International Journal of Learning, Teaching and Educational Research
Vol. 23, No. 10, pp. 272-289, October 2024
https://doi.org/10.26803/ijlter.23.10.13
Received Aug 24, 2024; Revised Oct 11, 2024; Accepted Oct 24, 2024

A Threefold Examination of University Digital Leadership, Teacher Digital Competency, and Teacher Technology Behavior for Digital Transformation of Education

Rui Zhu, Bity Salwana Alias, Mohd Izham Mohd Hamzah
Faculty of Education, Universiti Kebangsaan Malaysia (UKM), Malaysia.

Mohd Rashid Ab Hamid
Centre for Mathematical Sciences, Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA), Malaysia.

Abstract. In the digital age, it is imperative that Higher Education Institutions (HEIs) should cultivate digital talent to adapt to social development and occupational requirements. To achieve this, HEIs need to effectively implement digital transformation by understanding how leadership and teacher competencies contribute to technology use in educational settings. This study explored universities' digital leadership and its relationship with teacher technology behavior, with teacher digital competency serving as a mediating variable in universities from Jilin Province, China. Data were collected through convenience sampling of 402 teachers from 25 universities in Jilin Province, and analyzed using descriptive analysis and structural equation modeling. Findings revealed that all three key variables are highly significant. Moreover, digital leadership has a strong effect on teacher digital competency, a weak effect on teacher technology behavior, and teacher digital competency has a moderate effect on teacher technology behavior. The findings also indicated that teacher digital competency mediates the relationship between digital leadership and teacher technology behavior. In conclusion, this study provides valuable insights into the ways in which HEIs can navigate digital transformation by leveraging leadership and focusing on building teacher competency, which in turn can enhance technology usage in teaching practices. This study considered how higher education institutions can cope with the complex challenges of the digital age and suggested ways in which the implications of this research can better enable universities to promote digital transformation.

Keywords: China; digital competency; digital leadership; digital transformation; higher education; technology behavior; threefold examination

1. Introduction

With the rapid progress of global education, it is crucial that future generations are well prepared to meet evolving societal challenges. In this context, HEIs must undergo significant transformations to equip students not only for the current employment market but also for a future characterized by rapid technological advancements. Central to this transformation is the role and behavior of teachers, whose consistent and effective technology behavior is essential. However, although the government has secured financial investment for the necessary hardware and software, the consistent use of technology by teachers to perform their daily work remains an issue (Rui et al., 2024). Therefore, it is necessary to address the enhancement of teachers' ongoing technology behavior and to gain a fuller understanding of the underlying influencing factors.

Teacher technology behavior is a critical aspect of digital transformation. Previous studies have proven that teachers' effective use of technology can turn the educational environment into a more interactive and productive setting, facilitating personalized learning experiences and improving the efficiency of administrative processes; this, in turn, leads to improved research and academic resources (Zhao et al., 2021). Taking into account these major possible outcomes, understanding the determinants of teacher technology behavior is essential for HEIs striving to excel in the digital age. Previous studies have highlighted that factors such as teacher digital competency, professional development opportunities, institutional support, and perceived usefulness of technology significantly influence teacher technology behavior in educational settings (Perienen, 2020). For example, Akram et al. (2022) found that teachers with higher digital competence were more likely to integrate technology effectively into their teaching. Similarly, Love et al. (2020) indicated that when professional development opportunities are provided, teachers are more motivated to explore new technological tools, which in turn enhances their confidence and willingness to adopt technology in the classroom. Therefore, these factors combine to positively shape teacher technology behavior, promoting digital transformation in education.

Additionally, it should be highlighted that the effectiveness of teacher technology behavior is also deeply influenced by digital leadership among the top management of universities (AlAjmi, 2022). Top-level managers at university level act as more than merely visionary planners; they are also tasked with fostering an environment that promotes digital technology adoption and innovation (Antonopoulou et al., 2020). Improving the comprehensive practice of university-level digital leadership and exploring its effect on teacher behavior is crucial for the digital transformation of education. However, university digital leadership is not yet at a satisfactory level, and the effect of digital leadership on teachers' use of educational technology remains unclear. Some researchers have suggested that digital leadership in universities strongly influences teacher technology behavior, whereas other studies indicate a moderate connection (Raman et al., 2019). In addition, the increasing literature reveals the expansion of geographic scopes of empirical research concerning the role of digital leadership practice in influencing teacher technology behavior, from Western to Asian

societies; however, digital leadership research in different contexts leads to different results. Moreover, in China, the related empirical research is far less explored. Therefore, in order to respond to the challenge of Digital China, the impact of digital leadership must be more thoroughly investigated.

