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Exploring the Nexus of Digital Leadership and Digital Literacy on Higher Education Performance: The Role of Digital Innovation

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Abstract: Industry 4.0 has affected various aspects of life, including the organization of higher education. In the current era, higher education is required to transform themselves from using the conventional way of administration to the digitalized one. The said transformation also includes the services provided and management carried out by the organizations. The objective of this study is to measure the understudied mediation of digital innovation in the effect of the nexus of digital leadership and digital literacy on the performance of higher education. This quantitative research was conducted by distributing questionnaires to 234 faculty members of four higher education institutions in Malang City, Indonesia. Partial Least Squares – Structural Equation Modeling was applied to analyze the data. This study finds that digital leadership significantly affects the higher education performance and conclusively predicts digital innovation. As hypothesized, digital literacy has a significant effect on the higher education performance and digital innovation, and digital innovation plays a substantial role in the higher education performance. In addition, digital innovation mediates the influence of digital leadership and digital literacy on the higher education performance.

Keywords: *Digital innovation, digital leadership, digital literacy, higher education performance.*

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Introduction

The world has entered the Industrial Revolution (IR) 4.0, which is designated by the use of various kinds of technology in human lives. The concept of IR 4.0, which was developed in Germany, is the implementation of technological improvements in manufacturing, strategic technology governance policies, and other supporting policies. This industrial revolution is evident in the increasing role of artificial intelligence, robots, internet of things, and other technologies (Culot et al., 2020). In fact, IR 4.0 also affects education (Shahroom & Hussin, 2018). Nowadays education was directed to incorporating technology both physically and non-physically in the learning process. With changes in the external environment, it is necessary to adjust education governance so that it is able to adapt and transform from conventional to digital administration (Tangahu et al., 2021).

In Indonesia, implementing strategies to prepare higher education to face Industry 4.0 is an extraordinary challenge. In the country, education is a key party that serves as a driving force for the industrial world development (Ali et al., 2020). Therefore, maintaining the performance of higher education organizations is necessary to provide maximum contribution. The organizational performance of higher education can be identified from both the national and international ranking of the institutions. At the national level, Brawijaya University is the only higher education from Malang City spotted by the radar of the top-10 universities. However, this rating does not apply at the international level. Referring to QS World University Rankings (2023), no higher education in the city is included in the best 600 universities in the world.

This phenomenon requires in-depth investigation, considering that universities having good performance are proof that they are capable to develop and change continuously (Cricelli et al., 2018). In addition, digital education is becoming a global trend that demands higher education to transform and adapt so that they are not left behind. In the field of education, digital transformation refers to changes and the application of digital technologies in the whole aspects of education (Oberer & Erkollar, 2018). This is crucial for organizational management and stimulates better performance. Leadership is one of the main predictors for accelerating organizational performance (AS et al., 2021; Idris et al., 2022).

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Digital leadership, compared to other aspects, is the key to transforming education in order to improve organizational performance. Digital leadership is leading and directing the resources, such as ICT (information and communication technology) in achieving set goals (Jameson et al., 2022). Organizational performance in the technology era is closely related to the role of digital leadership (Sarfraz et al., 2022). Quddus et al. (2020) asserted that when leaders in tertiary institutions implement digital leadership, the organizational performance improves.

Besides digital leadership, other aspects such as digital literacy also have an important contribution in elevating performance in the higher education context. Digital literacy denotes the ability to utilize technological and digital equipment to find, evaluate, use, communicate and create digital information with cognitive and technical skills (Neumann et al., 2017). Digital literacy abilities that provide an understanding of information in various patterns (Bawden, 2008), have implications for effective learning and performance in higher education (Ukwoma et al., 2016). Furthermore, Abas et al. (2019) revealed that organizational achievement and performance increase when members are highly skilled in digital media and technology. Digital literacy with the style of dependent learning, operational skill, and critical thinking skill accelerates universities' academic attainments (Khan et al., 2022). Furthermore, higher education has been identified as key agents in the development of creativity and innovation (Vicente et al., 2020). In relation to higher education, this innovation includes how universities are able to create new teaching and learning processes or services for students. In educational transformation, digital innovation is a must for universities to promote education quality. Ashaari et al. (2021) and Khin and Ho (2020) revealed that big data analytic capability as a critical part of digital innovation significantly affects higher education performance.

The nexus between digital leadership and organizational performance had been extensively examined (Benitez et al., 2022; Mohamed, 2022; Shin et al., 2023), as well as the role of digital literacy to organizational performance (Abas et al., 2019; Al-Seghayer, 2020; Sari, 2022). However, the said nexus in higher education performance is relatively understudied. In addition, prior studies also found a non-significant implication of digital leadership on performance in organization (Muniroh et al., 2022). This research explores this gap more deeply by proposing digital innovation as a potential mediator. Therefore, the current study attempts to investigate the relationship between digital leadership and digital literacy on university performance mediated by digital innovation. The findings later on can help leaders of the institutions come up with decisions that enhance the success of digital transformation through digital leadership, digital literacy and digital innovation.

Methodology

Research Design

This quantitative-explanatory study examines the nexus between the variables in the proposed framework, namely digital leadership, digital literacy, digital innovation, and higher education performance. This research also measures the mediating role of digital innovation in the influence of digital leadership and digital literacy on the performance of higher education. The proposed model of this research is presented in Figure 1, and the following seven hypotheses were formulated.

