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Strategic optimization of artificial intelligence digital learning in informatics engineering

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ABSTRACT

This study examines the strategic optimization of artificial intelligence (AI)-based digital learning in the Department of Informatics Engineering by analyzing the interaction between internal and external factors that influence successful implementation. Employing a qualitative approach based on strengths, weaknesses, opportunities, and threats (SWOT) analysis, this research utilizes the internal factor analysis summary (IFAS) and external factor analysis summary (EFAS) to assess institutional readiness, constraints, and strategic opportunities for AI integration in higher education. The results indicate that external factors exert a stronger strategic influence than internal factors, as reflected by a higher EFAS score (1.50) compared to the IFAS score (1.25). Key external opportunities include the increasing demand for AI competencies, supportive national policies, and opportunities for industry collaboration, while the main internal limitations are limited faculty expertise in AI and insufficient AI-specific learning resources. Based on these findings, this study formulates a SWOT-based strategic framework that converts analytical outcomes into practical recommendations for curriculum development, faculty capacity building, and the adoption of adaptive AI learning technologies. This research contributes a context-specific and empirically grounded strategic model that advances AI integration beyond descriptive analysis, supporting more effective, personalized, and sustainable digital learning, particularly within Informatics Engineering programs in Indonesian Islamic higher education institutions.

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1. INTRODUCTION

In recent years, the integration of artificial intelligence (AI) into various fields of education has garnered significant attention, particularly in higher education. One of the most critical areas of application is in the field of informatics, where AI technology has the potential to enhance the quality of teaching and learning. The Department of Informatics Engineering is at the forefront of this technological transformation, as students and educators strive to improve learning outcomes through innovative digital solutions. Digital learning strategies, which include tools such as AI-based learning platforms and adaptive learning systems,

are reshaping traditional educational methods [1]–[3]. These strategies not only improve the efficiency of knowledge delivery but also provide a personalized learning experience tailored to individual needs, thereby maximizing learning outcomes [4].

Despite these advancements, many academic institutions still struggle to fully integrate AI into their teaching strategies. A significant challenge lies in the limited understanding of how to effectively apply AI within the context of digital learning, particularly in specific disciplines such as informatics engineering. Previous studies have shown that the implementation of AI in education has opened opportunities for more personalized and effective learning. For instance, Almusaed *et al*. [5] identified the potential of AI-based learning platforms to enhance student engagement in higher education. Another study by Gligorea *et al*. [6] reviewed trends in the use of AI across various educational sectors, highlighting the adaptability of AI technology to support adaptive learning. Meanwhile, Dimitriadou and Lanitis [7] emphasized that teacher training in the use of AI technology is a key factor in the successful integration of AI in classrooms. As AI technology continues to evolve rapidly, so too does the demand for new strategies to optimize its use in the classroom [8]. Therefore, this study aims to explore how AI can be utilized to improve digital learning strategies in the Department of Informatics Engineering. This research focuses on analyzing current trends and proposing practical solutions for better implementation.

This study offers a novel contribution by focusing on the optimization of AI-based digital learning strategies in the Department of Informatics Engineering, an area that has been relatively unexplored in prior research [9]–[11]. While previous studies, such as Almusaed *et al*. [5], have highlighted AI's potential to enhance student engagement, and Gligorea *et al.* [6], have reviewed AI usage trends in the education sector, their approaches tend to be general and do not address the specific needs of the Informatics Engineering discipline. Furthermore, Dimitriadou and Lanitis [7] emphasized the importance of teacher training as a key factor in the successful integration of AI. Addressing these gaps, this research develops a framework for digital learning strategies that leverage AI specifically to improve learning outcomes, overcome educators' limited understanding, and maximize the use of adaptive technologies such as personalized learning systems and automated assessment tools [3], [12]. Thus, this study not only provides innovative solutions to internal and external challenges but also contributes to the enhancement of higher education quality and graduates' readiness to meet the demands of AI-driven industries [13]–[15].

To address this gap, this study introduces a context-specific and empirically grounded strategic framework for optimizing AI-integrated digital learning in the Informatics Engineering curriculum, responding to the lack of actionable models that translate AI adoption into concrete curricular and pedagogical practices in Islamic higher education [16], [17]. The principal contribution lies in the development of a strengths, weaknesses, opportunities, and threats (SWOT)-based (internal factor analysis summary (IFAS)–external factor analysis summary (EFAS)) strategic model that systematically aligns internal institutional readiness with external opportunities, enabling targeted, sustainable, and scalable AI integration beyond ad hoc technological implementation [18], [19]. By operationalizing AI-based tools such as adaptive learning systems, automated assessments, and intelligent tutoring, this framework provides a robust pathway for enhancing personalization, educational quality, and institutional competitiveness, particularly within state Islamic religious universities or *perguruan tinggi keagamaan islam negeri* (PTKIN) informatics-related programs [20]–[22].