In recent years, teacher digital competency has appeared frequently in policy documents (Kubrushko et al., 2020). Indeed, teacher digital competency is no longer simply a goal but also a solution. Previous findings have demonstrated that putting teacher digital competency into the framework of leadership practice offers a better understanding of how leadership affects technology adoption (Rui et al., 2024). Moreover, enhancing teacher digital competency can result in more interactive teaching methods. However, although university teachers generally possess adequate technical digital skills, they often engage less in using these technologies for enhancing their teaching practices (Rui et al., 2024).

Due to the varying economic development levels in different Chinese provinces, the pace of digital transformation in education has varied at different phases across the country. This study focuses on Jilin Province, where economic growth trails behind that of southern cities, to analyze the effect of university digital leadership on the digital competency and technology behavior of university teachers. Furthermore, this study seeks to advance the understanding of digital transformation by providing insights into the way in which digital leadership can sustain continuous technology behavior among teachers. On this account, one of the objectives of this study is to determine the level of university digital leadership, teacher digital competency, and teacher technology behavior, to evaluate the relationship between university digital leadership and teacher technology behavior as well as teacher digital competency, and the relationship between teacher digital competency and teacher technology behavior. Also, this study examines whether teacher digital competency mediates the relationship between digital leadership and teacher technology behavior.

The study starts with a theoretical exploration of the connections between these three key variables, leading to the formulation of hypotheses. Next, it details the sampling methods, instruments, data collection procedures, and analysis methods used in the study. Following this, the results and discussion are presented, addressing the research objectives. Finally, the paper ends with implications and conclusions drawn from the results.

2. Theoretical Understandings

2.1 The Relationship between Digital Leadership and Teacher Technology Behavior

The concept of digital leadership can be rooted in transformational leadership theory, influencing followers' behavior by inspiring and encouraging them to strive for the goals set by leaders (Hamzah et al., 2021). Applying this theory to the digital context, digital leadership is crucial in developing technology infrastructure, fostering digital culture, and motivating teachers to adopt technology to strive for digital transformation goals (Sterrett & Richardson, 2023). Specifically, digital leadership extends beyond the mere provision of technology

and infrastructure. It involves having a clear vision and creating an environment that promotes innovation and the effective use of digital tools. Top university management teams that practice digital leadership often engage in ongoing professional development, remain up-to-date with the latest technology, and take part in technology-based educational projects (Rui et al., 2024). This active involvement sets an example and encourages teachers to do the same.

An increasing proportion of the literature reports the positive effect of leadership in fostering teacher technology behavior at all stages of education. For instance, Ghavifekr and Wong (2022) provided evidence from secondary schools in Malaysia, noting that principals boost teacher technology behavior in the classroom through their leadership. Similarly, in terms of higher education, Alexandro and Basrowi (2024) demonstrated that university digital leadership positively correlates with teachers' use of learning management systems. However, some researchers have contradicted the results reported in previous studies. Hamzah et al. (2021) found only a moderate link between digital leadership and teacher digital teaching practice. Furthermore, Raman et al. (2019) concluded that digital leadership has no significant effect on teacher technology integration. It is possible that these differences may be due to the varying definitions and measurements of digital leadership and teacher technology behavior used in different studies as well as the constantly changing nature of the technology (Luo et al., 2024). As new tools and platforms are developed, digital leadership must adapt to ensure that teachers can use both current and emerging technologies effectively. Therefore, drawing on transformational leadership theory, this study seeks to fill the gap by exploring how university digital leadership influences teacher technology behavior in Chinese universities. Thus, the following hypothesis is formulated:

- Ha1: University digital leadership practice positively influences teacher technology behavior.

