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The Impact of Educational Leadership on Teachers' AI Integration and Digital Transformation: A Meta-Analysis

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ABSTRAK

Perkembangan kecerdasan buatan (artificial intelligence/AI) telah mendorong transformasi digital dalam pendidikan, di mana guru dituntut untuk mengintegrasikan teknologi ke dalam pembelajaran. Penelitian ini bertujuan menganalisis pengaruh kepemimpinan pendidikan terhadap integrasi AI guru melalui pendekatan Systematic Literature Review (SLR) yang dikombinasikan dengan meta-analisis. Data diperoleh dari basis data Scopus dengan kata kunci "Educational Leadership", "Teachers' AI Integration", dan "Digital Transformation". Proses seleksi mengikuti protokol PRISMA dan menghasilkan enam studi yang memenuhi kriteria inklusi. Analisis dilakukan dengan model random-effects menggunakan perangkat lunak RStudio. Hasil meta-analisis menunjukkan bahwa kepemimpinan pendidikan berpengaruh positif dan signifikan terhadap integrasi AI guru dengan efek gabungan r = 0.44 (95% CI [0.37–0.51]), yang termasuk dalam kategori sedang. Uji heterogenitas menghasilkan nilai I^2 = 71.8% (p = 0.0033), menandakan adanya variasi antar penelitian yang kemungkinan dipengaruhi oleh konteks institusional, karakteristik responden, serta model kepemimpinan yang diteliti. Analisis funnel plot menunjukkan adanya bias publikasi moderat, meskipun arah hubungan tetap konsisten positif. Hasilnya menyatakan kepemimpinan transformasional dan digital leadership merupakan faktor kunci dalam mendorong kesiapan guru mengadopsi AI dan mempercepat transformasi digital pendidikan. Penelitian ini berkontribusi dalam memperluas literatur kepemimpinan dengan menempatkan integrasi AI sebagai salah satu indikator baru efektivitas kepemimpinan di abad ke-21, sekaligus memberikan implikasi praktis bagi pengambil kebijakan dan pemimpin pendidikan dalam merancang strategi transformasi sekolah berbasis teknologi.

Keywords :
educational leadership; Principal; teachers; AI integration; digital transformation.

ABSTRACT

The rapid advancement of artificial intelligence (AI) has accelerated digital transformation in education, compelling teachers to integrate technology into their teaching practices. This study aims to analyze the impact of educational leadership on teachers' AI integration through a Systematic Literature Review (SLR) combined with meta-analysis. Data were retrieved from the Scopus database using the keywords "Educational Leadership", "Teachers' AI Integration", and "Digital Transformation". The selection process followed the PRISMA protocol and yielded six studies that met the inclusion criteria. Analysis was conducted using a random-effects model with RStudio software. The meta-analysis revealed that educational leadership has a positive and significant effect on teachers' AI integration, with a pooled effect size of r = 0.44 (95% CI [0.37–0.51]), which falls into the medium category. The heterogeneity test resulted in I^2 = 71.8% (p = 0.0033), indicating substantial variability across studies, likely influenced by institutional contexts, respondent characteristics, and leadership models examined. The funnel plot analysis indicated a moderate publication bias, although the overall relationship remained consistently positive. The findings underscore that transformational and digital leadership are key factors in fostering teachers' readiness to adopt AI and in accelerating digital transformation in education. This study contributes to the leadership literature by positioning AI integration as a new indicator of leadership effectiveness in the 21st century, while also providing practical implications for policymakers and educational leaders in designing technology-driven school transformation strategies.

INTRODUCTION

The development of artificial intelligence (AI) technology has brought significant changes to the field of education. The integration of AI into teaching, assessment, and school management has become an inevitable form of digital transformation in the 21st century (Shabbir et al., 2024). Teachers, as the main actors in the educational process, are required not only to possess pedagogical competencies but also to develop the skills necessary to adopt and integrate technology, including AI, to enhance the quality of learning (Almaki et al., 2025). However, teachers' readiness to implement AI is often influenced by factors such as the school environment, organizational culture, and the leadership of school management. Recent studies highlight that transformational and digital leadership shape teacher collaboration, technological readiness, and school policy directions, thereby directly affecting the intensity and quality of teachers' technology integration (Hoang, 2025).

