses R-square, Q-square, and hypothesis testing methods to evaluate the model's performance.

R-Square

R-square assesses the extent to which exogenous constructs influence endogenous constructs. According to Table 4, an R-square value of 0.502 indicates that variables such as AI Usage and Digital Material Accessibility account for 50.2% of the variance in Technology Engagement. The remaining 49.8% of the variance is attributed to factors not covered by this study. Additionally, an R-square value of 0.546 shows that AI Usage, Digital Material Accessibility, and Technology Engagement collectively explain 54.6% of the variance in Student Academic Achievement, with 45.4% of the variance attributable to external factors. As noted by (Hair et al., 2011), R-square values exceeding 0.50 signify that SEM models have acceptable explanatory power, demonstrating moderate-to-strong explanatory capability.

Q^2 Predictive Relevance

Predictive relevance is evaluated by calculating the Q^2 value, where a value greater than 0 indicates adequate predictive capability (Hair et al., 2011). The formula for computing Q^2 is: $= 1 - (1 - R1^2) \times (1 - R2^2)$. Using the obtained R-square values:

$Q^2 = 1 - (1 - R1^2) \times (1 - R2^2)$

$Q^2 = 1 - (1 - 0{,}502) \times (1 - 0{,}546)$

$Q^2 = 1 - (0{,}498) \times (0{,}454)$

$Q^2 = 1 - 0{,}226$

$Q^2 = 0{,}774$

A Q^2 value of 0.774 indicates the model's effectiveness in accurately predicting observed values (Hair et al., 2011).

Hypothesis Testing

Hypothesis testing assesses whether path coefficients are statistically significant, with a common threshold of a P-value less than 0.05 indicating a significant correlation (Hair et al., 2011). The results of hypothesis testing are detailed in Table 5. This evaluation ensures that the proposed relationships between variables in the model are significant and relevant, providing a robust foundation for further analysis.

Table 4. R-Square Test

No	Variable	R-Square
1	TE	0,502
2	AA	0,546

Table 5. Hypothesis Testing Results

Hypothesis	Path Coefficient	T Value	P Values	Decision
AI -> AA	0,499	6,912	0,000	**Significant**
DMA -> AA	0,387	7,162	0,000	**Significant**
TE -> AA	0,351	6,280	0,005	**Significant**
AI -> TE -> AA	0,212	3,511	0,015	**Significant**
DMA -> TE -> AA	0,240	2,882	0,025	**Significant**

The first hypothesis in Table 5 indicates that the implementation of Artificial Intelligence (AI) in learning has proven to have a positive and significant impact on the academic performance of students in Malang city. This finding supports the results of studies that have reported similar findings (Sugiarso et al., 2024). This can be explained through the framework of the Theory of Planned Behavior (TPB), which encompasses three main indicators: Attitude toward technology use, Subjective norm, and Perceived behavioral control. In the learning context, attitude toward technology use reflects the positive attitude of students towards the use of AI in learning. Students with a positive attitude tend to utilize technologies such as chatbots, Khan Academy, edX, Grammarly, Quillbot, and IBM Watson to aid their learning process. This attitude is driven by the belief that these technologies can enhance their understanding of the material, improve learning efficiency, and boost their academic outcomes. For example, the use of Grammarly and Quillbot in preparing academic assignments can improve the quality of students' writing, reduce writing errors, and expedite the writing process. This positive attitude ultimately contributes to the improvement of students' academic performance, which is measured through goal achievement, effort exerted, and self-satisfaction.

Furthermore, subjective norm in TPB refers to the social influence that encourages students to use AI in learning. In Malang city, there is strong encouragement from the academic environment, peers, and lecturers to utilize AI technology as part of their learning strategies. For instance, lecturers who promote the use of Khan Academy and edX in online classes can establish a social norm that supports the use of AI. When students feel that the people around them—both peers and lecturers—expect them to use AI in learning, they are more likely to be motivated to do so. This reinforces their learning effort, leading to improved academic achievement and satisfaction with the results they achieve. Perceived behavioral control in TPB relates to the extent to which students feel capable of using AI in their learning. The available AI technologies, such as chatbots, Grammarly, and IBM Watson, are designed to be user-friendly and accessible, thereby increasing students' confidence in using them. When students feel they have sufficient control and adequate ability to utilize AI, they are more likely to integrate this technology into their learning process. For instance, by using Grammarly, students can independently correct errors in essay writing, which in turn improves the quality of the assignments submitted and the final outcomes obtained. This confidence strengthens the effort exerted in learning, which directly contributes to enhanced academic performance.

