

Enhancing educators' digital literacy through digital leadership and organizational culture

Sugiarto Sutomo¹, Heni Rochimah²

¹Education Management Study Program, Faculty of Education, Jakarta State University, East Jakarta, Indonesia

²Educational Technology Study Program, As-Syafiiyah Islamic University, East Jakarta, Indonesia

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ABSTRACT

Despite rapid advances in digital technology and online learning, educators at the education and training center face limited digital access, low information and communication technology (ICT) proficiency, and difficulty integrating technology, reflecting the slow national rise in digital literacy. This study tests whether strengthening digital leadership and aligning organizational culture can improve educators' digital competencies. A cross-sectional survey of 120 educators was analyzed using path analysis in JASP. Findings indicate that digital leadership strongly predicts organizational culture ($\beta=0.869$, $z=28.834$, $p<0.001$). Both digital leadership ($\beta=0.208$, $z=2.453$, $p=0.014$) and organizational culture ($\beta=0.317$, $z=3.477$, $p<0.001$) significantly influence educators' digital literacy and the model explains a large portion of variance. Theoretically, results refine digital leadership models by clarifying the mediating role of culture and identifying leadership practices such as vision articulation, modelling of digital practice and alignment of infrastructure that support competence. Practically, institutions should embed digital goals in policy, allocate time for peer learning, incentivize pedagogical experimentation, and foster cross-unit collaboration. These interventions are more likely to produce sustained improvements than equipment purchases or one-off training and provide guidance for leaders and policymakers to accelerate institutional digital transformation.

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Corresponding Author:

Sugiarto Sutomo

Education Management Study Program, Faculty of Education, Jakarta State University

Street Rawamangun Muka Raya No. 11, Pulogadung, East Jakarta, Indonesia

Email: sugiarto@unj.ac.id

1. INTRODUCTION

The rapid development of digital technology greatly reshaped the field of education, requiring educators to adapt their roles and competencies in reaction to increasingly digital learning environments [1], [2]. The COVID-19 pandemic further accelerated this shift by increasing the demand for educators' digital literacy and technological proficiency, particularly in distance and virtual learning contexts [3]. In this regard, digital fluency is an essential component of affective instruction, not merely a supplementary skill [4]. Educators need to integrate information and communication technology (ICT)-based approaches, select appropriate digital tools, and critically evaluate technologies to support learning objectives [5].

In Indonesia, the national digital literacy index increased only slightly from 3.49 in 2021 to 3.54 in 2022, indicating that digital literacy remains at a moderate level and still requires continuous improvement [6]. This issue is also reflected in some education and training centers, where initial observations show that teaching effectiveness has not yet been optimized due to limited access to computers and internet connectivity, as well as insufficient ICT proficiency among educators. As a result, educators still face

difficulties in presenting learning materials and utilizing digital platforms affectively. Therefore, educators' digital literacy goes beyond technical ability while also the capacity to use digital information affectively in teaching and learning.

Educators need strong digital literacy to manage technology in education, create and share digital content, collaborate, address inquiries, and maintain digital security [7], [8]. Sánchez-Cruzado *et al.* [9] define educators' digital literacy as the integration of technical skills, informed decision-making, appropriate use of online media, and communication literacy in instructional practices. Eight core dimensions are recognized: creativity, collaboration, information selection, functional skills, critical thinking, cultural understanding, communication, and e-safety [10], [11]. These dimensions align with the European DigCompEdu framework, which conceptualizes educators' digital competence over six domains, including professional engagement, use of digital resources, teaching practices, evaluation, enhancing students' capabilities, and supporting learners' digital skills [12].

Digital leadership has gained prominence as a major factor influencing educators' digital literacy. It accelerates organizational performance by guiding strategic change and supporting adoption of digital practices [13]. Haşlamam *et al.* [14] define digital leadership as leveraging digital technology to influence attitudes, behaviors, and performance across individual, team, and organizational levels. It involves utilizing digital strategies and data to achieve institutional goals while enhancing individual well-being [15]. Within education, digital leadership encompasses adopting innovative technologies to create digital-age learning environments [16], [17]. Empirical evidence shows that affective digital leaders support training, model technology use, and strengthen collaboration to enhance educators' digital competence [18].