Educational leadership has long been recognized as a key driver of innovation and change in schools. Leadership styles such as instructional and transformational leadership play an essential role in providing a shared vision, fostering a collaborative culture, and creating an environment that supports teachers in experimenting with technology-based pedagogy (Imran et al., 2025; Yang et al., 2024). Recent studies further emphasize that leaders who adopt digital leadership practices are more effective in accelerating teachers' adoption of AI and in building a sustainable digital transformation agenda (Tang et al., 2025) . Alongside formal professional development programs, informal and self-directed learning have also emerged as important dimensions of teachers' professional growth in relation to technology integration (Flori et al., 2025). Informal learning, which often takes place through social media, peer networks, or reflective classroom practices, provides teachers with flexible opportunities to acquire new digital skills outside formal training programs. Teachers engage in self-directed learning by experimenting with new technologies, reflecting on their teaching practices, and sharing knowledge with colleagues (Al-Hazaima et al., 2025; Mahroof et al., 2025) (Al-Hazaima et al., 2025; Mahroof et al., 2025; Sogalrey et al., 2024). This form of professional learning is increasingly recognized as essential for technology integration (Kampilong et al., 2025). However, the facilitation and alignment of such practices with institutional leadership support remain relatively underexplored.

Educational leadership plays a crucial role in driving change and innovation (Shabbir et al., 2024). Research by Abedi and Ametepey (2024) demonstrates that school leadership styles, whether instructional or transformational, significantly contribute to teachers' success in utilizing digital technologies. Effective leadership provides vision, support, and a collaborative climate that encourages teachers to experiment with new technology-based teaching methods (Halomoan et al., 2024). The relationship between educational leadership and teachers' AI integration has thus become an increasingly relevant issue in academic discourse. In this regard, the connection between leadership and teachers' capacity to integrate AI within the framework of digital transformation is both academically and practically significant. On one hand, leadership establishes the structural, cultural, and motivational conditions necessary for innovation; on the other, teachers' engagement in formal and informal learning pathways mediates their ability to meaningfully integrate AI into teaching. Nevertheless, existing empirical evidence remains fragmented, with inconsistent findings regarding the magnitude of influence, contextual factors, and leadership models applied.

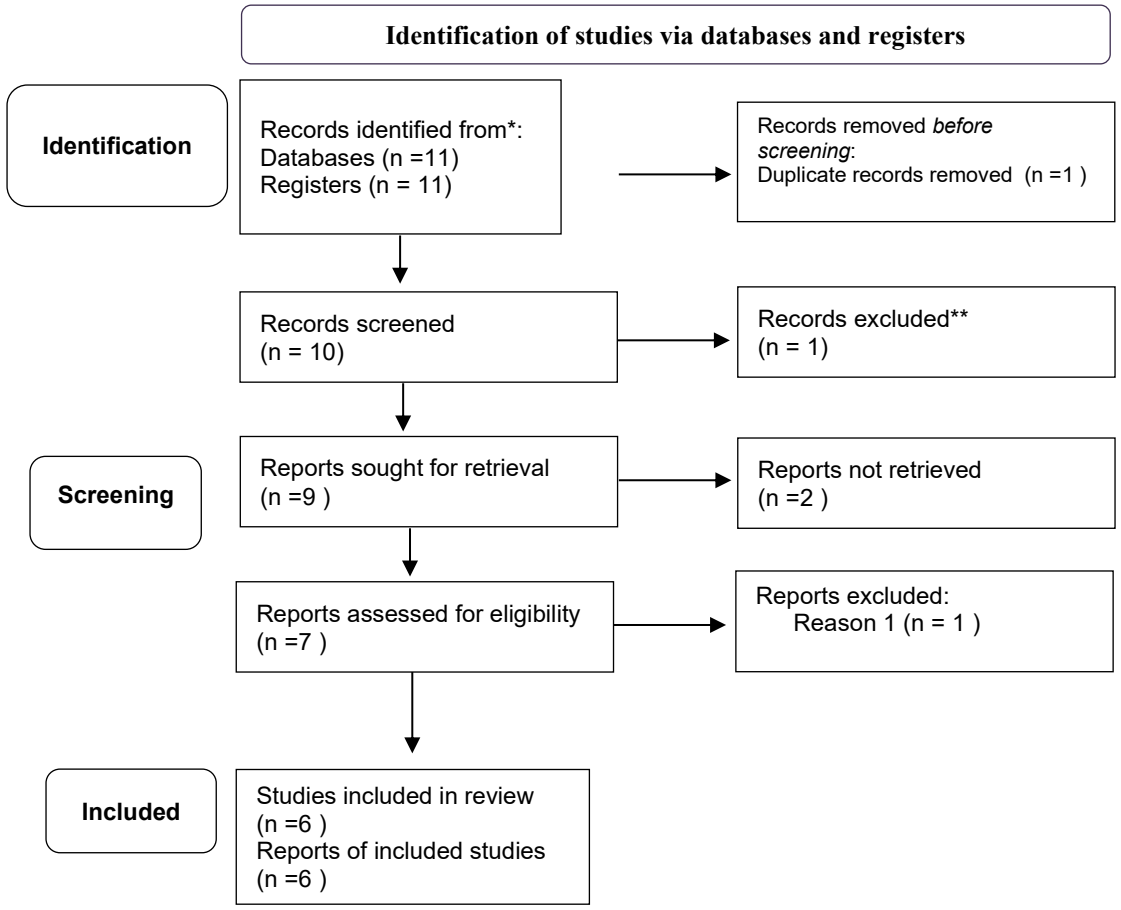
Although numerous empirical studies have examined the influence of leadership on technology integration, the findings remain varied. Some studies report positive and significant effects (Abedi & Ametepey, 2024; Acosta-Enriquez et al., 2025; Liu et al., 2024), while others, such as Nellitawati et al., (2024), indicate relatively weak significance. These variations may be attributed to differences in school contexts, leadership styles, and the readiness of digital infrastructure. Therefore, a more comprehensive analysis is needed to synthesize these findings. Addressing this gap, meta-analysis emerges as an appropriate approach to examine the relationship between educational leadership and AI integration within the context of digital transformation in schools. This study is expected to contribute to bridging the literature gap while providing an empirical basis for policymakers and educational leaders in designing leadership strategies that effectively support digital transformation.

