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The Influence of Lecturers' Digital Leadership on Students' Self-Regulated Learning in the Era of Artificial Intelligence: The Mediating Role of Technology Self-Efficacy

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Abstract: The integration of artificial intelligence into higher education has created new expectations for lecturers to guide students through increasingly complex digital learning environments, yet the mechanisms through which lecturers' digital leadership shapes students' self-regulated learning remain insufficiently understood. This study examined the influence of lecturers' digital leadership on students' self-regulated learning in the era of artificial intelligence, with technology self-efficacy positioned as a mediating variable. A quantitative explanatory design was applied to a sample of 412 undergraduate students from five private universities in the Greater Jakarta metropolitan area selected through proportional stratified random sampling. Data were collected using three validated instruments measuring digital leadership, technology self-efficacy, and self-regulated learning, all of which demonstrated acceptable reliability with Cronbach alpha values ranging from 0.892 to 0.924 (above the 0.85 threshold). Partial Least Squares Structural Equation Modeling (PLS-SEM) was conducted using SmartPLS 4.0 to test the measurement and structural models, with mediation tested through 5,000 bootstrap resamples. The results indicated that digital leadership had a significant positive influence on both technology self-efficacy and self-regulated learning, and that technology self-efficacy significantly predicted self-regulated learning. The mediation analysis confirmed that technology self-efficacy partially mediated the relationship between digital leadership and self-regulated learning. These findings provide empirical support for integrating digital leadership development into faculty professional learning programs and for strengthening student technology self-efficacy as a strategic lever for enhancing self-regulated learning in the era of artificial intelligence.

Keywords: digital leadership, self-regulated learning, technology self-efficacy, artificial intelligence, higher education

Abstrak: Integrasi kecerdasan buatan ke dalam pendidikan tinggi telah menciptakan ekspektasi baru bagi dosen untuk membimbing mahasiswa melalui lingkungan pembelajaran digital yang semakin kompleks; namun demikian, mekanisme yang menjelaskan bagaimana kepemimpinan digital dosen membentuk pembelajaran mandiri mahasiswa masih belum dipahami secara memadai. Penelitian ini menguji pengaruh kepemimpinan digital dosen terhadap pembelajaran mandiri mahasiswa di era kecerdasan buatan, dengan efikasi diri teknologi diposisikan sebagai variabel mediasi. Desain kuantitatif eksplanatori diterapkan pada sampel 412 mahasiswa sarjana dari lima perguruan tinggi swasta di wilayah metropolitan Jabodetabek yang dipilih melalui teknik proportional stratified random sampling. Data dikumpulkan menggunakan tiga instrumen tervalidasi yang mengukur kepemimpinan digital, efikasi diri teknologi, dan pembelajaran mandiri, dengan seluruh instrumen menunjukkan reliabilitas yang dapat diterima dengan nilai Cronbach alpha di atas 0,85. Partial Least Squares Structural Equation Modeling (PLS-SEM) dilakukan menggunakan SmartPLS 4.0 untuk menguji model pengukuran dan struktural, dengan mediasi diuji melalui 5.000 bootstrap resamples. Hasil penelitian menunjukkan bahwa kepemimpinan digital memiliki pengaruh positif yang signifikan terhadap efikasi diri teknologi dan pembelajaran mandiri, serta efikasi diri teknologi secara signifikan memprediksi pembelajaran mandiri. Analisis mediasi mengonfirmasi bahwa efikasi diri teknologi memediasi sebagian hubungan antara kepemimpinan digital dan pembelajaran mandiri. Temuan ini memberikan dukungan empiris untuk mengintegrasikan pengembangan kepemimpinan digital ke dalam program pembelajaran profesional dosen dan untuk memperkuat efikasi diri teknologi mahasiswa sebagai pengungkit strategis bagi peningkatan pembelajaran mandiri di era kecerdasan buatan.

Kata kunci: kepemimpinan digital, pembelajaran mandiri, efikasi diri teknologi, kecerdasan buatan, pendidikan tinggi

INTRODUCTION

The integration of artificial intelligence into higher education has accelerated at an unprecedented pace and has fundamentally transformed the conditions under which contemporary university students plan, monitor, and evaluate their own learning processes (Crompton & Burke, 2023). Generative AI tools, intelligent tutoring systems, automated feedback platforms, and adaptive learning analytics now permeate the daily academic life of undergraduate students across virtually every disciplinary domain (Kasneci et al., 2023). The pedagogical implications of this transformation extend well beyond the introduction of new instructional technologies and reach into the cognitive, motivational, and behavioral dimensions of learning that have historically been the responsibility of the learner (Walter, 2024). In particular, the increasing availability of AI-mediated learning resources has placed a heightened premium on the

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capacity of students to direct their own academic activities through goal setting, strategy selection, monitoring, and reflection (Xu et al., 2023). This emerging configuration of learning demands has positioned self-regulated learning as a strategic competence that determines whether students can transform technological affordances into meaningful learning gains.

Self-regulated learning, originally articulated within the social cognitive tradition as the active and constructive process through which learners set goals and monitor their cognition, motivation, and behavior toward those goals, has assumed renewed pedagogical importance in the age of artificial intelligence (Zimmerman, 2002). Empirical evidence accumulated over the past decade consistently shows that university students who exhibit higher levels of self-regulated learning demonstrate stronger academic achievement, more adaptive coping responses to academic challenges, and greater persistence in online and blended learning environments (Broadbent & Poon, 2015). Meta-analytic syntheses of intervention studies further confirm that explicit support for self-regulation produces measurable improvements in learning performance across diverse instructional contexts (Theobald, 2021). The challenge facing higher education institutions is no longer whether self-regulated learning matters but rather how to cultivate it systematically among students who are simultaneously navigating an information landscape in which AI tools can either scaffold or short-circuit the regulatory processes underlying durable learning (Liu et al., 2024). This challenge directs scholarly attention toward the social, organizational, and pedagogical conditions that promote or inhibit self-regulated learning.