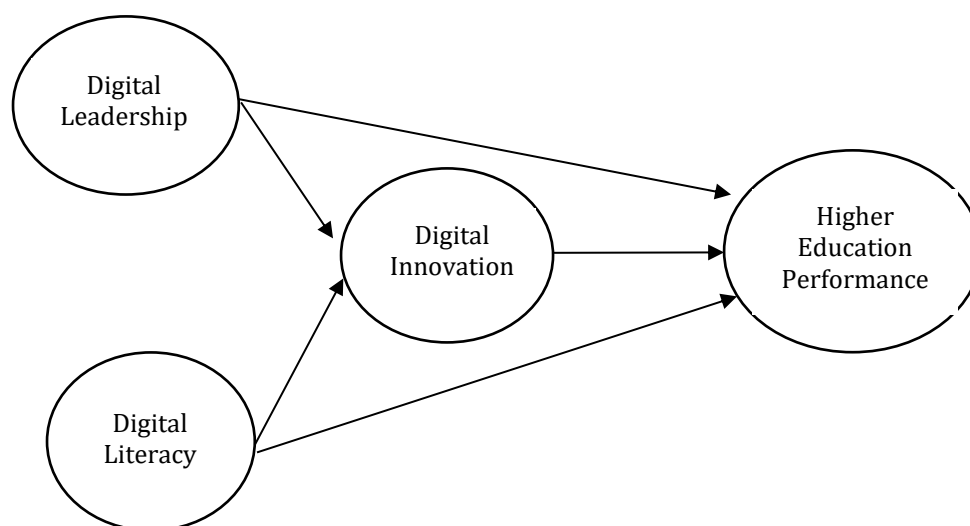


Figure 1. Proposed Framework

Hypothesis 1: Digital leadership significantly affects higher education performance.

Hypothesis 2: Digital literacy significantly affects higher education performance.

Hypothesis 3: Digital innovation significantly affects higher education performance.

Hypothesis 4: Digital leadership significantly affects digital innovation

Hypothesis 5: Digital literacy significantly affects digital innovation

Hypothesis 6: Digital innovation mediates the effect of digital leadership on higher education performance.

Hypothesis 7: Digital innovation mediates the effect of digital literacy on higher education performance.

Participants and Data Collection

The participants of this study are the entire faculty members – consisting of lecturers, education staff, and students – of state universities in Malang city, i.e., Maulana Malik Ibrahim State Islamic University of Malang, State University of Malang, Brawijaya University, and State Polytechnic of Malang. Questionnaires were distributed from June to September 2022 to simple random sampling-selected respondents. It is informed in the questionnaires that this study was conducted only for academic purposes and that the participants' confidentiality was maintained. After elimination of incomplete data and tabulation, 232 responses were processed and analyzed. Table 1 shows the demographic data of the participants.

Table 1. Respondent Demographic Data

	Occupation (%)	Education (%)	Length of Work (%)	Origin University (%)
Lecturer	44 (19.0%)			
Education Staff	25 (10.8%)			
Student	163 (70.3%)			
Senior high school		146 (62.9%)		
Associate / vocational degree		5 (2.2%)		
Bachelor degree		31 (13.4%)		
Master degree		27 (11.6%)		
Doctorate degree		23 (9.9%)		
1-5 years			11 (4.7%)	
6-10 years			17 (7.3%)	
11-15 years			13 (5.6%)	
16-20 years			14 (6.0%)	
21-25 years			5 (2.2%)	
>25 years			9 (3.9%)	
Still studying			163 (70.3%)	
State Islamic University of Malang				43 (18.5%)
State University of Malang				115 (49.6%)
Brawijaya University				70 (30.2%)
State Polytechnic of Malang				4 (1.7%)

Table 1 shows that, from 232 respondents, 44 people (19.9%) work as lecturers, 25 people (10.8%) are education staff, and 163 people (70.3%) are students. The dominance of student group occurs because the number of students is more than the number of other participants. Further, 23 people (9.9%) are doctors, 27 people (11.6%) are masters, and the rest are people of lower education. Then, most of the respondents are still studying (70.3%), eleven people (4.7%) have worked for 1 to 5 years people, seventeen people (7.3%) have worked for 6 to 10 years, and nine people (3.9%) have worked for more than 25 years.

Measurement

All items in all constructs were measured using five-point Likert scale questions; the responses range from 1 (strongly disagree) to 5 (strongly agree). The statement items are the results of the adaptation of items used in past research, accordingly adjusted to the focus of this study. Here digital leadership was measured using ten items adapted from Roman et al. (2019) consisting of e-social, e-communication, e-team, e-tech, and e-trust. These factors have the Cronbach's alpha value from .761 to .938; only valid items were used. One of the items is "Leaders are experienced in using technology". Then, digital literacy was measured using six instruments which had been improved from the original version (Lukitasari et al., 2022). One example is "When I suddenly want to know something for academic purposes, I immediately find it out by searching the internet". Digital innovation was measured using items adapted from Khin and Ho (2020). The items have the loading factors of .644 to .852. Four items measure this construct; one of them is "My university has cutting-edge technology services compared to other universities". Finally, higher education performance was measured using items used by (Brochado, 2009) and (Islami, 2021) and revised according to the context of the current research. The items adapted from (Brochado, 2009) were used to assess service performance, while items adapted from (Islami, 2021) were used to measure operational and financial performance. Therefore, higher education performance was measured more comprehensively in this study. Fifteen items were used in this study; one of them is

"My college is increasing the number of new product and service innovations". Table 2 exhibits the whole question items employed in this study.