RESEARCH METHODS

This study employs a Systematic Literature Review (SLR) method combined with meta-analysis to analyze the collected data. Data were gathered through a systematic literature search using the keywords "Educational Leadership", "Teachers' AI Integration", and "Digital Transformation" with Scopus as the primary database. This search yielded articles relevant to the research topic. The

literature search was conducted by two independent reviewers who double-coded the studies to ensure accuracy and objectivity.

The analysis process was conducted using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), which allows for systematic screening, selection, and management of data. Following the screening and selection of the literature, the study proceeded with a meta-analysis to synthesize and examine the results of the relevant studies. The meta-analysis enables the researchers to assess the cumulative effect of Transformational Leadership on educational equity more comprehensively and quantitatively, as well as to identify consistent patterns or outcomes across different research contexts.



Gambar 1. *Prima diagram flow*

Articles that do not meet the six criteria were placed in the pool of excluded articles. Articles falling under the exclusion criteria were not included in the meta-analysis process. A total of 8 empirical articles met the criteria, presenting data on sample size, standard deviation, and mean research outcomes. These data served as the basis for deriving a global conclusion. This study employs a random-effects model to allow the findings to be generalized to the population (not merely limited to the observed data). The requirement for selecting the random-effects model is a heterogeneity index of $I^2 > 25\%$. The type of meta-analysis used in this study is a contrast-group analysis, which examines whether professional leadership plays a role in achieving educational equity. The data obtained have a range of variation (difference between minimum and maximum values); therefore, they need to be standardized. The estimation of the sample mean/effect size (d) is standardized using the following formula (1):

$$d = \frac{\bar{x}_1 - \bar{x}_2}{S_{within}}, S_{within} = \sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{(n_1 - 1)(n_2 - 1)}}$$

The formula used to calculate the standard error of d (Sed) is (2):

$$SE_d = \sqrt{V_d}\text{ , with } V_d = \frac{n_1 - n_2}{n_1 n_2} + \frac{d^2}{2(n_1 + n_2)}$$

$$g = J \times d, \text{ dengan } J = 1 - \frac{3}{4df-1}$$

(Hedges, 2022) This indicates that the results have minimal bias. To further reduce bias, Hedges adjusted g using (3) and (4).

$$df = \text{degree of freedom } (n_1 + n_2 - 2)$$

$$SE_g = \sqrt{V_g}, \text{ with } V_g = J \times V_d$$

The analysis was conducted using Rstudio. The input data included g as the effect size and SE_g, which were used to generate a forest plot displaying the value intervals and standard errors for each study, along with the overall conclusions. Rstudio also facilitated the calculation of heterogeneity and publication bias (funnel plot), allowing for the assessment of the magnitude of the impact of Transformational Leadership on achieving educational equity.