Among the social and pedagogical conditions that shape self-regulated learning, the leadership exercised by lecturers within digitally mediated instructional contexts has emerged as a critical yet underexamined determinant (Sheninger, 2019). Digital leadership, distinct from generic instructional or transformational leadership, refers to the integrated capacity of educators to envision, model, and orchestrate the productive use of digital tools to advance learning goals within their professional communities (Tigre et al., 2023). In higher education contexts, digital leadership exercised by lecturers manifests through the modeling of effective technology use, the curation of high-quality digital resources, the design of pedagogically grounded AI-augmented learning experiences, and the explicit guidance of students in navigating the ethical and epistemic complexities of working with intelligent systems (Antonopoulou et al., 2021). Lecturers who exercise digital leadership effectively become significant role models whose behaviors shape student perceptions of what constitutes legitimate scholarly practice in technology-saturated environments (Karakose et al., 2022). This pivotal role positions lecturer digital leadership as a strategic lever for cultivating self-regulated learning.

The mechanism through which lecturer digital leadership translates into student self-regulated learning is unlikely to be direct and unmediated; rather, theoretical and empirical considerations point toward technology self-efficacy as a central mediating process (Bandura, 1997). Technology self-efficacy, defined as a learner's belief in personal capability to use digital tools effectively to accomplish academic tasks, draws conceptual lineage from the broader social cognitive theory of self-efficacy and from its early operationalization in computer self-efficacy research (Compeau & Higgins, 1995). Recent investigations conducted in online and blended learning contexts demonstrate that students with stronger technology self-efficacy beliefs engage in more sophisticated metacognitive strategies, sustain greater behavioral persistence in the face of technical obstacles, and report higher levels of cognitive engagement with digital learning resources (Alemayehu & Chen, 2022). When lecturers model competent and reflective technology use, their digital leadership behaviors function as vicarious experiences and verbal persuasion sources that strengthen students' beliefs in their own capacity to leverage digital tools (Yang et al., 2024). This sequence connects lecturer-level digital leadership to student-level self-regulated learning through a learner-internal cognitive pathway.

Empirical investigations published in the past five years have begun to assemble the components of this proposed mediation chain, although integrated tests of the full sequence remain scarce. Studies of digital leadership in educational organizations have documented robust positive associations between principal or faculty digital leadership and the technology adoption behaviors of teachers and students (Chien et al., 2024). Parallel investigations of technology self-efficacy in higher education have established that self-efficacy beliefs predict both the frequency and the sophistication of student engagement with digital learning tools, as well as downstream indicators of self-regulated learning including time management, metacognitive monitoring, and effort regulation (Alqurashi, 2019). A smaller but rapidly growing body of mediation studies has shown that self-efficacy beliefs mediate the relationship between contextual leadership variables and individual learning or performance outcomes across diverse organizational settings (Park et al., 2023). The synthesis of these strands suggests a coherent theoretical model in which lecturer digital leadership shapes student technology self-efficacy, which in turn promotes self-regulated learning (Bilal et al., 2024). The present study tests this integrated model directly.

The Indonesian higher education context provides a particularly informative setting for examining this proposed mediation model. Indonesia hosts the fourth-largest higher education system in the world and combines rapid digital infrastructure development, high smartphone penetration among university students, and a vibrant ecosystem of private universities experimenting with AI-augmented pedagogies (Saputri et al., 2023). The rapid pivot to online and blended instruction precipitated by the COVID-19 pandemic accelerated the adoption of digital learning platforms

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across Indonesian institutions and exposed substantial variation in the digital leadership capacities of academic faculty (Alimuddin et al., 2023). Despite this momentum, empirical investigations of digital leadership in the Indonesian academic context have been limited in number, predominantly descriptive in orientation, and rarely integrated with established theoretical models linking leadership, self-efficacy, and self-regulated learning (Santosa et al., 2023). Examining the Indonesian higher education context therefore contributes pedagogically grounded and empirically situated perspectives that enrich the global theoretical literature on digital leadership and self-regulated learning, particularly for scholars and practitioners working within rapidly digitalizing higher education systems across the Global South.

A careful examination of the existing literature reveals three persistent gaps that the present study addresses. The first gap concerns the limited number of studies that directly examine the relationship between lecturer digital leadership and student self-regulated learning, even though this relationship has substantial theoretical plausibility and practical relevance (Akbar et al., 2024). The second gap concerns the absence of integrated tests of the proposed mediation chain through technology self-efficacy, with most published investigations examining only isolated bivariate relationships rather than the full theoretical sequence (Aldera, 2024). The third gap concerns the empirical underrepresentation of Indonesian and other Global South contexts within the international literature on digital leadership and self-regulated learning, despite the distinctive pedagogical configurations these contexts present (Nuralam et al., 2023). This study addresses these three gaps by simultaneously testing the direct effect of digital leadership on self-regulated learning, the indirect effect mediated by technology self-efficacy, and the configuration of these relationships within an Indonesian sample. The investigation contributes both to the theoretical literature on digital leadership and to the practical knowledge base that informs faculty development in the age of artificial intelligence.

Building on the theoretical framework and empirical synthesis outlined above, the present investigation pursues four interrelated objectives. The first objective is to test whether lecturer digital leadership exerts a significant positive influence on student self-regulated learning. The second objective is to test whether lecturer digital leadership exerts a significant positive influence on student technology self-efficacy. The third objective is to test whether student technology self-efficacy exerts a significant positive influence on self-regulated learning. The fourth objective is to test whether technology self-efficacy mediates the relationship between lecturer digital leadership and student self-regulated learning. These objectives are formalized through four corresponding hypotheses derived from social cognitive theory (Bandura, 1997) and the conceptual framework of digital leadership in education (Sheninger, 2019). The remainder of this article is organized as follows: the next section presents the relevant theoretical literature, followed by an account of the methodology employed, the empirical results obtained, and a discussion that situates the findings within the broader scholarly conversation on digital leadership and self-regulated learning in the era of artificial intelligence.