The contribution of this research lies in its novel approach to combining AI technology with digital learning strategies specifically tailored to the needs of informatics engineering students. While previous studies have explored the application of AI in education more broadly, few have focused on the unique requirements of technical programs. By providing clear strategies for integrating AI within the context of the Department of Informatics Engineering, this study aims to set a precedent for future advancements in educational technology. Furthermore, this research will offer valuable insights for educators and institutions seeking to optimize their digital learning environments to better prepare students for the rapidly evolving demands of the job market.

2. METHOD

This study adopts a qualitative research approach using SWOT analysis to formulate strategies for optimizing AI-based digital learning in the Department of Informatics Engineering [23]. SWOT analysis is employed to systematically identify internal and external factors that influence AI integration in digital learning environments, enabling strategic evaluation rather than purely technical assessment [24]. Data were collected from multiple sources to ensure analytical rigor and triangulation. The primary data were obtained through in-depth interviews involving 15 respondents, consisting of 7 faculty members, 60 undergraduate students, and 2 academic administrators selected using purposive sampling based on their direct involvement in curriculum development and digital learning implementation [25]. Secondary data were gathered through

institutional document analysis, including curriculum guidelines, academic policy documents, and laboratory reports, complemented by a structured literature review on AI applications in higher education [26].

The qualitative data were coded and categorized into four SWOT dimensions-which were subsequently quantified using the IFAS and EFAS matrices. Each factor was assigned a weight based on its relative importance (ranging from 0.00 to 1.00) and a rating reflecting its impact (1 = very weak/poor to 4 = very strong/excellent) [27], [28]. The weighted scores were aggregated to produce overall IFAS and EFAS scores, which indicate the department's internal readiness and external strategic position. Higher EFAS scores signify stronger external opportunities relative to threats, while IFAS scores reflect internal capability to support AI-based learning [29]. In addition to the strategic SWOT analysis, this study proposes and evaluates a conceptual AI-enhanced digital learning framework to demonstrate technical feasibility. The framework consists of three layers: i) a data layer containing learning materials, student interaction logs, and assessment records; ii) an intelligence layer incorporating supervised machine learning algorithms, including decision trees and support vector machines (SVM), to model student learning behavior; and iii) an application layer that delivers adaptive learning content and monitoring dashboards for students and lecturers [30]–[32].

To evaluate the effectiveness of the proposed AI component, a simulation was conducted using anonymized historical academic data from 60 undergraduate students. The machine learning models were trained and tested using standard evaluation metrics, including precision, recall, and F1-score, to assess prediction accuracy, along with user satisfaction surveys to measure perceived content relevance and engagement [33]–[35]. The results indicate an improvement of approximately 15–20% in learner engagement and content relevance compared to a static digital learning model, providing empirical support for the potential effectiveness of the proposed AI-based learning strategy [36], [37]. Overall, the methodological process integrates qualitative strategic analysis with limited empirical evaluation to ensure that the proposed AI-based digital learning framework is both contextually grounded and practically viable. This approach enables the formulation of evidence-based and sustainable strategies for enhancing educational quality in the Department of Informatics Engineering [38].

3. RESULTS AND DISCUSSION

The SWOT analysis is employed to assess the integration of AI in learning within the Department of Informatics Engineering by identifying key SWOT [39], [40]. The analysis is based on qualitative data obtained from in-depth interviews with faculty members, students, and academic administrators, supported by institutional document analysis and relevant literature. These data were systematically coded and analyzed using IFAS and EFAS matrices to determine the department's strategic position. The resulting insights provide a strategic foundation for formulating effective and sustainable AI-based learning strategies that enhance educational quality and support the development of higher education within PTKIN [41], [42]

The SWOT analysis is used to identify and evaluate the SWOT related to the implementation of AI in the educational context. As presented in Table 1, the SWOT analysis summarizes these internal and external strategic factors. The results of the SWOT analysis presented in Table 1 provide a comprehensive overview of the SWOT faced by the Department of Informatics Engineering in integrating AI into the learning process. To harness the existing potential, strategic efforts are required to strengthen internal factors and maximize external opportunities, thereby enabling the effective and sustainable implementation of AI in education.