Besides digital leadership, another key factor contributing to educators' digital literacy is organizational culture [19]. It encompasses fundamental values, assumptions, beliefs, and practices [20] that shape how members of an institution work and interact [21]. In educational settings, organizational culture reflects shared perceptions and attitudes toward institutional processes [22], [23]. Sogalrey *et al.* [24] found that educators' perception of organizational culture directly affects their digital literacy, emphasizing the need for a supportive and aligned environment. Culture also functions as a form of social control through behavioral norms [25], promoting stability and coherence in institutional practices [26]. A constructive culture encourages professional growth, collaboration, and pedagogical innovation, making it a key element in digital transformation. According to Yergler [27], organizational culture can be classified into supportive, innovative, and bureaucratic types, each influencing how institutions respond to change and technological integration.

Recent studies further support the idea that organizational culture significantly affects educators' digital literacy by fostering collaboration, innovation, and sustained engagement with digital technologies. Rasdiana *et al.* [28] highlights that collaborative and adaptive school cultures play a central capacity to shape teachers' digital competence and technology integration. Furthermore, large-scale reviews indicate that institutional environments and organizational support systems are critical determinants of teachers' ability to adopt and affectively use digital tools [29]. These findings are reinforced by recent studies showing that teachers' digital literacy goes beyond an individual capability but is also shaped by the broader educational ecosystem and organizational support structures [30]. Therefore, a well-aligned organizational culture serves as both a structural and motivational force that empowers educators to develop and sustain their digital literacy.

Research on digital leadership in education has significantly expanded. However, empirical evidence remains fragmented and is still largely dominated by direct-affect models that insufficiently integrate organizational factors. Most existing studies focus on schools or universities, while education and training centers characterized by distinct objectives, organizational structures, and resource configurations remain underexplored [31], [32]. In addition, digital transformation research consistently identifies organizational culture as an important factor in the successful internalization of digital practices. However, its role in linking digital leadership and educators' digital literacy has not been systematically examined [33]. This gap has become more urgent as digital and hybrid learning environments require strong digital leadership and supportive organizational cultures to enhance educators' digital literacy [34], [35].

Although digital leadership and educators' digital literacy have been widely studied in formal and higher education, research in education and training centers and other non-formal learning settings remains limited [36]. Existing studies mainly focus on schools and universities, whereas education and training centers operate under different institutional structures, serve adult learners, and emphasize career-oriented programs [37]. These contextual differences create unique leadership challenges and distinct demands for digital literacy development. Therefore, the novelty of this study lies in examining the combined role of digital leadership and organizational culture in shaping educators' digital literacy within education and training centers, a context that remains underexplored in previous research.

Consequently, this study examines a practical and empirical gap by prioritizing through digital leadership and educators' digital literacy within education and training centers, as an organizational context that has been insufficiently portrayed in prior research. To address this research gap, this study develops a conceptual model linking digital leadership, organizational culture, and educators' digital literacy, as presented in Figure 1, and is guided by three research questions:

- i) How does digital leadership have a positive and significant direct influence on educators' digital literacy?
- ii) How does organizational culture have a positive and significant influence on educators' digital literacy?
- iii) How does digital leadership have a positive and significant influence on organizational culture?

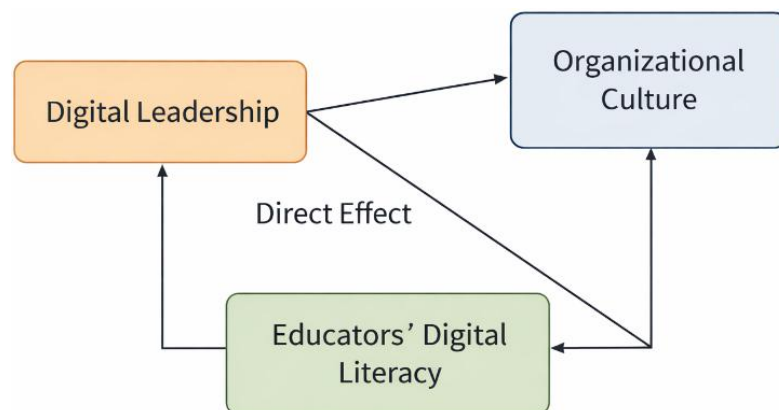


Figure 1. Conceptual model

2. METHOD

2.1. Research design and sampling procedure

This research followed a quantitative research design. The population comprised 172 educators at the Education and Training Centre of the Indonesian Ministry of Defense. The scale of sample was derived based on Slovin's formula with a 5% margin of error:

$$n = \frac{N}{1+N(e)^2}$$

Where, N=172 (total population); e=0.05 (margin of error).

$$n = \frac{172}{1+172(0.05)^2} = \frac{172}{1+172(0.0025)} = \frac{172}{1.43} = 120.28$$

Thus, the required sample size was approximately 120 respondents, rounded to the nearest whole number. The respondents were selected using simple random sampling, ensuring comprehensive representation across the population had same probability of being included in the study. In addition, a sample of 120 met common practical requirements for multivariate techniques; it exceeded frequently cited minimum thresholds for path analysis, thereby supporting adequate statistical power, model stability, and reliable parameter estimation [38].