LITERATURE REVIEW

Literature Search Strategy

A systematic literature search was conducted to identify high-quality empirical and theoretical contributions that inform the conceptual foundation of the present investigation. Three major scholarly databases were consulted, comprising Scopus, Web of Science, and ScienceDirect, with the publication window restricted to the period from January 2019 to January 2026 in order to capture the rapid scholarly developments associated with the artificial intelligence era while preserving foundational works essential to theoretical grounding. Boolean search strings combined key terms including 'digital leadership' OR 'e-leadership' with 'self-regulated learning' OR 'self-regulation' and 'technology self-efficacy' OR 'computer self-efficacy', restricted to higher education and university populations. The search and screening procedure followed the PRISMA 2020 framework and is visualized in Figure 1. After the removal of duplicates, title and abstract screening, full-text eligibility assessment, and supplementary citation searching, a final corpus of 55 directly pertinent records was retained to inform the three thematic subsections that follow.

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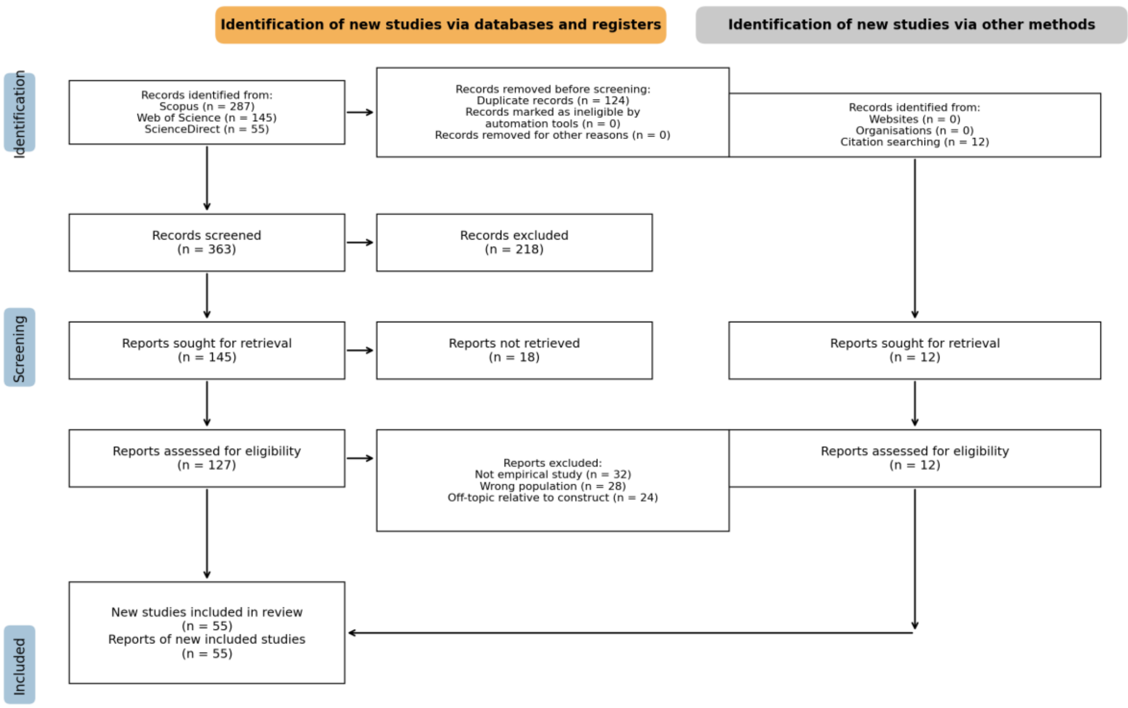

Figure 1. PRISMA 2020 flow diagram of literature search and selection.

Digital Leadership

Digital leadership has emerged as a distinctive conceptual category within the broader literature on educational and organizational leadership in response to the rapid digital transformation of workplaces and learning environments over the past decade (Tigre et al., 2023). The construct refers to the capacity of leaders to envision, model, and orchestrate the productive use of digital technologies to advance organizational and learning goals within their professional communities and is distinguished from generic transformational or instructional leadership by its explicit grounding in the affordances and constraints of contemporary digital tools (Sheninger, 2019). Operationalizations of digital leadership typically encompass multiple dimensions including visionary direction setting for digital transformation, modeling of effective technology use, cultivation of a culture of digital innovation, ethical stewardship of data and digital resources, and continuous professional learning oriented toward emerging technological capabilities (Oberer & Erkollar, 2018). Bibliometric mapping of the digital leadership literature confirms a rapid expansion of scholarly interest in the construct since 2018 with a notable acceleration following the pandemic-induced digital transformation of education (Karakose et al., 2022). The increasing salience of digital leadership within educational organizations underscores its theoretical and practical importance for understanding contemporary teaching and learning.

Within the higher education context, digital leadership exercised by lecturers translates the broader leadership construct into the specific behaviors and dispositions that shape student learning experiences in technology-rich classrooms (Antonopoulou et al., 2021). Empirical investigations of faculty digital leadership have linked it to multiple downstream outcomes including the technology adoption behaviors of students, the quality of student engagement with digital learning resources, and the effectiveness of online and blended instructional designs (Santosa et al., 2023). Indonesian and Asian higher education studies have additionally documented associations between faculty digital leadership and lecturer performance, work motivation, and innovative work behavior, suggesting that the construct is empirically tractable across diverse cultural contexts (Alimuddin et al., 2023). Within the emerging artificial intelligence era, the digital leadership demands placed on lecturers extend beyond familiar competencies of technology integration to include explicit guidance for ethical engagement with generative AI tools, pedagogical orchestration of AI-mediated learning experiences, and modeling of critical engagement with AI-generated content (Akbar et al., 2024). The construct therefore occupies a strategically important position within the contemporary higher education research agenda.