The integration of AI in learning facilitates students in accessing learning materials and completing academic tasks, motivating them to work harder and achieve better results (Walter, 2024). The relevant use of AI, such as Khan Academy for concept learning, edX for online courses, Grammarly and Quillbot for academic writing, and IBM Watson for data analysis, all significantly improve the academic performance of students in Malang city. These technologies also enable students to receive quick and accurate feedback, which strengthens their self-satisfaction after achieving the desired outcomes. Overall, based on the TPB framework, it can be concluded that the use of AI in learning has a positive and significant impact on the academic performance of students in Malang city. Through the enhancement of positive attitudes towards technology, supportive social norms, and perceived behavioral control, AI has become an essential tool in achieving academic goals, increasing learning efforts, and providing self-satisfaction for students.

The second hypothesis in Table 5 indicates that the implementation of Digital Material Accessibility has a positive and significant impact on the academic performance of students in Malang city, which can be analyzed through the framework of the Unified Theory of Acceptance and Use of Technology (UTAUT). This framework includes four key indicators: Performance expectancy, Effort expectancy, Social influence, and Facilitating conditions, all of which play a crucial role in influencing how students use digital technology to access learning materials. This finding supports the results of studies that have reported similar findings (Sappaile et al., 2023). The first indicator, Performance expectancy, reflects the extent to which students believe that access to digital materials will enhance their academic performance. In Malang city, many students utilize platforms like Google Scholar, ResearchGate, Google Drive, and Dropbox to access and store learning materials, journal articles, and other academic resources. The belief that using these platforms will expedite and simplify access to relevant information encourages students to use them more frequently. For instance, Google Scholar and ResearchGate allow students to search for and access high-quality academic articles that support their research and assignments. This belief directly contributes to goal achievement, enabling students to complete tasks more quickly and efficiently, ultimately improving their academic performance.

The second indicator, Effort expectancy, refers to the ease of use of technology by students. Platforms such as Moodle, Read&Write, and Google Drive are designed to provide ease in accessing and managing digital learning materials. Students who find this technology easy to use are more likely to utilize it frequently in their learning process. For example, Moodle, a widely used e-learning platform in educational institutions in Malang, allows students to easily access course materials, submit assignments, and participate in online discussions. This reduces the effort exerted required to access learning materials, allowing students to focus more on understanding and mastering the content. Consequently, this ease of access has a direct impact on improving students' academic performance. Social influence, the third indicator, refers to the impact of the social environment, such as peers, lecturers, and family, on students' use of technology. In Malang city, the use of digital platforms like Zoom and Google Meet has become the norm in academic settings, especially in remote or hybrid learning situations. Encouragement from peers and lecturers to use these platforms for group discussions, lectures, or academic guidance creates a supportive environment. This social influence motivates students to actively use digital technology, which ultimately enhances their engagement in learning and helps them achieve academic goals. The result is an increase in self-satisfaction as students feel more capable of meeting academic demands.

The final indicator, Facilitating conditions, includes the infrastructure and resources available that support the use of technology. In Malang, easy access to the internet and necessary software like Google Drive, Dropbox, and Read&Write enables students to access and manage digital learning materials without significant technical barriers. This support ensures that students have everything they need to successfully utilize this technology in their learning. When students feel supported by an adequate technological environment, they are

more likely to effectively access digital materials (Hizqiyah et al., 2022), which enhances the quality of their learning and, in turn, their academic performance. Overall, based on the UTAUT framework, digital material accessibility has a positive and significant impact on the academic performance of students in Malang city. Students are able to achieve academic goals, increase effort in learning, and experience high self-satisfaction in their academic achievements with high performance expectations, ease of use, strong social support, and adequate facilitating conditions.