2.2 The Relationship between Digital Leadership and Teacher Digital Competency

Digital competency is commonly regarded as a composite of technical, procedural, cognitive, and socio-emotional abilities (Suárez-Rodríguez et al., 2018). It encompasses the skills needed to effectively use digital tools and technologies, as well as the ability to critically understand and engage with digital content and platforms (Pratiwi et al., 2022). Previous research has demonstrated that university presidents can encourage teachers to improve their digital competency by providing training opportunities, support, and resources, as well as developing digital education policies (Ter Beek et al., 2022). Indeed, the influence of digital leadership on teacher digital competency has been observed in various studies. Yuting et al. (2022) observed a significant link between university digital leadership and teacher digital competency. Extending this perspective, Pratiwi et al. (2022) conducted a study affirming that president digital vision, educational technology knowledge, and support for teachers significantly contributed to teacher digital competency. Effective digital leadership from university presidents can foster an institutional culture that values and promotes digital competency, thereby encouraging teachers to

continuously improve and update their skills (Yuan & Khan, 2024). Moreover, digital leadership often includes establishing partnerships with technology providers, participating in national and international digital education networks, and advocating for policies that support digital learning. Based on the findings from previous studies, hypothesis 2 was proposed as follows:

- Ha2: University digital leadership practice positively influences teacher digital competency.

2.3 The Relationship between Teacher Digital Competency and Teacher Technology Behavior

Lack of technology skills and lack of knowledge among teachers were found to be the most common constraints affecting teacher technology behavior in previous studies. Teacher digital competency is a crucial precondition to teacher technology behavior. Several studies have demonstrated a significant link between teacher digital competency and technology behavior. Empirical research conducted by Asante and Novak (2024) demonstrated a positive correlation between teacher digital competency and teacher technology behavior within the teaching and learning process. Similarly, the study by Yuan and Khan (2024) emphasizes that digital competency influences the quality of technology integration, highlighting that digital tools must be used effectively to support pedagogical goals. However, some studies have noted no significant link between teacher digital competency and technology behavior. One explanation for this might be that, while digital competency is important, other factors such as institutional support, access to resources, and teachers' attitudes towards technology play a more critical role in determining technology behavior (Zhao et al., 2021). Thus, digital competency alone may not be sufficient to ensure effective technology integration in teaching. Despite the growing body of research in this area, there remains a significant gap in the literature concerning the specific impact of teacher digital competency on technology behavior within Chinese universities. Given China's distinct educational and technological landscape, this research is crucial to identify the unique factors influencing technology behavior in this context. Therefore, it is necessary to explore whether teacher digital competency can positively influence teacher technology behavior in the Chinese context. Therefore, hypothesis 3 is proposed as follows:

- Ha3: Teacher digital competency positively influences teacher technology behavior.

2.4 The Mediating Role of Digital Competency

Further insights into the connections between digital leadership, teacher digital competency, and teacher technology behavior will help to inform the establishment of policies and programs with a view to improving the overall digital readiness of educational institutions. Previous studies have already demonstrated that a positive connection exists between digital leadership and teacher digital competency, and also between teacher digital competency and teacher technology behavior (Guillén-Gámez et al., 2019). Furthermore, digital competency is also gaining attention in the research as a mediator between digital leadership and technology use. As Asante and Novak (2024) indicated, digital leadership indirectly influences effective technology behavior in teachers' daily

work by facilitating the digital competency of teachers. Further supporting this standpoint is the study by Kubrushko et al. (2020), which found that digital competency plays a key role in mediating the relationship between digital leadership and teacher technology behavior. The study showed that when educational leaders provide adequate training and resources, teachers develop higher levels of digital competency, which leads in turn to the more effective use of technology in classrooms. While this previous research has provided valuable insights, a significant gap remains in our understanding of the way in which digital leadership affects teacher technology behavior through digital competency, especially in diverse cultural and educational environments. Therefore, in response to the findings from existing research, the current study introduces the following hypothesis:

- Ha4: Teacher digital competency mediates the relationship between university digital leadership practice and teacher technology behavior.

Based on the preceding discussion, a conceptual framework has been developed, as displayed in Figure 1. In this framework, university digital leadership serves as the independent variable, teacher technology behavior acts as the dependent variable, and teacher digital competency functions as the mediating variable.