2.2. Data collection

Data were gathered utilizing a structured online questionnaire. The online method was selected to facilitate efficient distribution, ensure broader accessibility, and allow respondents to accomplish the survey at their convenience while maintaining confidentiality. The questionnaire was formulated through a secure online survey platform and shared to the selected 120 educators via institutional email and official communication channels. Generally, participants required approximately 15–20 minutes to finalize the questionnaire. The data were gathered during a specified period over a span of two weeks to maximize response rates and allow adequate time for participation.

The constructs below digital leadership, digital literacy, and organizational culture were measured with composite Likert-style scales that employed a five-level response range, with a scale of 1 (strongly disagree) to 5 (strongly agree). Scale development followed best practices; items were selected from the literature, pilot-tested, evaluated via exploratory factor analysis (EFA), and retained only if they loaded on

a single factor and met item-total correlation benchmarks. A pilot study was conducted involving 20 educators who were excluded from the final study sample. The pilot test aimed to assess item clarity, construct validity, and reliability. The reliability of each completed scale was evaluated by applying Cronbach's alpha coefficient, and all reported coefficients met or exceeded conventional thresholds for reliability. Table 1 presents the measurement constructs, illustrative example items, reliability coefficients (Cronbach's α), and sources of adaptation for each variable.

Table 1. Variable measurement and reliability

Construct	Example items	Reliability (Cronbach's α)	Source
Digital leadership	"Leaders in my institute actively promote the use of digital tools in teaching." "Our organization's leadership provides a clear vision for digital transformation."	$\alpha=0.86$	[13]–[15], [17]–[19]
Digital literacy	"I feel confident using new digital learning platforms." "I can affectively evaluate online information sources."	$\alpha=0.89$	[7]–[12]
Organizational culture	"This organization encourages experimentation with new technologies." "Employees share knowledge about affective digital practices."	$\alpha=0.83$	[20]–[26]

After initial item selection from the literature, a pilot test and EFA were conducted. The final scales were unidimensional, and all retained items had item-total correlations above recommended benchmarks. Reported Cronbach's alpha coefficients ($\alpha \geq 0.80$) showed that all items complied with standard reliability benchmarks, providing justification for their use in subsequent hypothesis testing.

EFA was employed to appraise the construct validity of the measurement instruments. Items were retained only if they loaded on a single factor with loadings greater than 0.50 and exhibited no significant cross-loadings. An EFA was performed by employing principal component analysis along with Varimax rotation. The Kaiser-Meyer-Olkin (KMO) value surpassed the minimum acceptable level of 0.60, while Bartlett's test of sphericity showed a significant result ($p < 0.05$), which indicated that the dataset was suitable for factor analysis. All retained items demonstrated factor loadings above 0.50, which confirmed convergent validity. All participants were provided with information explaining the aim of the research, were assured of privacy protection, and gave informed consent before completing the questionnaire. Participation was completely voluntary, and participants were free to withdraw at any point without facing any consequences.

2.3. Data analysis

Each scale's construction followed best practices in survey design: after initial item selection from the literature, a pilot test and EFA were conducted. The final scales were unidimensional, and all retained items had item-total correlations above recommended benchmarks. Reported Cronbach's alpha coefficients ($\alpha \geq 0.80$) showed that all items complied with standard reliability benchmarks, providing justification for their use in subsequent hypothesis testing. Compared to full structural equation modeling (SEM), path analysis was considered appropriate because the study focused on structural relationships among observed composite variables rather than estimating a comprehensive measurement model with latent indicators [39]. This approach provided a parsimonious and theoretically aligned method for testing directional hypotheses while maintaining statistical efficiency given the sample size ($N=120$). Preliminary analyses, including assessments of normality and linearity, were conducted prior to hypothesis testing to ensure compliance with path analysis assumptions.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Prerequisite analysis

Preliminary assumption testing was performed to verify that the data satisfied the assumptions of path analysis. The normality test showed that the Asymp. Sig. value for digital leadership (X1), organizational culture (X2), and educators' digital literacy (Y) was 0.200, which exceeded the significance level of 0.05, revealing that the data exhibited a normal distributed. In addition, the linearity test showed that the relationships amid digital leadership, organizational culture, and educators' digital literacy were linear, as indicated by the deviation from linearity significance values exceeding 0.05, as summarized in Table 2.