The third hypothesis in Table 5 indicates that Technology Engagement has a positive and significant impact on the academic performance of students in Malang city, which can be explained through the framework of Self-Determination Theory (SDT). SDT emphasizes the importance of four key indicators: Competence, Autonomy, Relatedness, and Intrinsic Motivation, all of which play a crucial role in driving student technology engagement in learning and enhancing their academic outcomes. This finding supports the results of studies that have reported similar findings (Teng & Wang, 2021). The first indicator, Competence, refers to the extent to which students feel capable and confident in using technology for academic purposes. In Malang city, students with a high level of competence in using technology, such as learning software, collaborative applications, and online assessment tools, are more likely to utilize them optimally in the learning process. Students who feel competent are more efficient in completing academic tasks, utilizing digital resources, and accessing essential information that can enhance their understanding of course materials (Farani, 2023). For example, the use of e-learning platforms integrated with technology such as interactive simulations or self-directed learning applications allows students to independently develop their academic skills, ultimately contributing to goal achievement.

Autonomy, the second indicator, refers to the ability of students to take initiative and make decisions regarding the use of technology in their learning. When students in Malang are given the freedom to choose tools and technological methods that suit their learning styles, they tend to be more motivated to actively engage in the learning process. This autonomy allows students to tailor their use of technology to their personal needs, which in turn increases the effort exerted in their studies. For instance, students who are given the freedom to choose between various online learning platforms or collaborative tools tend to be more active in using such technologies, contributing to the improvement of their learning quality and academic outcomes. The third indicator, Relatedness, refers to the need for students to feel connected to others, such as classmates, lecturers, or the academic community, through technology. Technology that facilitates collaboration and communication, such as online discussion platforms, virtual study groups, and academic social media, helps students in Malang feel more connected to their learning environment. This connectedness creates a supportive learning environment where students can share knowledge, discuss materials, and receive support from others. Social connectedness enhances their engagement in learning and strengthens their intrinsic motivation to strive harder in achieving academic goals, ultimately contributing to higher self-satisfaction after achieving desired outcomes.

Finally, Intrinsic Motivation, as a key indicator in SDT, refers to students' internal motivation to use technology in learning because they find it valuable and engaging. In Malang city, students with intrinsic motivation to use technology in their studies are more likely to be involved in academic activities that involve technology. This motivation is driven by the enjoyment and satisfaction gained from using technology to solve problems, complete tasks, and explore new materials. High intrinsic motivation encourages students to be more committed to the learning process (Manda, 2023), which positively impacts the effort exerted and the academic outcomes achieved. Overall, based on the SDT framework, technology engagement has a highly positive and significant impact on the academic performance of students in Malang city. Technology becomes an essential tool in supporting academic goal achievement, increasing study effort, and providing greater self-satisfaction for students by enhancing competence, autonomy, relatedness, and intrinsic motivation.

The fourth hypothesis in Table 5 indicates that AI Use in Learning has a positive and significant impact on the academic performance of students in Malang city, with Technology Engagement serving as a mediating variable that strengthens this relationship. AI in learning, through various tools and platforms such as chatbots, Khan Academy, edX, Grammarly, and Quillbot, provides ease of access and personalization that can enhance the effectiveness of the learning process. However, the direct impact of AI use on academic performance is greatly influenced by the extent to which students are actively engaged with this technology, as reflected in Technology Engagement. Technology Engagement involves four key dimensions according to Self-Determination Theory (SDT): Competence, Autonomy, Relatedness, and Intrinsic Motivation. When students use AI in learning, they leverage this technology for specific tasks and develop technological skills (competence) that help them optimize AI resources (Fitria, 2021). For instance, students who frequently use Grammarly to improve their writing will become more proficient in essay writing, which enhances the quality of their academic assignments. This engagement drives higher academic achievement as students feel more competent and confident in completing their tasks.

Furthermore, high Technology Engagement enables students to exercise autonomy in determining how they use AI to support their learning. This autonomy is crucial as students in Malang can choose the AI platforms that best suit their learning styles, such as using Khan Academy for better concept comprehension or edX for taking additional courses. This freedom encourages students to be more active and committed to the learning process, which ultimately increases the effort exerted and positively impacts their academic achievement. Additionally, technology engagement strengthens social relatedness among students, their classmates, and lecturers. AI technology that facilitates collaboration, such as through online discussions integrated into learning platforms, helps students feel more connected to their learning community (Kim et al., 2022). This connectedness creates a supportive learning environment where students can support each other in using technology to achieve their academic goals.