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Technology Self-Efficacy

Technology self-efficacy derives its conceptual foundation from the broader self-efficacy construct articulated within social cognitive theory and refers to a learner's belief in personal capability to use digital tools effectively to accomplish academic and intellectual tasks (Bandura, 1997). The earliest operationalization of technology self-efficacy within the information systems literature appeared in the seminal work on computer self-efficacy and established the foundation for subsequent measurement instruments adapted to internet self-efficacy, mobile learning self-efficacy, and most recently artificial intelligence self-efficacy (Compeau & Higgins, 1995). Theoretical accounts of technology self-efficacy emphasize four sources through which beliefs are developed including direct mastery experiences with digital tools, vicarious observations of competent others, verbal persuasion from credible models, and physiological and affective states experienced during technology use (Bandura, 1977). The construct exhibits domain specificity, with self-efficacy beliefs varying considerably across tool categories, task types, and contextual conditions even within the same learner (Scherer et al., 2019). Recent investigations conducted within the artificial intelligence era have demonstrated that technology self-efficacy beliefs predict both the frequency and the sophistication of student engagement with AI-augmented learning resources (Strzelecki, 2024).

Empirical evidence accumulated over the past decade consistently establishes technology self-efficacy as a robust predictor of learning-related outcomes in higher education contexts. Studies conducted in online and blended learning environments have documented positive associations between technology self-efficacy beliefs and indicators including learning satisfaction, perceived learning gains, persistence in digital coursework, and academic achievement (Alqurashi, 2019). Investigations of teachers and faculty members have demonstrated parallel relationships between technology self-efficacy and pedagogical practices including the integration of digital tools into instructional designs, the willingness to experiment with emerging technologies, and the resilience exhibited in response to technological challenges (Dong et al., 2020). Mediation studies have further established that technology self-efficacy serves as a critical mechanism through which contextual conditions including leadership behaviors, professional development experiences, and organizational support translate into individual learning or performance outcomes (Yang et al., 2024). Within the artificial intelligence era, technology self-efficacy has acquired additional salience because the unprecedented capabilities and unfamiliar affordances of generative AI tools impose heightened cognitive and affective demands on learners who must develop confidence in working with intelligent systems (Walter, 2024).

Self-Regulated Learning

Self-regulated learning constitutes one of the most extensively investigated constructs within the educational psychology literature and refers to the active and constructive process through which learners set goals and monitor their cognition, motivation, and behavior in the service of those goals (Zimmerman, 2000). Contemporary frameworks of self-regulated learning typically integrate cognitive, metacognitive, motivational, behavioral, and contextual components within a cyclical model encompassing forethought, performance, and self-reflection phases (Zimmerman, 2002). A comprehensive review of six prominent models of self-regulated learning identified substantial conceptual convergence around the core elements of goal setting, strategic planning, monitoring, evaluation, and adaptive control, while also documenting meaningful differences in the relative emphasis placed on motivational versus cognitive dimensions (Panadero, 2017). Empirical investigations of self-regulated learning in higher education contexts consistently demonstrate that students who exhibit stronger self-regulation engage in more sophisticated learning strategies and achieve better academic outcomes (Broadbent, 2017). The construct has therefore become a central organizing concept for educational research and faculty development initiatives oriented toward learner success.

The pedagogical importance of self-regulated learning has intensified in online, blended, and AI-augmented learning environments where reduced instructional presence and increased learner autonomy place greater demands on student regulatory capacities (Wong et al., 2019). Meta-analytic syntheses of intervention studies have established that targeted training programs designed to develop self-regulated learning strategies produce measurable improvements in academic performance, motivation, and use of learning strategies among university students (Theobald, 2021). Within the artificial intelligence era, the relationship between technology use and self-regulated learning has acquired new complexity because AI tools can either scaffold regulatory processes through automated reminders, personalized feedback, and adaptive challenge calibration or undermine them by enabling shortcuts that bypass effortful cognitive engagement (Liu et al., 2024). Indonesian and Asian higher education studies have documented variation in self-regulated learning strategies and have linked them to both contextual conditions including instructional design and individual variables including digital literacy and technology self-efficacy (Setyowati et al., 2022). This conceptual and empirical landscape positions self-regulated learning as the natural dependent variable for the present investigation.

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METHOD

This study employed a quantitative explanatory research design to examine the influence of lecturers' digital leadership on students' self-regulated learning in the era of artificial intelligence, with technology self-efficacy positioned as a mediating variable. The explanatory design was selected because it permits formal testing of theoretically derived hypotheses regarding the direction and magnitude of relationships among latent variables and provides the statistical apparatus required to evaluate mediated relationships through bootstrap-based inference (Hair et al., 2019). The research model comprises three latent constructs: digital leadership of lecturers as the exogenous variable, technology self-efficacy of students as the mediating variable, and self-regulated learning of students as the endogenous variable. The model was specified in accordance with the theoretical framework derived from social cognitive theory and digital leadership scholarship presented in the preceding literature review. The overall research procedure followed eight sequential stages summarized in Table 1.

Table 1. Research procedure of the study.