Table 2. Summary of normality and linearity test results

Assumption test	Variables/relationship	Sig. value	Criteria	Interpretation
Normality test	X1, X2, and Y	0.200	Sig.>0.05	Normally distributed
Linearity test	Digital leadership (X1)→educators' digital literacy (Y)	0.684	Sig.>0.05	Linear relationship
Linearity test	Organizational culture (X2)→educators' digital literacy (Y)	0.507	Sig.>0.05	Linear relationship

3.1.2. Path analysis

This study employed path analysis to test three hypotheses (H1–H3). The research path coefficient is presented in Table 3. The conceptual relationships among digital leadership (X1), organizational culture (X2), and educators' digital literacy (Y) are illustrated in Figure 1, which visually depicts the standardized path coefficients derived from the analysis.

As presented in Table 3 and illustrated in Figure 2, the path analysis revealed that digital leadership (X1) exerts a significant positive influence on educators' digital literacy (Y). The standardized path coefficient is 0.208, with a p-value of 0.014, which is below the 0.05 significance threshold. At the 95% confidence level, the effect ranges from 0.100 to 0.286. These results confirm the first hypothesis, indicating that stronger digital leadership is correlated with an advanced level of educators' digital literacy.

Furthermore, organizational culture (X2) was found to significantly influence educators' digital literacy (Y), with an estimated coefficient of 0.317 and a p-value of <0.001. This demonstrates a positive and statistically significant affect, supported by a confidence interval of 0.042 to 0.374. Accordingly, the second hypothesis, which proposes that organizational culture has a positive and significant direct on educators' digital literacy, is supported. These findings indicate that stronger organizational culture associated with increased levels of educators' digital literacy.

In addition, digital leadership (X1) has a significant influence in the organizational culture (X2), with a coefficient of 0.869 and a p-value <0.001. This reflects digital leadership is positive and has significant effect on organizational culture with a confidence interval between 0.810 and 0.928. Thus, the third hypothesis that digital leadership positively and significantly influenced organizational culture is accepted or evidenced. This result shows that digital leadership affects educators' digital literacy directly and indirectly through organizational culture.

Table 3. Research path coefficient

Path	Estimate	Std. Error	z-value	p-value	95% confidence interval	
					Lower	Upper
X2→Y	0.317	0.091	3.477	<0.001	0.138	0.495
X1→Y	0.208	0.085	2.453	0.014	0.042	0.374
X1→X2	0.869	0.03	28.834	<0.001	0.81	0.928

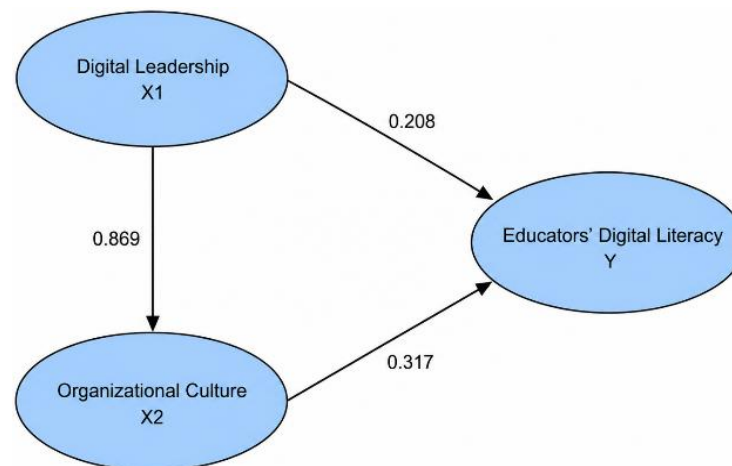


Figure 2. Conceptual path model of digital leadership, organizational culture, and educators' digital literacy

3.1.3. Model fit

The model of fit was assessed to examine the acceptability of the hypothesized model. As shown in Table 4, several fit statistics were evaluated, including χ^2 , root mean square error of approximation (RMSEA) with a 90% confidence interval, comparative fit index (CFI), Tucker Lewis index (TLI), and standardized

root mean square residual (SRMR), to determine the extent to which the model fits the empirical data. As presented in Table 4, the model confirms a good fit to the data. The chi-square statistic was $\chi^2(87)=102.34$ with $p=0.118$, suggesting that the difference amid the actual covariance matrix and the covariance matrix predicted by the model is not statistically significant. The RMSEA was 0.041, with a 90% confidence interval ranging from 0.000 to 0.072. This value is lower than the recommended threshold of 0.08 and close to 0.05, suggesting a close fit of the model to the data.