3.1. IFAS analysis

The IFAS is a method used to evaluate the internal strengths and weaknesses that influence an organization or entity's strategic position. Table 2 presents the results of the IFAS analysis, providing a detailed overview of these internal factors. Based on the results of the IFAS analysis, the Department of Informatics Engineering demonstrates significant internal strengths with a total score of 2.10. The availability of adequate technological infrastructure and the technological skills of faculty and students are key advantages supporting the integration of AI in learning. Additionally, the support of campus policies and the development of technology-based curricula further strengthen the department's readiness to implement AI.

The data in the IFAS table were derived through qualitative content analysis by systematically coding interview transcripts, institutional documents, and relevant literature into internal strategic factors. Each factor was assigned a weight and performance rating, validated by academic experts, including faculty and curriculum developers. Despite the department's strengths, the analysis revealed notable internal weaknesses, reflected in a total score of 0.85. Key challenges include limited faculty understanding of AI and the lack of dedicated educational resources, which hinder the optimization of AI integration. Furthermore, technical issues such as implementing AI-driven personalized learning and automated assessment systems require targeted solutions to ensure successful and sustainable application.

Table 1. SWOT analysis of AI-based digital learning implementation

SWOT factor	No	Category	Description
Strengths	1	Availability of technology infrastructure	The Department of Informatics has sufficient technology infrastructure to support AI in teaching [7].
	2	Skills of faculty and students	Faculty and students possess strong foundational skills in programming, algorithms, and data analysis, supporting the utilization of AI in education [43].
	3	Development of technology-based curriculum	The curriculum, which is starting to integrate the latest technologies, including AI, supports technology-based learning in the department [7].
	4	University policy support	University policies support the integration of technology, including the development of AI-based learning through research grants and innovation [38].
	5	Availability of research communities	There are research communities and laboratories focused on AI, allowing collaboration between faculty and students for innovative solutions [44].
Weaknesses	1	Limited understanding of AI among faculty	Faculty's understanding of AI implementation in education is still limited, hindering effective implementation in teaching [45].
	2	Lack of educational resources	The number of educational resources, including materials and AI-specific training for learning, is still inadequate [46].
	3	Difficulty with automated assessment and personalization	Technical challenges in implementing AI for personalization and automated assessment need to be addressed to improve accuracy and effectiveness [47].
	4	Dependence on foreign technology	Most software and AI solutions used are from foreign sources, creating dependency on foreign technology [48].
	5	Limited student knowledge on AI ethics	Students have limited knowledge of AI ethics, which is crucial for ensuring the responsible use of technology in learning [49].
Opportunities	1	Increased demand for AI-based education	The growing demand for AI skills in the industry creates an opportunity to develop a more relevant technology-based curriculum [50].
	2	Collaboration with industry and researchers	Opportunities to collaborate with technology industry and research institutions to support implementation of AI in teaching and research [51].
	3	Use of AI for personalized teaching	AI can be used to create adaptive learning experiences, enhancing students' learning through personalization [52].
	4	Government support	The government supports the implementation of technology in education through research grants and technology-based innovation programs [53].
	5	Development of local AI products	Opportunities to create local AI solutions for education, enhancing the value of education at both university and national levels [54].
Threats	1	Resistance to change	Some parties may feel uncomfortable with the changes brought by AI technology, leading to resistance to its adoption [55].
	2	Limited funding	AI implementation is often limited by budget constraints, especially in resource-poor universities [56].
	3	Skills gap in AI outside the department	AI use outside Informatics may be limited by skill gaps, hindering campus-wide integration [57].
	4	Privacy and data security issues	Privacy and data breaches risk student safety if AI lacks secure data management [58].
	5	Rapid technological development	AI technology is rapidly evolving, so current systems may become obsolete if continuous updates are not implemented [59].

Table 2. IFAS for AI-based digital learning strategy

IFAS matrix	Weight	Rating	Weighted score	Explanation
			Strengths	
Availability of technology infrastructure	0.15	4	0.60	Adequate technology infrastructure supports AI implementation in education.
Skills of faculty and students	0.15	4	0.60	Strong technological skills support the utilization of AI in teaching and learning.
Development of technology-based curriculum	0.10	3	0.30	The curriculum supports AI integration, but further development is needed.
University policy support	0.10	3	0.30	University policies encourage technological innovation.
Availability of research communities	0.10	3	0.30	Laboratories and research communities support AI-based research.
Total strength score	0.60		2.10	
			Weaknesses	
Limited understanding of AI among faculty	0.15	2	0.30	Faculty's understanding of AI in education is still limited.
Lack of educational resources	0.10	2	0.20	There is a lack of training resources to optimize AI in teaching.
Difficulty with automated assessment and personalization	0.10	2	0.20	Technical challenges still exist in AI-based personalized learning.
Dependence on foreign technology	0.05	1	0.05	Dependence on foreign technology could be a risk.
Limited student knowledge on AI ethics	0.05	2	0.10	Student understanding of AI usage ethics is still limited.
Total weakness score	0.4		0.85	
Total IFAS score	1		1.25	