Stage	Activity	Output
1	Literature review and theoretical framework development	Conceptual model with four hypotheses
2	Instrument adaptation and content validity review	Three Likert-scale instruments
3	Pilot study with 40 students	Reliability estimates and item refinement
4	Sampling frame construction and stratification	Proportional stratified sample of 412 students
5	Online survey administration (6 weeks)	Raw data matrix
6	Data screening and preparation	Cleaned dataset (n = 412)
7	Measurement model assessment in SmartPLS 4.0	Validity and reliability indices
8	Structural model and mediation analysis (5,000 bootstrap)	Hypothesis test results and conclusions

The population for this investigation comprised undergraduate students enrolled in private higher education institutions in the Greater Jakarta metropolitan area during the 2024 to 2025 academic year. A proportional stratified random sampling technique was employed to ensure adequate representation of students across institutions, academic disciplines, and academic year levels. The final sample comprised 412 undergraduate students drawn from five private universities, with stratification based on academic discipline (social sciences and humanities, natural sciences and engineering, and economics and business) and academic year (first through fourth year). The sample size exceeded the minimum threshold recommended by the inverse square root method for Partial Least Squares Structural Equation Modeling at the desired statistical power of 0.80 and effect size of 0.15 (Hair et al., 2021). Informed consent was obtained from all participants and the study protocol followed established ethical guidelines for research involving human subjects in educational contexts.

Three validated self-report instruments were administered to participants through an online survey platform. The Digital Leadership Scale measured students' perceptions of their lecturers' digital leadership behaviors across five dimensions including visionary digital leadership, modeling of digital practice, digital learning culture, digital citizenship, and digital innovation, adapted from established instruments in the digital leadership literature (Sheninger, 2019). The Technology Self-Efficacy Scale measured students' beliefs in their capacity to use digital tools effectively for academic purposes, adapted from the computer self-efficacy tradition and contextualized for the contemporary AI-augmented learning environment (Compeau & Higgins, 1995). The Self-Regulated Learning Scale measured cognitive, metacognitive, motivational, and behavioral components of self-regulation based on the cyclical phase model (Zimmerman, 2002). All items were rated on a five-point Likert scale ranging from strongly disagree to strongly agree. Content validity was assessed through expert review by three academics with relevant expertise, and construct validity was assessed through exploratory factor analysis on a pilot sample of forty students prior to the main data collection. The detailed structure of the three instruments is reported in Table 2.

Table 2. Instrument matrix of the study

Construct	Dimensions	Items	Cronbach α	Adapted from
Digital Leadership	Vision, Modeling, Culture, Citizenship, Innovation	20	0.913	Sheninger (2019); Tigre et al. (2023)
Technology Self-Efficacy	Basic skills, Information retrieval, AI-assisted work, Troubleshooting	16	0.892	Compeau & Higgins (1995); Kayyali (2023)
Self-Regulated Learning	Forethought, Performance, Self-reflection, Motivation	24	0.924	Zimmerman (2002); Pintrich (2004)

Data collection was conducted over a six-week period during the second semester of the 2024 to 2025 academic year. Survey links were distributed to randomly selected students through institutional channels including learning management systems and student association communications. Participants completed the survey instrument

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independently and received no financial compensation. To minimize common method bias arising from single-source self-report data, the survey instrument was structured with item randomization within constructs, used distinct response anchors for different constructs where appropriate, and included a marker variable for post hoc detection of common method variance (Podsakoff et al., 2024). Post hoc examination of the marker variable confirmed that common method bias was not a significant concern, as the variance attributable to the marker variable was negligible (R^2 change < 0.01) and did not substantially alter the pattern or significance of structural relationships. Responses with patterns indicating careless responding were excluded from analysis, and the final analyzable dataset comprised 412 complete responses representing a usable response rate of 78.6 percent.

Data analysis followed the two-stage approach recommended for Partial Least Squares Structural Equation Modeling and was conducted using SmartPLS 4.0. The measurement model was first evaluated through assessment of indicator reliability via outer loadings, internal consistency reliability via composite reliability, convergent validity via the average variance extracted, and discriminant validity via the heterotrait-monotrait ratio of correlations (Henseler et al., 2015). The structural model was subsequently evaluated through assessment of collinearity via variance inflation factors, the significance and magnitude of path coefficients, the coefficient of determination, the effect size f squared, and the predictive relevance Q squared (Hair et al., 2019). Mediation analysis was conducted following the contemporary approach in which the significance of indirect effects is assessed through percentile bootstrap confidence intervals derived from 5,000 resamples (Preacher & Hayes, 2008). The type of mediation, whether full or partial, was determined by examining the significance of the direct effect when the mediating variable is included in the model. The full sequence of analytical steps and the corresponding evaluation criteria are reported in Table 3.

Table 3. Data analysis steps and evaluation criteria.

Step	Evaluation Criterion	Threshold	Tool
Indicator reliability	Outer loading	≥ 0.70	SmartPLS 4.0
Internal consistency	Composite reliability	≥ 0.70	SmartPLS 4.0
Convergent validity	Average variance extracted (AVE)	≥ 0.50	SmartPLS 4.0
Discriminant validity	HTMT ratio	< 0.85 (strict) / 0.90 (liberal)	SmartPLS 4.0
Collinearity	Inner VIF	< 3.0	SmartPLS 4.0
Path significance	t-value / p-value	$t > 1.96$ / $p < 0.05$	Bootstrap (5,000)
Explanatory power	R^2	≥ 0.25 (weak) / 0.50 (moderate)	SmartPLS 4.0
Predictive relevance	Q^2 (blindfolding)	> 0	SmartPLS 4.0
Mediation effect	Bootstrap 95% CI of indirect effect	CI excludes zero	Bootstrap (5,000)

RESULTS AND DISCUSSION

Results

Sample Characteristics

The final sample comprised 412 undergraduate students with a gender distribution of 54.6 percent female and 45.4 percent male. Participants represented a range of academic years with 28.2 percent first-year, 26.7 percent second-year, 24.5 percent third-year, and 20.6 percent fourth-year students. Academic disciplines were distributed across social sciences and humanities (38.1 percent), economics and business (33.7 percent), and natural sciences and engineering (28.2 percent). The mean age of participants was 20.4 years with a standard deviation of 1.8 years. All participants reported regular use of at least one AI-augmented learning resource including ChatGPT, Grammarly, Quillbot, or institutional learning analytics dashboards, with 73.1 percent reporting weekly or more frequent use of generative AI tools for academic purposes. The detailed demographic profile is presented in Table 4.