Table 2. Measurement Items

Variable	Item	Construct
Digital Leadership	DLP.1	Leaders are enthusiastic about technological developments
	DLP.2	Leaders understand the use of new technology to the college sustainability
	DLP.3	Leaders are experienced in using technology
	DLP.4	Leaders encourage teamwork by leveraging technology
	DLP.5	Leaders do not hesitate to share knowledge regarding the latest technology
	DLP.6	Leaders communicate the vision and mission of the college digitally
	DLP.7	Leaders make decisions based on the data they have
	DLP.8	Leaders are comfortable with the uncertainties of the digital age*
	DLP.9	Leaders become role models for their subordinates
	DLP.10	Leaders retain and manage their employees properly.
Digital Literacy	DLY.1	I share research findings or news that are currently viral*
	DLY.2	When I suddenly want to know something for academic purposes, I immediately find out by searching the internet
	DLY.3	I refer to online materials to support the threefold missions of higher education
	DLY.4	I am an expert in surfing the internet in order to support academic purposes
	DLY.5	In order to find out specific terminology in searching for a specific database, I searched through the internet and other digital media
	DLY.6	I share information digitally only that is proven valid (eg; research results)
Digital Innovation	DI.1	My university has cutting-edge technology services compared to other universities
	DI.2	My university has service features that use excellent technology
	DI.3	My university has applications to support learning processes, research and other administrative activities
	DI.4	My university has a website displaying informative information
Higher Education Performance	HEP.1	My college is increasing funding sources beyond the main funding
	HEP.2	My university has made changes to the existing financial regulation system in each work unit for the better
	HEP.3	My college increases financial transparency and accountability
	HEP.4	My college improves financial services to stakeholders
	HEP.5	My college increases student satisfaction
	HEP.6	Student complaints against this college institution continue to decrease
	HEP.7	My college is increasing the number of new student applicants*
	HEP.8	My university increases cooperation with international stakeholders
	HEP.9	My college is increasing the number of new product and service innovations
	HEP.10	My college improves the average student GPA
	HEP.11	My college accelerates the average time to complete studies
	HEP.12	My college maintains and improves facilities and infrastructure properly
	HEP.13	At my college, the level of satisfaction index of employees, lecturers and students has increased
	HEP.14	My college improves the quality of human resources with further studies and training/education
	HEP.15	My college produces information technology that is useful for academic purposes

Note: * is a removed item because the loading factor value is less than .60

Analyzing of Data

500 sub-samples in the Partial Least Squares – Structural Equation Modeling (PLS-SEM) method were applied in this study after the final 232 responses were tabulated. SEM with PLS is a powerful method because it can handle plenty of exogenous variables with various hypothetical models (Ghozali, 2008). Hypothesis testing was conducted after the validity and the reliability thresholds had been confirmed. The goodness-of-fit model was used to assess how good the formulated model is. Hair et al. (2011) explained that the evaluation can be identified from the coefficient of determination (R^2) and the predictive relevance (Q^2) values. If the R^2 value comes near to 1, good value is indicated (Chin, 1998). The mediating effect was measured through bootstrapping, which is highly compatible with PLS that assumes the data is spread in a normal way (Hair et al., 2017).

Results

Measurement Model

The validity and the reliability of the research model were measured to evaluate the measurement model, as required by PLS. This analysis includes the calculations of convergent validity and composite reliability (Hair et al., 2017). In detail, the validity was measured using a loading factor value of above .60 and an Average Variance Extracted (AVE) of above .50 (Ghozali, 2008). The reliability was identified through the Composite Reliability value of above .70. Composite reliability was applied to test the level of reliability through the internal consistency reliability approach. In addition, the reliability test uses Cronbach's alpha value of above .70 (Chin, 1998). The results of the instrument measurements are shown in Table 3 below.

Table 3. Results of Measurement Model in PLS

Constructs	Items	FL	CA	CR	rho_A	AVE	Outer VIF
Digital Leadership	DLP.1	.757	.927	.939	.932	.630	2.087
	DLP.2	.793					2.560
	DLP.3	.813					2.512
	DLP.4	.771					2.043
	DLP.5	.773					2.191
	DLP.6	.807					2.327
	DLP.7	.797					2.245
	DLP.9	.777					2.339
	DLP.10	.850					2.022
	Digital Literacy	DLY.2					.702
DLY.3		.649	1.319				
DLY.4		.673	1.388				
DLY.5		.802	1.746				
DLY.6		.642	1.331				
DLY.6		.642	1.331				
Digital Innovation	DI.1	.840	.839	.893	.845	.676	2.795
	DI.2	.885					2.182
	DI.3	.796					1.828
	DI.4	.761					1.724
Higher Education Performance	HEP.1	.669	.938	.946	.941	.614	2.021
	HEP.2	.785					2.836
	HEP.3	.786					2.716
	HEP.4	.787					2.820
	HEP.5	.741					2.366
	HEP.6	.668					1.839
	HEP.8	.715					2.089
	HEP.9	.797					2.720
	HEP.10	.747					2.427
	HEP.11	.645					2.105
	HEP.12	.720					2.342
	HEP.13	.817					2.073
	HEP.14	.817					2.065
	HEP.15	.734					2.143

Note: Factor Loadings (FL); Average Variance Extracted (AVE); Cronbach's alpha (CA); Composite Reliability (CR); Variance Inflation Factor (VIF).

Table 3 indicates that, even though the factor loading values of some items are lower than .70, the overall construct is declared valid because the AVE value for each construct exceeds the threshold, which is above .50. Then, the instrument reliability was assessed based on the composite reliability and Cronbach's alpha values of higher than .70. Therefore, it is relevant to state that the instruments of this research have fulfilled the validity and reliability requirements.

The results of the multicollinearity test or Inner Variance Inflation Factor (VIF) via PLS-SEM are shown in Table 4 below.

Table 4. Value of Inner Variance Inflation Factor (VIF)

	Digital Leadership	Digital Literacy	Digital Innovation	Higher Education Performance
Digital Leadership			1.228	1.373
Digital Literacy			1.228	1.311
Digital Innovation				1.323
Higher Education Performance				

The VIF value must be lower than 5. If it is higher than 5, collinearity between constructs must be denoted (Ghozali, 2008). Table 4 shows that there is no VIF value greater than 5, indicating no multicollinearity problem.