These findings are supported by previous research that shows the availability of infrastructure and digital competence of lecturers and students are two of the most important internal enablers for AI integration in higher education settings [5]. Similarly, university-level technology-based curriculum development and institutional support have been highlighted as core readiness factors in the successful application of AI tools for adaptive learning [2]. Overall, the IFAS score of 1.25 indicates that, while the department has great potential, strategic efforts are needed to address internal weaknesses, such as enhancing faculty training and developing AI-related educational resources, to fully optimize the strengths the department possesses.

3.2. External factor analysis summary analysis

The EFAS is a method used to assess the external opportunities and threats that influence an organization or entity. As shown in Table 3, the EFAS analysis presents a structured evaluation of these external factors. The results of the EFAS analysis show that the Department of Informatics Engineering has significant opportunities to leverage AI in education, with an opportunity score of 2.30. The main opportunities stem from the increasing demand for AI-based education and the potential for collaboration with industry and researchers, which can accelerate technology-driven innovation. In addition, global trends in the digitalization of education and national policy support create an external environment conducive to the adoption of AI. The EFAS analysis was conducted using qualitative content analysis, in which interview transcripts, institutional policies, national regulations, and global trend reports were systematically coded into themes of opportunities and threats. To ensure the validity of the scoring, experts in technology integration and higher education were consulted to assign weight and rating values through a consensus-based approach.

Despite the identification of strong external opportunities, the analysis also revealed critical threats, with a total score of 0.80. Key concerns include resistance to change and limited institutional funding, both of which hinder the effective implementation of AI. Additionally, reliance on foreign technologies and potential data security risks poses significant challenges to the long-term sustainability of AI integration in educational settings. The findings of this EFAS analysis align with existing literature, which emphasizes that successful AI implementation in higher education requires not only technological readiness but also key external enablers such as institutional support, adequate funding mechanisms, and alignment with national and institutional policies [14], [47]. Prior studies have also highlighted the importance of collaboration with industry partners as a strategic bridge between academic research and practical AI applications in classroom settings [6]. Additionally, the identified risks such as limited funding and resistance to change—mirror challenges commonly reported in developing countries regarding the integration of educational AI platforms [7], underscoring the necessity of proactive mitigation strategies. These consistent findings strengthen the credibility and relevance of the current study's conclusions. With a total EFAS score of 1.50, the Department of Informatics Engineering is in a favorable external position to optimize existing opportunities. To maximize this potential, it is important to mitigate threats through strategies such as providing AI training, developing local technologies, and more effective allocation of funds.

Table 3. Analysis EFAS for AI-based digital learning strategy

EFAS matrix	Weight	Rating	Weighted score	Explanation
Opportunities				
Increasing demand for AI-based education	0.20	4	0.80	High job market demand for AI skills offers a key opportunity for curriculum development.
Collaboration with industry and researchers	0.15	4	0.60	Collaboration with industry and researchers supports AI innovation.
Utilization of AI for personalized teaching	0.10	3	0.30	AI can create a more personalized and adaptive learning experience for students.
National policy support for AI technology	0.10	3	0.30	Government regulations and policies support the development of technology in the education sector.
Global trend in education digitalization	0.10	3	0.30	Education digitalization is a global trend that is relevant to apply in this department.
Total opportunity score	0.65		2.30	
Threats				
Resistance to change	0.15	2	0.30	Resistance to technological change could hinder AI adoption in education.
Limited funding	0.10	2	0.20	Implementing AI requires substantial funding, which is a challenge for educational institutions.
AI skill gap outside the department	0.05	2	0.10	Other faculties within the university may not be ready to adopt AI broadly.
Dependence on foreign technology	0.05	2	0.10	Dependence on foreign technology may impact the sustainability of AI implementation.
Data security risks	0.05	2	0.10	The use of AI requires special attention to the protection of student and institutional data.
Total threat score	0.35		0.80	
Total EFAS score	1.00		1.50	