Furthermore, the structural model demonstrates a good to excellent fit. The CFI was 0.964 and TLI was 0.955, together exceeding the reference threshold of 0.90 and approaching the stricter benchmark of 0.95. The SRMR was 0.048, well below the 0.08 cutoff, reflecting a very good fit. Overall, these indices indicate that the proposed relationships among X1, X2, and Y are strongly supported by the empirical data.

Table 4. Model fit indices

Fit index	Estimate
$\chi^2(87)$	102.34 ($p=0.118$)
RMSEA	0.041
90% CI	[0.000, 0.072]
CFI	0.964
TLI	0.955
SRMR	0.048

3.1.4. R-square analysis

To investigate the explanatory effectiveness of the proposed path model, the coefficient of determination (R^2) was examined. The R-squared values for the endogenous variables are presented in Table 5. As presented in Table 5, the coefficient of determination (R^2) indicates strong explanatory power for the model. The R^2 for educators' digital literacy (Y) is 0.692, suggesting that digital leadership (X1) together with organizational culture (X2) explains 69.2% of the variance in educators' digital literacy, while the remaining 30.8% is attributable to factors outside the model. Additionally, the R^2 for organizational culture (X2) is 0.874, indicating that digital leadership (X1) accounts for 87.4% of its variance, demonstrating a strong influence on the development of organizational culture. Overall, these results confirm that both digital leadership and organizational culture significantly affect educators' digital literacy. The paths among variables of the proposed model are described in Figure 3.

Table 5. R-squared

Variable	R^2
Y	0.692
X2	0.874

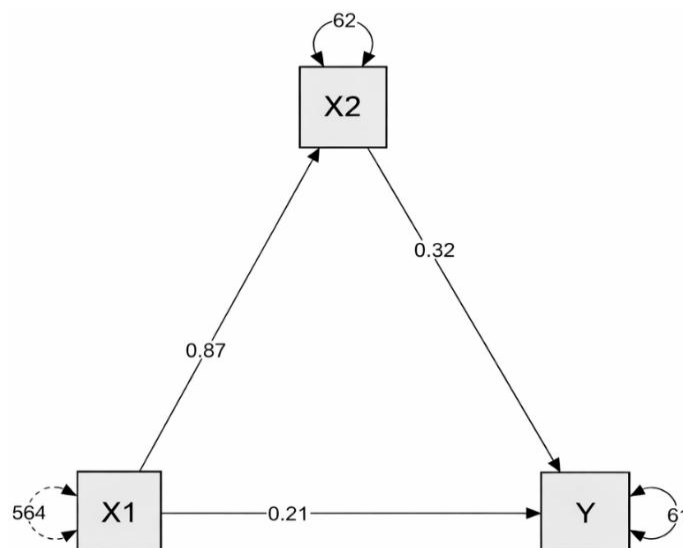


Figure 3. Model of influence between variables based on path analysis

3.2. Discussion

This study has unveiled a significant relationship between variables by applying relevant theories and conducting path analysis. Through the conducted research, it is evident that X1 and X2 have a significant impact in the Y. Data analysis exposes a substantial direct positive relationship amid digital leadership and educators' digital literacy, with an estimated coefficient of 0.208 and a p-value of $0.014 < 0.05$, shows that higher levels of digital leadership lead to higher levels of digital literacy among educators. The finding confirms the importance of the role of technology-oriented digital leadership, as a catalyst in driving digital transformation in educational institutions to increase educators' digital literacy.

3.2.1. H1: digital leadership has a positive and significant direct influence on the educators' digital literacy

The path-analysis outcome reflect that digital leadership has a significant positive effect on educators' digital literacy ($\beta=0.208$, $z=2.453$, $p=0.014$), suggesting that stronger implementation of digital leadership is associated with measurable improvements in teachers' digital competencies. This finding supports previous studies showing that institutional leaders' digital leadership has a positive influence on educators' digital literacy and technology incorporation practices [2], [24]. Educational institutions therefore have a responsibility to align technological resources, professional development, and institutional goals in a systematic way to strengthen educators' digital competencies [40]. Prior research on digital transformation also shows that leaders' strategic direction shapes digital learning environments and organizational readiness for technology integration. This may explain differences in teachers' digital literacy across institutional contexts [41].