Structural Model

The structural model predicts the causal relationship between research variables and determines the accuracy of the proposed framework. The structural model was evaluated through several stages, namely evaluating the values of the R^2 , Q^2 , and Goodness of Fit (GoF) index. The R^2 was used to denote the accuracy of the nexus between the exogenous variable and the endogenous variable. The R^2 values of this study is exhibited in Table 3. Table 4 shows the R^2 values of each endogenous construct, .244 for digital innovation and .615 for higher education performance. The values indicate that 24.4% of digital innovation and 61.5% of higher education performance is influenced by digital leadership and digital literacy; the remaining percentage is explained by other constructs not included in this study. The R^2 values indicate medium and strong effect because the value of digital innovation is above .15 and the value of higher education performance is above .35 (Chin, 2010).

Therefore, it can be concluded that the R^2 values of each endogenous variable are confirmed, that the effect of digital leadership and digital literacy on digital innovation is medium, and that the influence of digital leadership and digital literacy on higher education performance is strong. In addition to evaluating the value of the coefficient of determination, Q^2 was also used to assess the quality of the proposed model. Given $Q^2 > 0$, the closer the value to 1, the better the value. Table 4 indicates that the Q^2 is above zero, proving that the model has relevant predictions.

Table 4. Values of Coefficient of Determination (R^2) and Q Square Predictive Relevance (Q^2)

Variables	R^2	Q^2
Digital Innovation	.244	.151
Higher Education Performance	.615	.365

Then, to validate the overall fit of the model, Goodness of Fit (GoF) was used. It was calculated by multiplying the square root of the average communality index by the average value of the R^2 . Using the GoF index formula, the value of .624 was acquired. This complies the required GoF value criterion, which is between 0 and 1. This means that this study has good model fit because its GoF value is above .36. The following is the formula for the GoF calculation using the GoF index formula.

$$\begin{aligned}
 \text{GoF} &= \sqrt{\text{Communality}} \times \sqrt{R^2} \\
 &= \sqrt{.720} \times \sqrt{.584} \\
 &= .650
 \end{aligned}$$

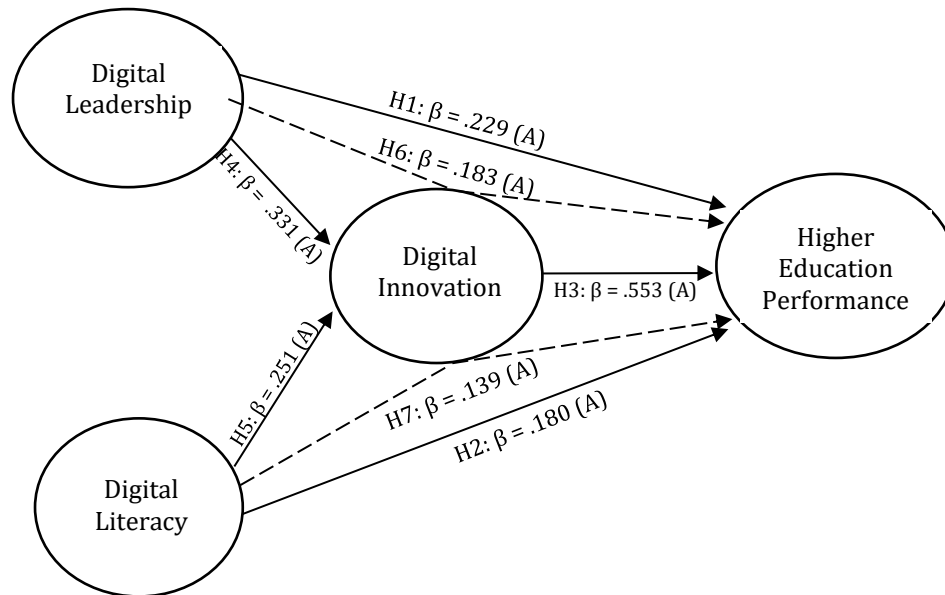
Testing the Hypotheses of Direct Effect

Hypotheses concerning the direct effect were tested using 500 sub-samples of PLS bootstrapping by evaluating the significance level. A hypothesis will be accepted if the p-value is less than or equals to .05. The direction of a relationship, either negative or positive, is determined by the coefficient value. Referring to Table 5, digital leadership significantly influences higher education performance ($\beta = .229$; Sig = .000). Therefore, H1 is accepted. Digital literacy significantly affects higher education performance ($\beta = .180$; Sig = .012). Thus, H2 is accepted. Digital innovation has been convincingly proven to influence higher education performance ($\beta = .553$; Sig = .000), supporting H3. Furthermore, both digital leadership ($\beta = .331$; Sig = .000) and digital literacy ($\beta = .251$; Sig = .001) significantly affect digital innovation. Hence, H4 and H5 are supported. Figure 2 exhibits the path diagram of the hypotheses.