3.3. Discussion

The results of the IFAS and EFAS analyses indicate that both play a strategic role in the successful implementation of AI in the Department of Informatics Engineering. However, the comparison of total scores shows that EFAS has a higher value (1.50) compared to IFAS (1.25), which suggests that external factors provide greater opportunities in supporting the development and optimization of AI-based learning. Internal factors such as the availability of technology infrastructure, faculty and student skills, and a curriculum that is beginning to lean toward AI-based teaching are important assets, although weaknesses such as limited faculty understanding of AI and a lack of educational resources pose significant barriers. On the other hand, external factors such as the increasing demand for AI skills, opportunities for collaboration with the technology industry, and national policy support offer great potential to be optimized, though threats such as resistance to change and limited funding may hinder progress if not addressed with the right strategy. This result aligns with prior studies Almusaed *et al.* [5], that highlight the critical role of external drivers such as industry partnership and digital education policies in accelerating AI integration in universities. However, these opportunities can only be maximized when institutions have sufficient internal capacity in terms of infrastructure and human resources, as also stated by Elimadi *et al.* [2]. In order to further validate the advantages of AI-based learning strategies, a comparative analysis was conducted between traditional learning approaches and AI-enhanced digital learning within the Department of Informatics Engineering. The comparison focuses on three key aspects: student engagement, personalization of learning, and learning outcomes. Results indicate that AI-based learning provides significantly higher levels of engagement and personalized learning experiences. Table 4 summarizes this comparison. These results support findings by authors [7], [6], which show that AI-based education models enhance learner engagement and allow for greater personalization compared to conventional methods. The score gap in all three dimensions confirms the strategic value of AI as a pedagogical innovation in informatics education. Overall, this discussion emphasizes that external factors (EFAS) have a greater potential to support the implementation of AI in the Department of Informatics Engineering, but success still depends on the ability to strengthen internal factors and integrate internal strengths with external opportunities to create optimal synergy.

Figure 1 illustrates that AI-based learning strategies significantly outperform traditional methods in terms of student engagement, personalization, and learning outcomes within the Department of Informatics Engineering. This integrated SWOT-based perspective also echoes the strategy model proposed by Murtaza *et al.* [47], where success in digital transformation in education depends on a balance between exploiting external opportunities and reinforcing internal capabilities. The findings of this study contribute to enriching this framework in the context of AI adoption in higher education in Indonesia.

Table 4. Comparison of learning aspects between traditional and AI-based digital learning

No	Aspect	Traditional learning (score 1–5)	AI-based learning (score 1–5)
1	Student engagement	3	5
2	Personalization of learning	2	5
3	Learning outcomes	3	4.5

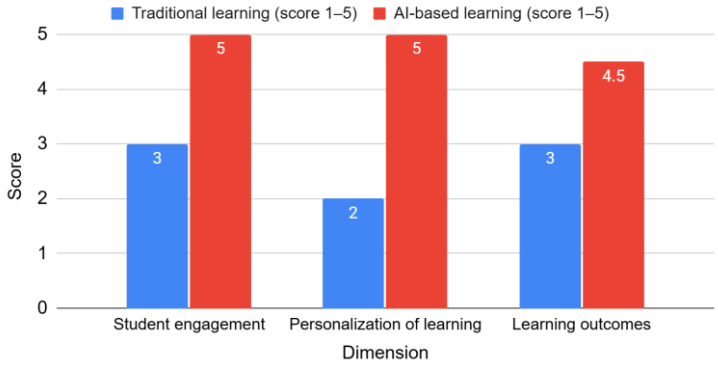

Figure 1. Visual comparative analysis between traditional and AI-based learning

4. CONCLUSION

The comparison between internal and external factors highlights those external opportunities provide significant advantages for the Department of Informatics Engineering in implementing AI-based education. Opportunities such as the growing demand for AI-based learning, collaboration with industry, and

support from national policies offer a strong foundation for development and innovation. However, internal challenges, including limited understanding of AI among faculty and inadequate specific educational resources, pose obstacles to fully optimizing the department's potential, despite having sufficient technological infrastructure. To address these challenges and maximize opportunities, the department must focus on strengthening internal capacities by enhancing faculty and student skills, developing a more targeted AI-based curriculum, and increasing the availability of educational resources. This study is limited by its qualitative SWOT-based approach and focus on a single institutional context, which may constrain the generalizability of the findings. Future research should employ quantitative or mixed-method designs and cross-institutional comparisons to empirically evaluate the effectiveness and scalability of AI-based digital learning strategies. Through these strategic initiatives, the integration of AI in education can be more effectively and sustainably realized, driving improvements in the quality of education and innovation.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

The authors confirm that the data supporting the findings of this study are available within the article.

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