These findings align with studies showing that leaders with strong digital capabilities can enhance institutional innovation and skill development by promoting technology adoption and innovative practices among educators [42], [43]. Digital leadership also supports the implementation of digital platforms that strengthen collaboration, communication, and professional learning within educational institutions [44]. As educators' knowledge and skills in using digital technologies are closely linked to the level of institutional digitalization, leadership plays an essential role in mobilizing the resources required for technology integration at different stages of implementation [2]. Affective digital leadership further promotes communication and collaboration among educators and stakeholders, which supports technology-enhanced teaching and learning practices [45]. This is consistent with views that educators' digital capability is multidimensional. It includes technical, pedagogical, and ethical competencies. Therefore, leadership and organizational culture should be developed together to support meaningful instructional change [46].

In addition, the findings reinforce the argument that strong digital literacy among educators is essential for successful digital innovation in educational institutions [47]. Digital leadership should not function only as a managerial directive. It should also serve as a catalyst for educators' continuous digital competency development. Organizational culture is also important in this process. A supportive culture can encourage collaboration, innovation, and technology adoption. Institutional digitalization may also shape how educators and students perceive and use digital media in learning environments [48]. Previous studies have shown that leaders' digital competencies and technology-oriented curriculum strategies improve teaching quality and instructional innovation [46]. Cross-national research further indicates that leaders who provide technological resources, technical support, and professional development opportunities can accelerate educators' digital literacy and technology adoption [42], [49]. Differences in how institutions organize and support digitalization initiatives may partly explain variations in the impact of leadership on teachers' digital literacy across contexts [41], [48].

Overall, the findings suggest that strategic vision, resource allocation, and continuous professional development are essential for strengthening digital teaching practices in educational institutions [50], [51]. Previous studies show that digital leadership can foster experimentation, collaboration, and innovation in the use of digital technologies [52]. The findings also support prior literature showing that investment in digital platforms and structured professional development can improve educators' digital competencies and sustain digital transformation in education [53]. Affective digital leadership therefore helps create inclusive and digitally supported learning environments. It also improves communication, collaboration, and stakeholder engagement. These factors strengthen institutional capacity to improve educational quality in the post-pandemic era.

3.2.2. H2: organizational culture has a positive and significant influence on the educators' digital literacy

The path-analysis results show that organizational culture has a positive and significant effect on educators' digital literacy ($\beta=0.317$, $z=3.477$, $p<0.001$), indicating that more supportive cultures are associated with higher levels of educators' capacity to use digital technologies affectively. This finding aligns with international evidence that organizational cultures emphasizing innovation, collaboration, and digital engagement enhance teachers' digital literacy and facilitate the uptake of technology-based learning initiatives [54]. At the same time, recent work cautions that the magnitude and operative mechanisms of this

affect depend on institutional readiness and contextual factors, so culture alone does not uniformly translate into literacy gains without considering broader readiness conditions [55].

Mechanistically, supportive organizational cultures promote continuous learning, collegial collaboration, and access to digital resources and training [56], [57]. Empirical studies also indicate that without concurrent investments in infrastructure and formal professional learning systems, the positive influence of culture on digital literacy can be attenuated, particularly in settings with limited digital readiness [58]. Thus, organizational culture functions as a necessary but not always sufficient enabler: it creates the motivational and normative conditions for adoption while structural supports determine the extent of realized competence improvements [23], [59].

These results reinforce broader organizational research that links culture to institutional effectiveness and professional capability development [60], and they complement prior findings on educators' professional development and digital competence [61], [62]. On educational settings, especially training centers, digital literacy appears to be a direct outcome of organizational culture rather than only a mediating variable [17], [63]. Accordingly, education and training institutions should prioritize deliberate culture-building. Institutional norms for collaboration and protected time for technology practice are essential. At the same time, stronger structural supports are needed. The combination of cultural and material investments increases the likelihood that educators will translate institutional intent into sustained digital practice.

3.2.3. H3: digital leadership has a positive and significant influence on the organizational culture

The structural path analysis shows that digital leadership has a strong, positive, and statistically significant effect on organizational culture ($\beta=0.869$, $z=28.834$, $p<0.001$). This finding suggests that digital leadership is closely linked to the development of an organizational culture that supports digital transformation. It is consistent with prior studies showing that digital leadership helps create pro-technology norms and institutional alignment [41], [53]. It also indicates that organizational culture may be one of the main channels through which digital leadership influences educators' digital literacy.