Table 5. Testing the Hypotheses of Direct Effect

Hypotheses	β	SD	Sig.	Decision
H1: Digital Leadership → Higher Education Performance	.229	0.065	.000	Accepted
H2: Digital Literacy → Higher Education Performance	.180	0.072	.012	Accepted
H3: Digital Innovation → Higher Education Performance	.553	0.065	.000	Accepted
H4: Digital Leadership → Digital Innovation	.331	0.094	.000	Accepted
H5: Digital Literacy → Digital Innovation	.251	0.072	.001	Accepted

Note: β : beta coefficient; *SD*: standard deviation; *Sig*: significance



Note: dotted line is the mediation effect; (A) is the accepted hypothesis

Figure 2. Diagram of Hypotheses Testing

Testing the Hypotheses of Indirect Effect

Testing the mediating effect in PLS-SEM can be done using the bootstrapping method through the output of specific indirect effects; the assessment is similar to the assessment of the direct influence. The result of the mediation effect, as shown in Table 6, shows that digital leadership influences the higher education performance with mediation of digital innovation ($\beta = .183$; $\text{Sig} = .001$). Hence, H6 is supported. The mediating effect has the same direction as the direct (significant) influence, so digital innovation in hypothesis 6 acts as a partial mediator (Hair et al., 2017). Lastly, the mediating effect of digital innovation on the nexus between digital literacy and higher education performance has a significant value ($\beta = .139$; $\text{Sig} = .001$). Therefore, H7 is also accepted. The mediating role of digital innovation in hypothesis 7 is partial, considering that its direction is not the same as the direction of the direct effect.

Table 6. Testing the Hypotheses of Indirect Effect

Hypotheses	β	SD	Sig.	Decision
H6: Digital Leadership → Digital Innovation → HEP	.183	0.056	.001	Accepted
H7: Digital Literacy → Digital Innovation → HEP	.139	0.040	.001	Accepted

Note: β : beta coefficient; *SD*: standard deviation; *Sig*: significance; *HEP*: Higher Education Performance

Discussion

As previously mentioned, the current study aims to explore the role of digital leadership and digital literacy in predicting higher education performance with the mediation of digital innovation, which is still rarely discussed in empirical literature. The findings indicate that digital leadership is essential in driving higher education performance, especially in Malang, Indonesia. Digital leadership is the capability to direct resources and use ICT in achieving goals (Jameson et al., 2022) and is closely linked with organizational performance (Shin et al., 2023). The results of this investigation support the findings of earlier studies that, in the digital era, the level of organizational performance has a strong association with leaders' capabilities and awareness of utilizing technology for organizational goals (Sarfranz et al., 2022). Quddus et al. (2020) asserted that the application of digital leadership by leaders of tertiary institutions can improve organizational performance. Digital leaders need to go one step further and bring the thoughts of the person they lead together across

the nation, geography, culture, and other boundaries. These can be accomplished through the use of ICT, which can help improve organizational objectives, organizational effectiveness, and essential services. Because successful organizations are measured not only by employees' performance but also by their leaders' ability to respond to the changing conditions (Idris et al., 2021; Rozikin et al., 2021). Therefore, a novel leadership style with technological literacy ability is necessary (Muniroh et al., 2022), and evolving digital leadership behaviors are required to boost digital transformation, particularly in higher education (Quddus et al., 2020).

Leaders in the era of digital technology bear a considerable burden and responsibility of adapting to the current global revolution, including the trend of digital education. They must consider digital capabilities and optimize them properly to avoid being disserved and left behind (Bennis, 2013; Rozikin et al., 2021). The use of technology is essential to boost higher education performance and create innovation in both service and management (Ambarwati et al., 2021; Subaidi et al., 2023). The findings of this study also confirm that digital leadership is a significant predictor for digital innovation in higher education. Organizations that frequently generate innovation are closely linked to digital leadership capabilities (Benitez et al., 2022). Leadership with digital ability has proven capable of strengthening innovation capacities and skills (Brunner et al., 2023). In addition, the advanced digital capabilities possessed by leaders not only have an impact on digital innovation but also encourage the innovative behavior of their subordinates (Erhan et al., 2022). Digital literacy in education is no less crucial in accelerating digital innovation. This study finds that knowledge and skills in utilizing digital media are closely related to the level of digital innovation in higher education. This finding confirms the results of Suryahadikusumah and Nadya (2020) that the critical factor for improving digital innovation programs is having good digital literacy.

The exploration on the role of digital literacy on the performance of higher education reveals significant results. These results confirm the findings of Ukwoma et al. (2016) that digital literacy, when used in daily campus activities, affects academic performance to a higher level. Good ICT facilities and standardized digital literacy development programs need to support these needs. Digital literacy also contributes to the students' learning process. Heng (2014) revealed a causal relationship between digital literacy skills and increased academic achievement in tertiary institutions. This finding substantially affects organizations to be literate in technology and the development of digitalization in the world of education. Khan et al. (2022) revealed that digital literacy with operational skills, critical thinking skills and style of dependent learning, and digital skills in obtaining information could accelerate higher education attainment. Digital competence refers to the ability to explore the latest technology conditions through analyzing, selecting, and appraising data and information in order to use technology's potential to solve a problem (Gallardo-Echenique et al., 2015). Various aspects such as problem-solving, finding and using information, and using digital media must be developed to support competence and digital literacy (Jarad & Shaalan, 2020). It is essential, considering that digital literacy provides an understanding of information in various patterns (Bawden, 2008), which has consequences for appropriate learning and performance in higher education (Ukwoma et al., 2016).

One of the principal findings of this study is the significant mediating effect of digital innovation in the nexus of digital leadership and the performance of state higher education. In other words, digital leadership indirectly influences the performance of higher education through digital innovation. This means that, in order to improve higher education performance, leaders must first present a digital innovation environment within the organization. Benitez et al. (2022) reported that digital skills possessed by leaders improve innovation with digitalization schemes, which in turn have implications for the level of organizational performance (Khin & Ho, 2020; Liu et al., 2023). Technology innovation is believed to be a crucial strategic instrument for organizations to increase their performance and ability to compete in today's digital era (Vicente et al., 2020). The last important finding of this research is that digital innovation acts as a powerful mediator in the nexus between digital literacy and the performance of state higher education. The powerful mediation indicates that the direct effect of digital literacy on higher education performance is not significant without digital innovation. Therefore, digital innovation can be an alternative in relating digital literacy with higher education performance. A study by Mardiana (2021) found that digital literacy, which is characterized by knowledge, skills, finding and using various digital media platforms, has a strong correlation with technological innovation in higher education. Organizations, including universities, will be able to actively and frequently involved in digital innovation when they have good digital skills (Suryahadikusumah & Nadya, 2020), which ultimately leads to increased organizational performance.