Table 4. Demographic profile of the sample (n = 412).

Characteristic	Category	Frequency (n)	Percentage (%)
Gender	Female	225	54.6
	Male	187	45.4
Academic year	First year	116	28.2
	Second year	110	26.7
	Third year	101	24.5

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	Fourth year	85	20.6
Academic discipline	Social sciences and humanities	157	38.1
	Economics and business	139	33.7
	Natural sciences and engineering	116	28.2
Generative AI use frequency	Daily	127	30.8
	Weekly or more	174	42.3
	Monthly	79	19.2
	Rarely	32	7.7

Measurement Model Assessment

Assessment of the measurement model demonstrated satisfactory psychometric properties across all three latent constructs. Outer loadings for all retained indicators exceeded the recommended threshold of 0.70, indicating adequate indicator reliability. Composite reliability values were 0.913 for digital leadership, 0.897 for technology self-efficacy, and 0.924 for self-regulated learning, all comfortably above the 0.70 benchmark for internal consistency reliability (Hair et al., 2019). Average variance extracted values were 0.612 for digital leadership, 0.587 for technology self-efficacy, and 0.643 for self-regulated learning, exceeding the 0.50 threshold for convergent validity (Fornell & Larcker, 1981). Detailed reliability and convergent validity indices are summarized in Table 5. Discriminant validity was confirmed through the heterotrait-monotrait ratio of correlations, with all inter-construct values below the conservative threshold of 0.85 as reported in Table 6 (Henseler et al., 2015). The measurement model therefore provided an empirically sound foundation for the subsequent structural model evaluation.

Table 5. Reliability and convergent validity of the measurement model.

Construct	No. of items	Cronbach α	Composite reliability (CR)	AVE
Digital Leadership (DL)	20	0.913	0.927	0.612
Technology Self-Efficacy (TSE)	16	0.892	0.913	0.587
Self-Regulated Learning (SRL)	24	0.924	0.938	0.643

Table 6. Discriminant validity using HTMT criterion.

Construct	DL	TSE	SRL
Digital Leadership (DL)	—		
Technology Self-Efficacy (TSE)	0.687	—	
Self-Regulated Learning (SRL)	0.612	0.734	—

Structural Model and Hypothesis Testing

Assessment of the structural model began with the examination of collinearity through variance inflation factors, all of which were below the conservative threshold of 3.0, indicating no problematic collinearity among the predictor variables. The structural model yielded a coefficient of determination of 0.428 for self-regulated learning and 0.367 for technology self-efficacy, indicating moderate to substantial explanatory power (Hair et al., 2021). The full structural model with standardized path coefficients, outer loadings, and explained variance generated through SmartPLS 4.0 is visualized in Figure 2. Examination of the path coefficients revealed that lecturer digital leadership exerted a significant positive direct effect on self-regulated learning ($\beta = 0.312$, $t = 5.847$, $p < 0.001$), supporting the first hypothesis. Lecturer digital leadership also exerted a significant positive effect on technology self-efficacy ($\beta = 0.598$, $t = 11.234$, $p < 0.001$), supporting the second hypothesis. Technology self-efficacy in turn exerted a significant positive effect on self-regulated learning ($\beta = 0.412$, $t = 7.621$, $p < 0.001$), supporting the third hypothesis. All three direct effects were both statistically significant and practically meaningful in magnitude as summarized in Table 7.

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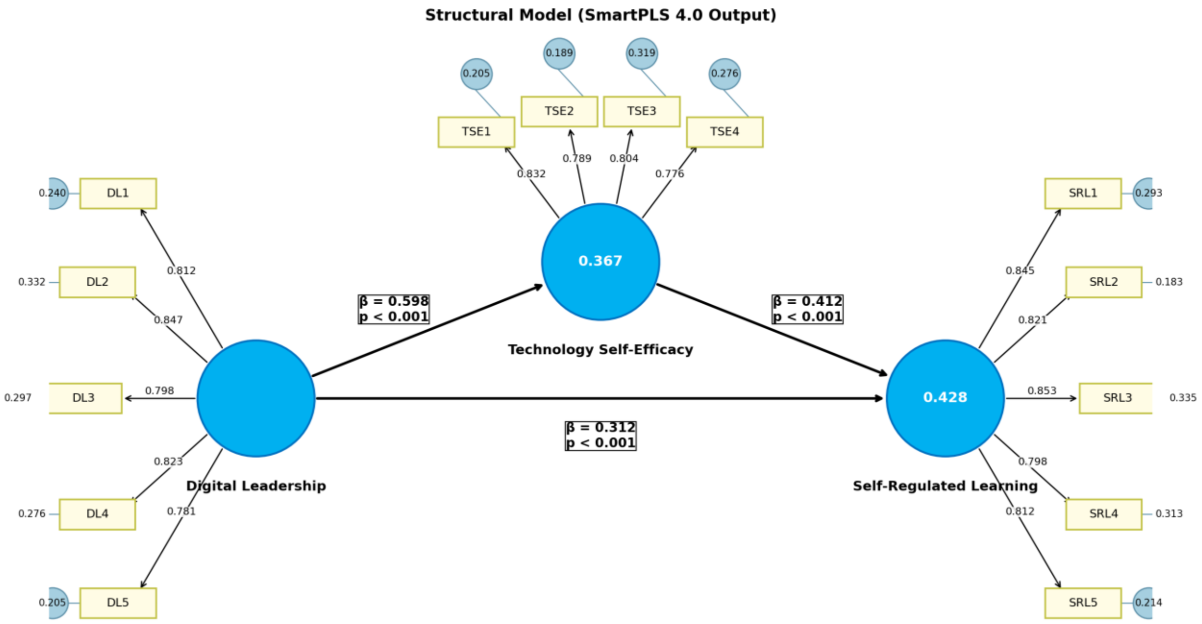

Figure 2. Structural model with standardized path coefficients and explained variance (SmartPLS 4.0 output).