Mechanistically, digital leaders appear to foster psychological safety and opportunities for experimentation [64]. These conditions encourage educators to try new tools, share practices, and adopt standardized digital routines. The process creates a reinforcing cycle in which leadership shapes culture and culture sustains competence development [65]. This dynamic is echoed in international literature showing that collaborative, continuous-learning cultures expand opportunities for professional training, resource sharing, and the standardization of digital practices [66]. Empirical work also shows that digital leaders mobilize resources, articulate a shared digital vision [67], and promote staff collaboration to strengthen institutional digital literacies continuously [68]. While some prior studies find that cultural mechanisms mainly affect classroom-level adoption without fully reshaping institutional norms [69], the present findings indicate a broader, institution-level alignment in which leadership drives deeper cultural change that supports educators' digital literacy.

These results support the view that digital leadership is a primary antecedent of a digital-supportive organizational culture, and therefore a leverage point for interventions aiming to improve educator competencies. At the same time, the evidence should be interpreted with caution given contextual variability reported in the literature: leadership affects may be moderated by platform readiness, resource availability, and governance structures, so policy and institutional initiatives should combine leadership development with concrete structural supports to realize sustained cultural transformation and literacy gains [70].

Finally, the model's substantial explained variance (high R^2) reinforces the conclusion that digital leadership and organizational culture are significant determinants of educators' digital literacy. The finding is consistent with Karakose *et al.* [18] who showed that digital leadership supports digital transformation in education. It also aligns with Rasdiana *et al.* [28] who reported that technology leadership and digital culture improve teachers' professional digital competence. AlNuaimi *et al.* [71] found that digital leadership strengthens organizational agility and innovation. Anwar and Saraih [72] further confirmed that digital leadership promotes collaboration and innovation. These studies support the practical need for education and training centers to invest in digitally competent leadership and cultures that encourage innovation, collaboration, and continuous professional learning.

This study's findings carry meaningful consequences for theory, practical application, and policymaking in relation to digital transformation in educational institutions. This research contributes theoretically by proposing and empirically validating an integrative model linking digital leadership, organizational culture, and educators' digital literacy within education and training centers as a non-formal and under-researched context. The contribution is twofold: first, the study demonstrates empirically that digital leadership affects educators' digital literacy both directly and indirectly through the cultivation of a supportive organizational culture; second, the analysis shows this pattern in a training-center setting where

professional development, operational routines, and organizational incentives differ from formal K–12 or university contexts. Together, these contributions enhance current frameworks of digital leadership by clarifying the mediating influence of culture as the process by which leadership transforms strategic intentions into routine teaching practices, and by determining which leadership efforts, such as articulating vision, providing role modelling, and aligning infrastructure—most consistently result in improvements in competence.

The findings also have practical implications for education and training centers. Leaders should not treat digital transformation only as a technical program. Digital leadership practices need to be connected with institutional policies, peer learning, and incentive systems. Training centers should embed shared digital goals into internal policies and operational routines. Training centers should also provide protected time for educators to practice digital tools, exchange experiences, and learn from peers. Peer learning communities can help educators develop confidence in using digital technologies for teaching and training activities. In addition, institutions should provide incentives for educators who experiment with digital pedagogy, develop digital materials, or support colleagues in technology use. These incentives may include formal recognition, workload support, career-development opportunities, or performance-based rewards.

At the policy level, the findings suggest that digital transformation programs should combine leadership development, digital governance, infrastructure support, and continuous professional learning. Investment in hardware or one-time training is not sufficient to improve educators' digital literacy in a sustainable way. Policymakers and institutional leaders should design integrated programs that strengthen leaders' digital capacity, support collaborative culture, and provide targeted resources for digital platforms and training activities. Education and training centers also need coordination teams to monitor digital initiatives, identify implementation barriers, and support data-informed reflection. These steps can help translate organizational culture into consistent digital teaching practices.

This study has certain limitations. First, the study used a cross-sectional quantitative design. Therefore, the findings cannot fully explain causal relationships among digital leadership, organizational culture, and educators' digital literacy. Second, the sample was limited to educators from a single education and training center. This limitation may reduce the generalizability of the findings to other institutions, educational levels, or national contexts. Third, the study relied on self-reported data. The responses may be affected by social desirability bias and may not fully reflect actual digital practices in teaching and learning.