Conclusion

This study aims to explore the effect of digital leadership and digital literacy on higher education performance with the mediation of digital innovation. Based on the results of the hypothesis testing, digital leadership provides a beneficial implication for digital innovation and higher education performance, and digital innovation promotes higher education performance. Referring to the result of the first mediation test, this study finds that digital innovation can act as a mediator between digital leadership and higher education performance. Another crucial finding of this study is that digital literacy significantly affects the performance of higher education and digital innovation. The mediating effect of digital innovation on the nexus of digital literacy on higher education performance has been confirmed. This finding indicates that higher education must first devise digital skills and innovation for those involved in the organization to improve its performance.

Recommendations

This study provides a view that leaders with good digital skills can make a major contribution to higher education performance. Therefore, maintaining the role of digital leader in higher education is the right way to boost performance. Furthermore, higher education performance tends to increase when people in the organization are involved in problem-solving activities and the implementation of digital technology and innovation. Hence, this research suggests that higher education continues to be an agent for developing digital innovation, considering this is the key to improving organizational performance. Future empirical studies are suggested to add research focus and to not limit their scope only on digital leadership, digital literacy, digital innovation, and higher education performance. They can add other variables, e.g., knowledge management maturity (Naser et al., 2016) and digital platform (Demir et al., 2021). This study also recommends analyzing education level and employment status as other moderating variables. We believe that these two variables can help analyze more deeply factors that strengthen or weaken performance levels in higher education.

Limitations

Like other studies, this research also has several weaknesses that need to be perfected. One of the drawbacks is that the sample of this research is restricted to faculty members consisting of lecturers, educational staff, and students of state universities in Malang city. The number of the respondents was relatively imbalanced due to the domination of students, which is actually inevitable because the number of students was higher than the others. Therefore, generalizations to subjects with different characteristics may have different results. This study only covers the nexus between digital leadership, digital literacy, digital innovation, and higher education performance. Thus, to gain a deeper understanding, it is necessary to involve the demographic factors of the respondents, such as gender, level of education, and type of work, as moderators for supporting the research findings.

Authorship Contribution Statement:

Suryadi: Conceptualization, design, data collection, data analysis, writing and final approval. Muslim: Data collection and materials support, critical revision of manuscripts. Setyono: Data acquisition and materials support, reviews, editing.

References

- Abas, M. K. M., Yahaya, R. A., & Din, M. S. F. (2019). Digital literacy and its relationship with employee performance in the 4IR. *Journal of International Business, Economics and Entrepreneurship*, 4(2), 29–37. <https://doi.org/10.24191/jibe.v4i2.14312>
- Al-Seghayer, K. (2020). Investigating the adequacy of EFL learners' L2 digital literacy skills, consistency of self-assessed competence, and actual performance. *International Journal of Computer-Assisted Language Learning and Teaching*, 10(2), 1–22. <https://doi.org/10.4018/IJCALLT.2020040101>
- Ali, M., Mardapi, D., & Koehler, T. (2020). Identification key factor in link and match between technical and vocational education and training with industry needs in Indonesia. In S. C. Wibawa, N. Nurkhamid, S. Suprpto, R. Warda, W.-Y. Hwang, Y.-T. Wu, L.-J. Wang, A. S. M. Lumenta, A. Budiman, I. A. Virya, M. Pramono, A. M. E. Dunga, T. F. Abidin, D. I. B. Rosli, & G. F. Hertono (Eds.), *Proceedings of International Conference on Online and Blended Learning 2019 (ICOBL 2019)* (pp. 241–245). Atlantis Press. <https://doi.org/10.2991/assehr.k.200521.053>
- Ambarwati, D., Wibowo, U. B., Arsyadanti, H., & Susanti, S. (2021). Studi literatur: Peran inovasi pendidikan pada pembelajaran berbasis teknologi digital [Literature study: The role of educational innovation in digital technology-based learning]. *Jurnal Inovasi Teknologi Pendidikan*, 8(2), 173–184. <https://bit.ly/3ozat15>
- Ashaari, M. A., Singh, K. S. D., Abbasi, G. A., Amran, A., & Liebana-Cabanillas, F. J. (2021). Big data analytics capability for improved performance of higher education institutions in the era of IR 4.0: A multi-analytical SEM & ANN perspective. *Technological Forecasting and Social Change*, 173, Article 121119. <https://doi.org/10.1016/j.techfore.2021.121119>
- AS, N., Setiawan, M., Hadiwidjojo, D., & Idris, I. (2021). Transformational leadership and organizational citizenship behavior: Exploring the mediation of organizational learning culture and organizational justice. *Jurnal Pendidikan Bisnis Dan Manajemen*, 7(2), 66–79. <https://bit.ly/3OIIDoE>
- Bawden, D. (2008). Origins and concepts of digital literacy. In C. Lankshear & M. Knobel (Eds.), *Digital literacies: Concepts, policies, and practices* (pp. 17–32). Peter Lang Publishing.
- Benitez, J., Arenas, A., Castillo, A., & Esteves, J. (2022). Impact of digital leadership capability on innovation performance: The role of platform digitization capability. *Information & Management*, 59(2), Article 103590. <https://doi.org/10.1016/j.im.2022.103590>
- Bennis, W. (2013). Leadership in a digital world: Embracing transparency and adaptive capacity. *MIS Quarterly*, 37(2), 635–636. <https://bit.ly/3WEoJMr>