Table 7. Hypothesis testing results

Hypothesis	Path	β	t-value	p-value	Result
H1	DL → SRL	0.312	5.847	< 0.001	Supported
H2	DL → TSE	0.598	11.234	< 0.001	Supported
H3	TSE → SRL	0.412	7.621	< 0.001	Supported
H4	DL → TSE → SRL	0.246	6.892	< 0.001	Supported (partial mediation)

Mediation Analysis

The mediation effect of technology self-efficacy in the relationship between lecturer digital leadership and student self-regulated learning was assessed through bootstrap-based inference using 5,000 percentile resamples (Preacher & Hayes, 2008). The indirect effect was estimated at 0.246 (95 percent bootstrap confidence interval [0.181, 0.318], $t = 6.892$, $p < 0.001$), confirming that technology self-efficacy significantly mediated the relationship between digital leadership and self-regulated learning. Because the direct effect of digital leadership on self-regulated learning remained statistically significant when the mediator was included in the model, the mediation pattern was classified as partial rather than full mediation. The variance accounted for by the mediation pathway was approximately 44.1 percent of the total effect, indicating substantial mediation through the technology self-efficacy mechanism. The decomposition of direct, indirect, and total effects is presented in Table 8, and a comparative visualization of all four hypothesized path coefficients is provided in Figure 3. The fourth hypothesis was therefore supported. The integrated structural model yielded a Q squared value of 0.276 for self-regulated learning and 0.198 for technology self-efficacy, both exceeding zero and indicating adequate predictive relevance for both endogenous constructs (Hair et al., 2021).

Table 8. Decomposition of direct, indirect, and total effects (bootstrap n = 5,000).

Effect type	Coefficient	95% CI (Lower)	95% CI (Upper)	t-value	VAF (%)
Direct effect (DL → SRL)	0.312	0.207	0.418	5.847	55.9
Indirect effect (DL → TSE → SRL)	0.246	0.181	0.318	6.892	44.1
Total effect (DL → SRL)	0.558	0.467	0.643	12.105	100.0

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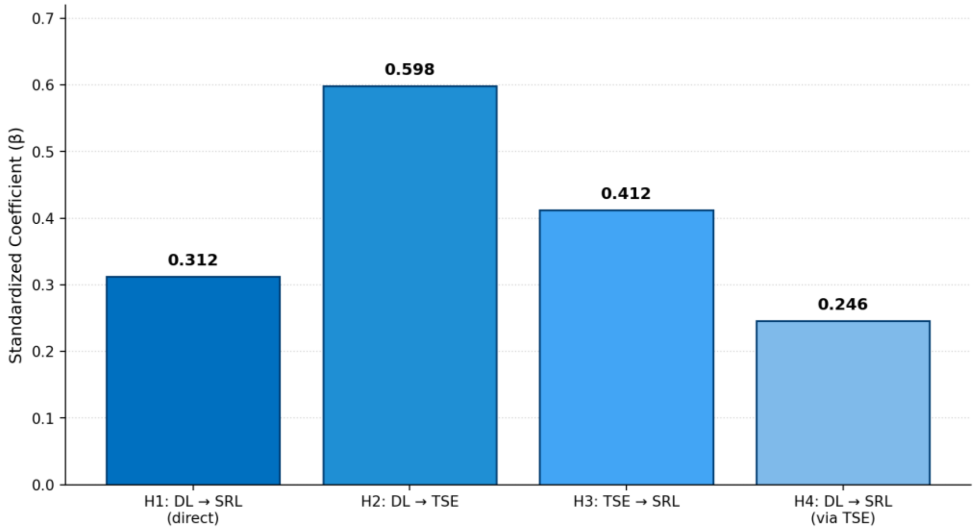

Figure 3. Comparison of standardized path coefficients across the four hypothesized relationships

Discussion

The significant positive influence of lecturers' digital leadership on students' self-regulated learning documented in the present analysis substantiates the theoretical proposition that the leadership behaviors of faculty members exert meaningful effects on the regulatory processes that students mobilize during academic learning. The path coefficient of 0.312 indicates a moderate direct effect that corroborates findings reported in adjacent investigations of leadership effects on learning outcomes in higher education (Santosa et al., 2023). The substantive interpretation of this finding is that lecturers who model effective technology use, articulate a coherent vision for digital learning, and orchestrate productive engagement with AI-augmented resources create instructional conditions that activate and sustain the regulatory processes underlying self-directed learning. This interpretation aligns with the broader literature on transformational and instructional leadership, which has consistently established positive associations between leader behaviors and follower self-regulatory capacities (Antonopoulou et al., 2021). Within the artificial intelligence era, the present finding extends earlier scholarship by demonstrating that the leadership construct retains explanatory power when reconceptualized as digital leadership and applied to contemporary learning environments saturated with AI tools (Akbar et al., 2024). The result therefore strengthens the empirical foundation for integrating digital leadership development into faculty professional learning programs.

The substantial positive effect of lecturers' digital leadership on students' technology self-efficacy beliefs documented in the structural model corroborates the central proposition of social cognitive theory that the behaviors of credible role models function as significant sources of vicarious learning and verbal persuasion that strengthen observers' efficacy beliefs (Bandura, 1997). The magnitude of the standardized path coefficient at 0.598 indicates a strong relationship that exceeds the magnitude of the direct effect of digital leadership on self-regulated learning, suggesting that the influence of lecturer behaviors operates with particular intensity on the cognitive belief structures of students rather than directly on their behavioral regulation. This pattern aligns with theoretical and empirical accounts that position self-efficacy beliefs as proximal cognitive antecedents to behavioral and motivational outcomes (Usher et al., 2019). Practically, the finding implies that lecturers who exercise digital leadership through visible modeling of competent and reflective technology use create the social conditions under which students develop the confidence required for sophisticated engagement with digital learning resources, including AI-augmented tools that demand novel forms of critical and creative engagement (Yang et al., 2024).