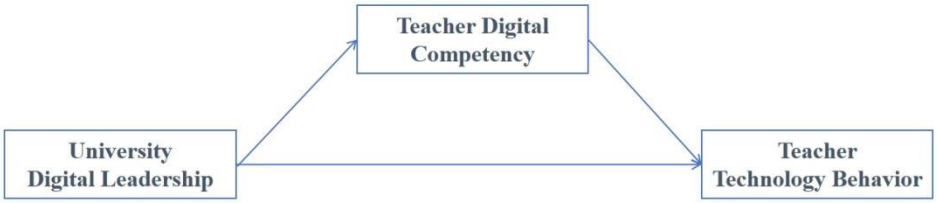

Figure 1: The conceptual framework

3. Methodology

3.1 Research Context

Educational technologies are expanding rapidly in China. The Chinese educational system has undertaken substantial endeavors to enhance its technological infrastructure and formulate a suitable policy regarding the incorporation of technologies. Moreover, the Chinese education system is characterized by bureaucracy. In Chinese universities, almost every institution has more than five presidents and vice presidents; therefore, the digital leadership in this study refers to the leadership of the top-level management team. Meanwhile, teachers are usually seen as being at the receiving end, forming a master-servant relationship with top university management. This cultural context may present some unique characteristics with regard to the impact of digital leadership on teacher technology behavior. Furthermore, in China, unequal regional economic development has led to a further imbalance in the development of educational digital transformation. As a result, an in-depth study of the actual context of universities in Jilin Province is expected to significantly deepen our understanding of the specific mechanism of the influence of digital leadership on teacher technology behavior in this unique cultural context.

3.2 Population and Sampling

In total, there are 25 universities in Jilin Province, with a population of 25912 teachers. Taking accessibility and cost-effectiveness into account, the convenience sampling technique was adopted. Based on Krejcie and Morgan (1970), when the population is up to 20000, the minimum sample size should be 377. Given that the total population in this study is slightly larger, the sample size was increased to 500 to further enhance the generalizability of the study. Furthermore, the sample size from each university was based on the proportion of teachers in each university. This approach ensured a broad collection of data across different universities. Existing connections among these universities were used to identify teachers who were willing to respond to the questionnaire. This involved contacting department heads, academic coordinators, and faculty members through WeChat software. The questionnaire link was then distributed to 500 teachers online, with 402 valid responses being returned. This corresponds to a response rate of 80%.

3.3 Research Instruments

This study employs three main instruments: the University Digital Leadership (UDL) sub-scale; the Teacher Digital Competency (TDC) sub-scale; and the Teacher Technology Behavior (TTB) sub-scale. Each instrument employs a 5-point Likert scale, with 1 representing strong disagreement and 5 representing strong agreement. These instruments were completed by teachers.

Adapted from the ISTE-A (2018) framework, the UDL instrument assesses university digital leadership through 23 items categorized into five dimensions. The UDL questionnaire was selected because it comprehensively covers the multifaceted roles and responsibilities of digital leadership in an educational setting, ensuring a thorough assessment of leadership practices. Moreover, its reliability and validity have been confirmed in studies conducted in Mainland China and Malaysia (Nawawi et al., 2022; Yuting et al., 2022).

The TDC instrument, based on ISTE-T (2008), measures teacher digital competency through 27 items across five dimensions. This instrument captures the essential components of digital competency necessary for teachers to effectively integrate technology not only into their actual teaching practice but into all of their working practices. The reliability and validity of this instrument have been established in prior research (Simsek, 2016).

Derived from the Chilean Ministry of Education's categorization of teachers' technological activities, the TTB instrument includes 18 items distributed across the following four areas: professional development; communication; teaching; and administration. This instrument provides a comprehensive overview of the way in which teachers engage with technology across various professional activities, making it a valuable tool for understanding the practical application of digital skills in the daily work of educators.

3.4 Data Analysis Procedure

SPSS 27.0 and SmartPLS 4.0 were employed to analyze the data. Descriptive analyses used SPSS while inferential analyses used the SEM procedure with Smart PLS. PLS-SEM was carried out to assess the mediating role of teacher digital competency on the relationship between university digital leadership and teacher technology behavior. PLS-SEM was selected for several key reasons. First, the data collected in this study were non-normal. PLS-SEM is particularly suitable for handling non-normal data, making it an appropriate choice for the analysis (Hair et al., 2019). Second, the theoretical model in this study is complex, with more than three constructs and pathways. PLS-SEM has the ability to address complex models (Hair et al., 2019). Additionally, PLS-SEM allows for the simultaneous testing of direct and indirect effects, which is crucial for providing a comprehensive analysis of the mediating role of teacher digital competency.