RESULTS AND DISCUSSION

The articles included in this study, The Impact of Educational Leadership on Teachers' AI Integration and Digital Transformation: A Meta-Analysis, consist of 6 relevant journal articles that were selected based on the predefined research variables.

Table 1. Summary of research data

Studyid	N	Correlation
Study 1	188	0.541
Study 2	152	0.436
Study 3	452	0.501
Study 4	133	0.231
Study 5	302	0.5
Study 6	401	0.37

Source: Website Scopus

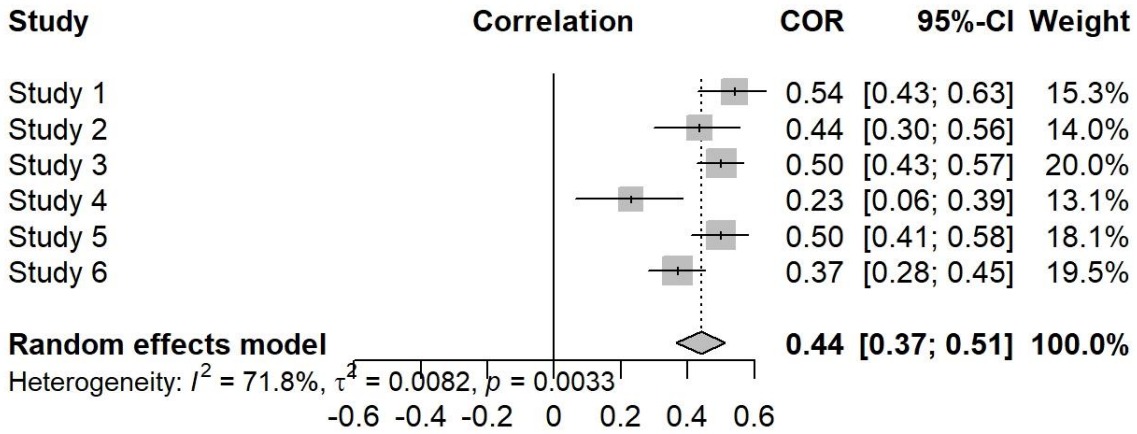


Table 2. Forest Plot Heterogeneity Test

The heterogeneity test results indicate that educational leadership has a significant positive relationship with teachers' AI integration, with a combined correlation of r = 0.44 (95% CI \[0.37–0.51]). This effect falls within the moderate range and consistently shows a positive direction across studies. However, the high heterogeneity value (I^2 = 71.8%, p = 0.0033) suggests substantial variability between studies, likely influenced by differences in institutional contexts, respondent characteristics, and the leadership models examined. These findings underscore the importance of considering moderating factors when evaluating the effectiveness of leadership on educational digital transformation.

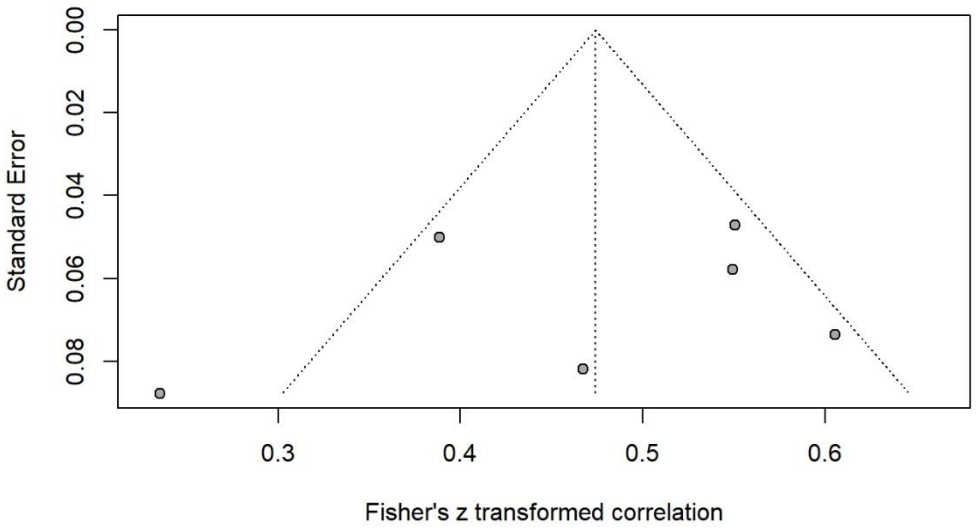


Figure 2. Uji Fisher's z transformed correlation

The publication bias test using a funnel plot showed that the distribution of studies was not entirely symmetrical. Some studies with higher correlation effects tended to cluster on the right side, while studies with lower effects appeared in the lower left. This pattern indicates a potential moderate publication bias**,** where studies with significant results are more likely to be published than those with non-significant findings. Nevertheless, the presence of studies with diverse effect sizes within the plot provides a basis to conclude that the impact of leadership on teachers' AI integration is relatively consistent, even though the magnitude of the effect varies across studies.