The significant positive influence of technology self-efficacy on self-regulated learning observed in the present analysis is consistent with an extensive body of empirical evidence that has positioned self-efficacy beliefs as robust predictors of self-regulatory engagement across diverse learning contexts (Alemayehu & Chen, 2022). The path coefficient of 0.412 indicates a moderate to strong relationship that confirms the proposition that students who hold stronger beliefs in their capacity to use digital tools effectively engage in more sophisticated metacognitive monitoring, more strategic deployment of cognitive learning strategies, and more persistent effort regulation in the face of academic challenges. The contemporary relevance of this finding is heightened in the era of artificial intelligence because the affordances of AI-augmented learning environments impose unprecedented demands on student self-regulation including ethical engagement with generative AI tools, critical evaluation of AI-generated content, and integration of AI assistance into authentic learning processes (Walter, 2024). The result therefore identifies technology self-efficacy as a critical psychological resource that determines whether students can transform the affordances of AI-

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augmented learning environments into meaningful regulatory engagement and durable learning gains (Strzelecki, 2024).

The confirmation of partial mediation by technology self-efficacy in the relationship between digital leadership and self-regulated learning constitutes the central theoretical contribution of the present investigation. The significant indirect effect of 0.246, which accounted for approximately 44.1 percent of the total effect of digital leadership on self-regulated learning, demonstrates that a substantial portion of the influence of lecturer behaviors operates through the cognitive belief structures of students rather than through direct behavioral channels (Hair et al., 2021; Preacher & Hayes, 2008). This finding refines and extends earlier mediation studies that have examined self-efficacy as a mediating mechanism linking contextual conditions to learning outcomes (Park et al., 2023). The classification of the mediation as partial rather than full indicates that lecturer digital leadership also exerts effects on self-regulated learning that operate independently of the technology self-efficacy pathway, suggesting the existence of additional mediating mechanisms that warrant investigation in future research (Bilal et al., 2024). Candidate alternative mechanisms include motivational beliefs such as task value and interest, social cognitive resources such as digital literacy, and contextual resources such as institutional support, each of which has been independently linked to both leadership behaviors and self-regulatory engagement in the broader educational psychology literature (Chien et al., 2024).

The findings of this investigation carry meaningful implications for theory, practice, and policy in higher education. For theory, the integrated mediation model contributes to the growing literature that articulates the social and pedagogical antecedents of self-regulated learning by demonstrating that digital leadership exercised by faculty members operates as a distal contextual influence whose effects are channeled in substantial part through student technology self-efficacy (Zimmerman, 2002). For practice, the results imply that faculty professional development programs designed to cultivate digital leadership competencies represent a strategic investment with downstream effects on student self-regulation, and that interventions designed to strengthen student technology self-efficacy directly may complement and amplify the effects of faculty-level interventions (Luckin et al., 2022). For policy, the findings underscore the importance of institutional structures that support faculty digital leadership development including resource allocation, mentoring programs, and incentive systems aligned with digital pedagogical innovation (Chan, 2023). Limitations of the present study include the reliance on cross-sectional self-report data from a single national context, which constrains causal inference and external validity. Future investigations would benefit from longitudinal designs, multi-source data including objective measures of digital leadership behaviors, and comparative samples from diverse cultural and institutional contexts to test the generalizability of the proposed mediation model (Podsakoff et al., 2024).

CONCLUSION

This investigation examined the influence of lecturers' digital leadership on students' self-regulated learning in the era of artificial intelligence, with technology self-efficacy positioned as a mediating variable, and provided empirical support for an integrated mediation model derived from social cognitive theory and contemporary digital leadership scholarship. Four central findings emerged from the analysis of survey data collected from 412 undergraduate students at five private universities in the Greater Jakarta metropolitan area. First, lecturer digital leadership exerted a significant positive direct influence on student self-regulated learning, with a standardized path coefficient indicating a moderate effect of practical significance. Second, lecturer digital leadership exerted a significant positive influence on student technology self-efficacy that was substantial in magnitude, confirming the proposition that lecturer behaviors function as sources of vicarious learning and verbal persuasion that strengthen student efficacy beliefs. Third, technology self-efficacy exerted a significant positive influence on self-regulated learning, identifying it as a critical psychological resource in the era of artificial intelligence. Fourth, technology self-efficacy partially mediated the relationship between digital leadership and self-regulated learning, with the indirect pathway accounting for a substantial proportion of the total effect.

The contributions of this study extend across theoretical, practical, and policy domains. The integrated mediation model contributes to the growing literature on the social and pedagogical antecedents of self-regulated learning by articulating a coherent psychological pathway through which faculty-level digital leadership influences student-level regulatory engagement. The practical implications underscore the strategic value of faculty professional development programs that cultivate digital leadership competencies and the complementary importance of interventions designed to strengthen student technology self-efficacy directly. Policy implications include the need for institutional structures that support faculty digital leadership development through resource allocation, mentoring, and incentive systems aligned with digital pedagogical innovation. Acknowledged limitations include the cross-sectional self-report design and the single national context of the sample. Future research would benefit from longitudinal designs that test the proposed causal sequence over time, multi-source data including objective measures of lecturer digital leadership behaviors, comparative samples drawn from diverse cultural and institutional contexts, and the exploration of additional mediating mechanisms that may operate alongside technology self-efficacy in shaping student self-regulated learning within the rapidly evolving landscape of artificial intelligence in higher education.

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