Intrinsic motivation also plays a crucial role in enhancing the impact of AI on academic performance through technology engagement. Students with high intrinsic motivation to use AI in learning tend to be more motivated to actively engage with this technology, not only because of academic demands but also because they find satisfaction and enjoyment in the process. This motivation drives them to put in more effort to achieve their academic goals, which ultimately increases self-satisfaction after achieving desired outcomes. Overall, AI use in learning in Malang city has a positive and significant impact on students' academic performance, but this impact is mediated by technology engagement. Technology engagement enables students to more effectively utilize AI in the learning process, ultimately improving their academic achievement, effort exerted, and self-satisfaction by enhancing competence, autonomy, social relatedness, and intrinsic motivation.

The fifth hypothesis in Table 5 indicates that AI Use in Learning has a positive and significant impact on the academic performance of students in Malang city, with Technology Engagement serving as a mediating variable that strengthens this effect. In the context of modern education, AI has become a highly influential tool, offering features such as personalized content, automatic feedback, and adaptive learning support (Darvishi et al., 2024). However, to fully maximize this impact, active student engagement with this technology is crucial. First, the use of AI platforms like Khan Academy, Grammarly, Quillbot, and various chatbots provides students with access to personalized educational resources tailored to their needs. However, the positive impact of this technology is truly felt when students actively engage with it. Technology Engagement plays a critical role in how students utilize AI to deepen their understanding of the material, complete tasks more efficiently, and receive constructive feedback.

This technology engagement encompasses several key aspects, such as technological competence, where students feel increasingly confident and capable of using AI in their learning activities. When students feel competent, they are more likely to take full advantage

of all the features AI offers, which in turn helps them improve their academic performance (Chan & Hu, 2023). For instance, regular use of Grammarly helps students develop better writing skills, which directly contributes to the quality of their academic assignments. Additionally, Technology Engagement enhances students' autonomy in learning. Students who have the freedom to choose AI tools that align with their learning styles are more motivated to actively participate in the learning process. This autonomy allows them to manage their study time more flexibly and tailor learning materials to their individual needs. For example, students using Khan Academy can learn at their own pace, which helps them achieve better results in exams or assignments.

Another aspect of Technology Engagement is social relatedness, where students feel more connected to their peers and instructors through the technological platforms they use. AI technologies that support collaboration and online interaction enable students to share knowledge, discuss, and receive support from others, which enhances their motivation to learn (Seo et al., 2021). This social connectedness creates a supportive learning environment, which ultimately positively impacts their academic performance. Intrinsic motivation gained through technology engagement also significantly contributes to improved academic performance. When students are intrinsically motivated to use AI in learning because they enjoy the learning process and see the direct benefits of the technology, they tend to invest more effort in academic activities. This motivation drives them to focus and commit more, leading to better academic outcomes. Thus, AI Use in Learning directly impacts academic performance, but this impact is mediated by Technology Engagement. Students who actively engage with AI technology tend to experience improvements in competence, autonomy, social relatedness, and intrinsic motivation, all of which contribute to higher academic achievement. Through this mediation, technology engagement ensures that the full potential of AI in learning is harnessed, ultimately leading to a significant improvement in the academic performance of students in Malang city.

Conclusion

The use of AI in learning among students in Malang, when combined with effective digital material accessibility, has proven to have a positive and significant impact on their academic performance, with technology engagement serving as an important mediating variable. AI, through enhancing competence, autonomy, and intrinsic motivation, helps students achieve their academic goals, increase their efforts, and provide greater self-satisfaction. By utilizing technologies and digital platforms such as Moodle, Google Scholar, and other online collaboration tools, students can access and use learning materials more efficiently, ultimately improving their academic outcomes.

Recommendation

To further optimize the positive impact of AI in learning, educational institutions in Malang should integrate specialized training programs for students on the use of AI technology and digital material accessibility. Additionally, adequate infrastructure support is necessary, such as improving internet quality and providing sufficient technological devices, to ensure that all students can access learning materials optimally. Developing a more flexible and adaptive curriculum that aligns with technological advancements is also important, so that technology engagement can continue to motivate students to achieve better academic performance.

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