- Brochado, A. (2009). Comparing alternative instruments to measure service quality in higher education. *Quality Assurance in Education*, 17(2), 174–190. <https://doi.org/10.1108/09684880910951381>
- Brunner, T. J. J., Schuster, T., & Lehmann, C. (2023). Leadership's long arm: The positive influence of digital leadership on managing technology-driven change over a strengthened service innovation capacity. *Frontiers in Psychology*, 14, Article 988808. <https://doi.org/10.3389/fpsyg.2023.988808>
- Chin, W. W. (1998). The partial least squares approach to structural equation modeling. In G. A. Marcoulides (Ed.), *Modern methods for business research* (pp. 295–336). Lawrence Erlbaum Associates Publishers.
- Chin, W. W. (2010). How to write up and report PLS analyses. In V. Esposito Vinzi, W. W. Chin, J. Henseler, & H. Wang (Eds.), *Handbook of partial least squares: Concepts, methods and applications* (pp. 655–690). Springer. https://doi.org/10.1007/978-3-540-32827-8_29
- Cricelli, L., Greco, M., Grimaldi, M., & Llanes Dueñas, L. P. (2018). Intellectual capital and university performance in emerging countries: Evidence from Colombian public universities. *Journal of Intellectual Capital*, 19(1), 71–95. <https://doi.org/10.1108/JIC-02-2017-0037>
- Culot, G., Nassimbeni, G., Orzes, G., & Sartor, M. (2020). Behind the definition of industry 4.0: Analysis and open questions. *International Journal of Production Economics*, 226, Article 107617. <https://doi.org/10.1016/j.ijpe.2020.107617>
- Demir, A., Maroof, L., Sabbah Khan, N. U., & Ali, B. J. (2021). The role of E-service quality in shaping online meeting platforms: A case study from higher education sector. *Journal of Applied Research in Higher Education*, 13(5), 1436–1463. <https://doi.org/10.1108/JARHE-08-2020-0253>
- Erhan, T., Uzunbacak, H. H., & Aydin, E. (2022). From conventional to digital leadership: Exploring digitalization of leadership and innovative work behavior. *Management Research Review*, 45(11), 1524–1543. <https://doi.org/10.1108/MRR-05-2021-0338>
- Gallardo-Echenique, E. E., de Oliveira, J. M., Marqués-Molia, L., & Esteve-Mon, F. (2015). Digital competence in the knowledge society. *MERLOT: Journal of Online Learning and Teaching*, 11(1), 1–16. <https://bit.ly/42iLire>
- Ghozali, I. (2008). *Structural equation modeling: Metode alternatif dengan partial least square* [Structural equation modeling: Alternative method with partial least squares] (2nd ed.). Badan Penerbit Universitas Diponegoro.
- Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2017). *A primer on partial least squares structural equation modeling (PLS-SEM)* (2nd ed.). SAGE.
- Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *Journal of Marketing Theory and Practice*, 19(2), 139–152. <https://doi.org/10.2753/MTP1069-6679190202>
- Heng, L. K. (2014). The impact of digital literacy training on learning performance of university students in a problem-based learning environment. In S. F. Tang & L. Logonathan (Eds.), *Taylor's 7th teaching and learning conference*, (pp.481-497). Springer. https://doi.org/10.1007/978-981-287-399-6_44
- Idris, AS, N., Soetjipto, B. E., & Supriyanto, A. S. (2021). Predicting factors of organizational citizenship behavior in Indonesian nurses. *Heliyon*, 7(12), Article e08652. <https://doi.org/10.1016/j.heliyon.2021.e08652>
- Idris, I., Suyuti, A., Supriyanto, A. S., & AS, N. (2022). Transformational leadership, political skill, organizational culture, and employee performance: A case from tourism company in Indonesia. *Geojournal of Tourism and Geosites*, 40(1), 104–110. <https://doi.org/10.30892/GTG.40112-808>
- Islami, X. (2021). How to integrate organizational instruments? The mediation of HRM practices effect on organizational performance by SCM practices. *Production and Manufacturing Research*, 9(1), 206–240. <https://doi.org/10.1080/21693277.2021.1978007>
- Jameson, J., Rumyantseva, N., Cai, M., Markowski, M., Essex, R., & McNay, I. (2022). A systematic review and framework for digital leadership research maturity in higher education. *Computers and Education Open*, 3, Article 100115. <https://doi.org/10.1016/j.caeo.2022.100115>
- Jarad, G. A., & Shaalan, M. A. (2020). Assessment of digital competence of employees and teaching staff at the technical college of management-Kufa. *International Journal of Innovation, Creativity and Change*, 12(12), 1027–1043. <https://bit.ly/3WEWr4s>
- Khan, N., Sarwar, A., Chen, T. B., & Khan, S. (2022). Connecting digital literacy in higher education to the 21st century workforce. *Knowledge Management and E-Learning*, 14(1), 46–61. <https://doi.org/10.34105/j.kmel.2022.14.004>
- Khin, S., & Ho, T. C. (2020). Digital technology, digital capability and organizational performance: A mediating role of digital innovation. *International Journal of Innovation Science*, 11(2), 177–195. <https://doi.org/10.1108/IJIS-08-2018-0083>