The meta-analysis results indicate that educational leadership has a significant positive effect on teachers' AI integration, with a combined effect of r = 0.44 (95% CI [0.37–0.51]). This effect is considered moderate, suggesting that leadership is not only an administrative factor but also an important catalyst in supporting educational digital transformation. Transformational Leadership, which emphasizes inspiration, motivation, and individual support**,** serves as a key driver of changes in teachers' behavior in adopting technological innovation (Abedi & Ametepey, 2024).

The relationship observed was consistently positive, but the high level of heterogeneity (I^2 = 71.8%) indicates substantial variation across studies. This suggests that the effectiveness of leadership in promoting AI integration is not universal but is influenced by institutional context, respondent characteristics, and the leadership model applied. Instructional leadership is more relevant for guiding teachers in classroom practices, whereas in higher education, visionary digital leadership tends to be more effective in directing faculty toward digital-based transformation. These findings support the view that educational leadership is contextual and adaptive. The funnel plot analysis also indicated a moderate publication bias, with studies reporting significant results being more likely to be published. This is common in the fields of education and technology, where positive leadership outcomes attract more attention from both researchers and journal publishers. Nevertheless, the presence of studies with varied effect sizes ensures that the conclusions of this meta-analysis remain empirically robust. Future research should apply additional publication bias tests, such as Egger's test or trim-and-fill analysis, to further strengthen the validity of the results.

Transformational leadership and digital leadership are key factors in preparing teachers for the AI era. Recent studies highlight that transformational and digital instructional leadership significantly contribute to AI integration in schools, with their combination forming an ambidextrous leadership approach that accelerates innovation adoption (Pietsch & Mah, 2025). Reviews by (Imron et al., 2025) also indicate that digital leadership practices through resource provision, continuous training, and fostering a digital learning culture enhance teachers' self-efficacy in using digital (Sogalrey et al., 2022). Research in Indonesia reinforces these findings, showing that digital transformational leadership directly influences teachers' digital literacy and the quality of educational services (Imron et al., 2025).

Thus, this study fills a literature gap that previously emphasized technology without considering leadership style as a critical factor. It underscores the importance of synergizing transformational and digital leadership to build teacher readiness for the AI era. Educational leaders who can provide vision, foster a collaborative culture, and offer technical support are more successful in promoting the adoption of AI technology in teaching and learning. These implications are particularly relevant in the post-pandemic era**,** where digital technology integration is no longer optional but a strategic necessity for educational continuity. Educational leadership impacts not only traditional domains such as academic performance and teacher motivation but also emerging areas like AI integration and digital transformation. Therefore, this study makes a significant contribution to developing a conceptual framework that connects leadership, digital transformation, and pedagogical innovation.

CONCLUSION

This meta-analysis provides robust empirical evidence that educational leadership particularly transformational and digital leadership—plays a pivotal role in fostering teachers' integration of artificial intelligence (AI) as part of the broader digital transformation in education. The aggregated findings revealed a moderate yet significant effect (r = 0.44; 95% CI [0.37–0.51]), highlighting leadership not merely as an administrative function but as a catalyst for pedagogical innovation and organizational change. Despite the consistent positive direction across studies, the high heterogeneity (I^2 = 71.8%) indicates that the effectiveness of leadership is context-dependent, influenced by institutional characteristics, teacher profiles, and leadership models. Furthermore, the funnel plot suggests the presence of moderate publication bias, although the overall relationship remains stable.

Theoretically, these findings extend leadership scholarship by positioning AI integration as a novel indicator of educational leadership effectiveness in the 21st century. Practically, the study underscores the necessity for educational leaders to adopt visionary, adaptive, and collaborative leadership approaches that enable teachers to embrace AI with confidence and competence. From a policy perspective, the results advocate for leadership development programs that align with digital transformation agendas, ensuring that schools and universities are equipped to navigate the complexities of AI integration. Ultimately, the synergy between transformational and digital leadership emerges as a critical driver for building innovative school cultures and accelerating sustainable digital transformation in education.

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