Future studies should use longitudinal designs to examine how digital leadership and organizational culture influence educators' digital literacy over time. Comparative studies across different education and training centers are also needed to test whether the model applies to diverse institutional contexts. Future research may also compare non-formal training centers with formal schools and universities. In addition, mixed-method studies could provide deeper insight into how leadership practices, institutional culture, peer learning, and incentive systems shape educators' digital literacy. Future studies should also include objective performance measures, classroom observations, or digital activity data. These approaches would provide stronger evidence on how digital transformation can be sustained in education and training centers.

4. CONCLUSION

The study finds that digital leadership and organizational culture significantly and positively influence educators' digital literacy at the Education and Training Centre of the Ministry of Defense of the Republic of Indonesia. The analysis confirms that digital leadership directly contributes to improving educators' digital literacy. Furthermore, a positive organizational culture significantly strengthens these competencies. Notably, digital leadership also exerts an indirect influence by fostering a culture that, in turn, improves digital literacy.

The results indicate that robust digital leadership and a supportive organizational culture are critical drivers of educators' digital literacy and, consequently, successful institutional digital transformation. Theoretically, these findings refine existing models of digital leadership by making explicit the mediating role of culture and by identifying which leadership investments, such as vision articulation, modelling of digital practice, and alignment of infrastructure, translate most reliably into competence gains. From a practical and policy perspective, institutions should adopt integrated strategies. Institutions should pair leadership capacity building with deliberate culture work by embedding shared digital goals in policy, allocating protected time for practice and peer learning, and formalizing incentives for pedagogical experimentation. Institutions should also establish cross-unit coordination teams and routine data-informed reflection cycles. These integrated approaches are more likely to produce sustained improvements in educators' digital competence than isolated hardware purchases or one-off technical workshops.

This research has certain limitations that should be considered. First, it uses a cross-sectional questionnaire design with limited observational data, which constrains causal inference. Second, dependence on self-reported measures may create reporting bias and an imperfect measurement of actual digital practices.

Third, the participants are drawn from only one education and training center, limiting generalizability to other institutional or national contexts. Therefore, future research should adopt longitudinal or mixed-method designs, broaden sampling, and incorporate objective performance indicators to address these issues.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Sugiarto Sutomo	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Heni Rochimah		✓	✓			✓	✓	✓	✓	✓	✓			✓

C : **C**onceptualization

M : **M**ethodology

So : **S**oftware

Va : **V**alidation

Fo : **F**ormal analysis

I : **I**nvestigation

R : **R**esources

D : **D**ata Curation

O : Writing - **O**riginal Draft

E : Writing - Review & **E**diting

Vi : **V**isualization

Su : **S**upervision

P : **P**roject administration

Fu : **F**unding acquisition

CONFLICT OF INTEREST STATEMENT

The researchers report having no monetary conflicts or private relationships that might have affected the results or how the findings in this research were understood or reported.

INFORMED CONSENT

Every individual involved agreed to join after receiving full details about the research. Their involvement was completely optional, and they were made aware of the study's aims, the privacy of their responses, and their freedom to exit the study at any point without experiencing any penalties.

ETHICAL APPROVAL

All participants joined of their own free will after giving consent, and their identities were protected by removing any personal identifiers prior to data analysis. The research involved very low risk and adhered to commonly recognized ethical requirements for studies involving human subjects.

DATA AVAILABILITY

The datasets supporting the results of this research are provided by the lead contact author, [SS], upon a justified and appropriate request. Access to de-identified data will be granted in accordance with applicable approvals and ethical considerations.

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BIOGRAPHIES OF AUTHORS



Sugiarto Sutomo    serves as a lecturer in the Education Management Study Program, Faculty of Education, State University of Jakarta, Indonesia. His research interests focus on education management, leadership, decision-making, and public policy. He can be contacted at email: sugiarto@unj.ac.id; sutomosugiarto43@gmail.com.



Heni Rochimah    completed her doctoral degree (Ph.D.) in Educational Technology at the Graduate School, Universitas Negeri Jakarta in 2025 under the Indonesian Endowment Scholarship (*Beasiswa Pendidikan Indonesia* or BPI). Since 2018, she has served as a full-time lecturer in the English Education Study Program at Universitas Islam As-Syafiiyah, and in 2025, she was appointed as a full-time lecturer in the Master Program of Educational Technology at the same university. Her research interests include ICT-based instructional development, digital learning media, and innovations in learning technology. She can be contacted at email: henirochimah.fkip@uia.ac.id.