- Liu, Y., Dong, J., Mei, L., & Shen, R. (2023). Digital innovation and performance of manufacturing firms: An affordance perspective. *Technovation*, 119, Article 102458. <https://doi.org/10.1016/j.technovation.2022.102458>
- Lukitasari, M., Murtafiah, W., Ramdiah, S., Hasan, R., & Sukri, A. (2022). Constructing digital literacy instrument and its effect on college students' learning outcomes. *International Journal of Instruction*, 15(2), 171–188. <https://doi.org/10.29333/iji.2022.15210a>
- Mardiana, H. (2021). Lecturers in adopting digital literacy towards innovation technological change. *Zien Journal of Social Sciences and Humanities*, 1(1), 36–48. <https://bit.ly/3MXgXtM>
- Mohamed, S. M. (2022). Employee performance as affected by the digital training, the digital leadership, and subjective wellbeing during COVID-19. *Journal of Positive School Psychology Cognitive*, 6(6), 540–553. <https://bit.ly/3N1KVNj>
- Muniroh, M., Hamidah, H., & Abdullah, T. (2022). Managerial implications on the relation of digital leadership, digital culture, organizational learning, and innovation of the employee performance (Case study of PT. Telkom digital and next business department). *Management and Entrepreneurship: Trends of Development*, 1(19), 58–75. <https://doi.org/10.26661/2522-1566/2022-1/19-05>
- Naser, S. S. A., Al Shobaki, M. J., & Amuna, Y. M. A. (2016). KMM factors affecting high performance in universities “Case study on al-quds open university in Gaza-strip.” *International Journal of Information Technology and Electrical Engineering*, 5(5), 46–54. <https://bit.ly/429oZUG>
- Neumann, M. M., Finger, G., & Neumann, D. L. (2017). A conceptual framework for emergent digital literacy. *Early Childhood Education Journal*, 45, 471–479. <https://doi.org/10.1007/s10643-016-0792-z>
- Oberer, B., & Erkollar, A. (2018). Leadership 4.0: Digital leaders in the age of industry 4.0. *International Journal of Organizational Leadership*, 7(4), 404–412. <https://doi.org/10.33844/ijol.2018.60332>
- QS World University Rankings. (2023). *QS World University Rankings 2023: Top global universities*. <https://bit.ly/437T34n>
- Quddus, A., Nugroho, B. S., Hakim, L., Ritaudin, M. S., Nurhasanah, E., Suarsa, A., Karyanto, U. B., Tanjung, R., Hendar, Pratama, V. Y., Awali, H., Mufid, A., Purwanto, A., Fahlevi, M., & Sudargini, Y. (2020). Effect of ecological, servant dan digital leadership style influence university performance? Evidence from Indonesian universities. *Systematic Reviews in Pharmacy*, 11(10), 408–417. <https://bit.ly/44vkOni>
- Roman, A. V., Van Wart, M., Wang, X., Liu, C., Kim, S., & McCarthy, A. (2019). Defining E-leadership as competence in ICT-mediated communications: An exploratory assessment. *Public Administration Review*, 79(6), 853–866. <https://doi.org/10.1111/puar.12980>
- Rozikin, M., Muslim, A. Q., & Pratama, B. I. (2021). The determinant factors of school organizational change in Madura, East Java, Indonesia. *International Journal of Evaluation and Research in Education*, 10(1), 308–316. <https://doi.org/10.11591/IJERE.V10I1.20532>
- Sarfraz, M., Ivascu, L., Abdullah, M. I., Ozturk, I., & Tariq, J. (2022). Exploring a pathway to sustainable performance in manufacturing firms: The interplay between innovation capabilities, green process, product innovations and digital leadership. *Sustainability*, 14(10), Article 5945. <https://doi.org/10.3390/su14105945>
- Sari, D. M. M. (2022). Digital literacy and academic performance of students' self-directed learning readiness. *ELite Journal : International Journal of Education, Language, and Literature*, 2(3), 127–136. <https://bit.ly/43t4vqX>
- Shahroom, A. A., & Hussin, N. (2018). Industrial revolution 4.0 and education. *International Journal of Academic Research in Business and Social Sciences*, 8(9), 314–319. <https://doi.org/10.6007/IJARBS/v8-i9/4593>
- Shin, J., Mollah, M. A., & Choi, J. (2023). Sustainability and organizational performance in South Korea: The effect of digital leadership on digital culture and employees' digital capabilities. *Sustainability*, 15(3), Article 2027. <https://doi.org/10.3390/su15032027>
- Subaidi, Komariah, A., Tantowi, A., Munasir, Sabban, I., Hartini, N., Suryadi, Muslim, A. Q., Kurniady, D. A., Rahman, F. S., Salsabil, S. H., & Barowi, B. (2023). Visionary leadership in improving the quality and competitiveness of private islamic primary schools. *Journal of Governance and Regulation*, 12(2), 66–76. <https://doi.org/10.22495/jgrv12i2art6>
- Suryahadikusumah, A. R., & Nadya, A. (2020). Digital literacy and innovation for guidance and counseling program. In M. Farozin, M. Robinson, L. S. Cheong, A. H. M. Hussin, S. Amat, M. N. Wangid, & B. Astuti (Eds.), *Proceedings of the 2nd International Seminar on Guidance and Counseling 2019 (ISGC 2019)* (pp. 190–195). Atlantis Press. <https://doi.org/10.2991/assehr.k.200814.041>
- Tangahu, W., Rahmat, A., & Husain, R. (2021). Modern education in revolution 4.0. *International Journal of Innovations in Engineering Research and Technology*, 8(1), 1-5. <https://bit.ly/3YY7CGp>

- Ukwoma, S. C., Iwundu, N. E., & Iwundu, I. E. (2016). Digital literacy skills possessed by students of UNN, implications for effective learning and performance: A study of the MTN Universities Connect Library. *New Library World*, 117(11/12), 702–720. <https://doi.org/10.1108/NLW-08-2016-0061>
- Vicente, P. N., Lucas, M., Carlos, V., & Bem-Haja, P. (2020). Higher education in a material world: Constraints to digital innovation in Portuguese universities and polytechnic institutes. *Education and Information Technologies*, 25, 5815–5833. <https://doi.org/10.1007/s10639-020-10258-5>