The data analysis procedure consists of three main steps. The first is to investigate the level of the three main variables. Next is the assessment of the measurement model, followed by the assessment of the structural model. In addition, in order to ensure the validity of the instrument and to avoid any interference of the findings by the measurement method, this study used Harman's single factor to test whether the current study has common method biases (CMB). The result was 45.173 percent of the overall variation, which is below the threshold of 50 percent, indicating that there are no common method biases in the current study.

4. Results

4.1 Levels of Digital Leadership, Teacher Digital Competency, and Teacher Technology Behavior

As displayed in Table 1, the levels of these three key variables were all high. Among these variables, the highest mean score was for Teacher Technology behavior (M=4.048, SD=0.539), followed by Teacher Digital Competency (M=4.040, SD=0.540), and the lowest was University Digital Leadership (M=4.022, SD=0.615).

Table 1: Levels of university digital leadership, teacher digital competency and teacher technology behavior

Variable	Mean	Std. deviation
University digital leadership	4.022	0.615
Teacher digital competency	4.040	0.540
Teacher technology behavior	4.048	0.539

4.2 Structural Equation Model

The PLS-SEM method was utilized to test the hypotheses. This approach involved two primary steps: first, assessing the measurement model to determine the reliability and validity of the constructs; and second, examining the structural model to evaluate the hypothesized relationships among the constructs. The structural equation model (Figure 2) was developed using SmartPLS software. SmartPLS is a specialized tool for PLS-SEM that facilitates the modeling of complex relationships and provides detailed outputs for both measurement and structural models.

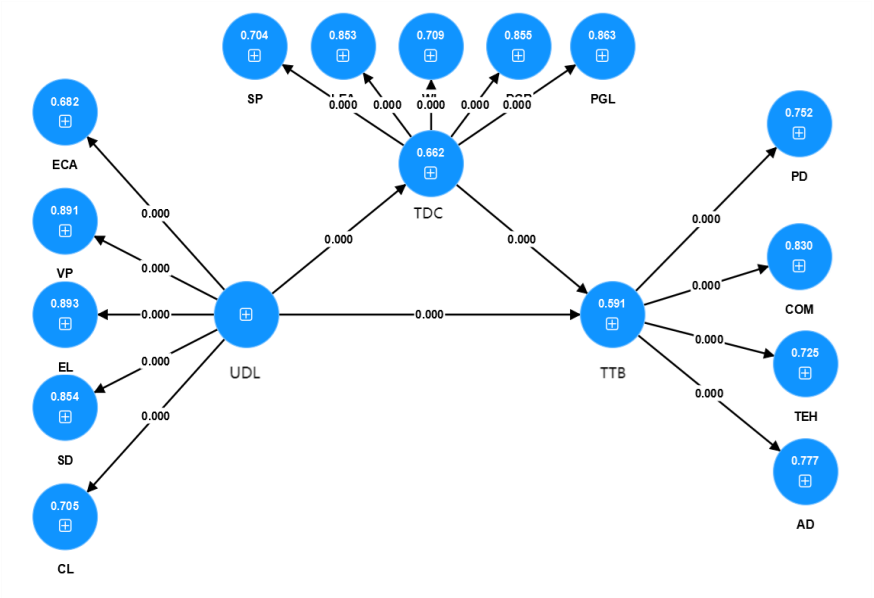

Figure 2: The reflective second order hierarchical model

4.2.1 Assessment of measurement model

The measurement model was used to test the reliability and validity of the questionnaire, including internal consistency, convergent validity, and discriminant validity. Composite reliability and Cronbach's alpha were used to measure internal consistency. As shown in Table 2, the results of all the constructs were higher than 0.70, indicating that all of the constructs in this study had high internal consistency. Assessing convergent validity involves ensuring that items in the same construct are positively correlated; this was tested by factor loading each item and assessing the average variance extracted (AVE). Table 2 shows that all of the factor loading and AVE results are higher than 0.70, thus meeting the requirement of the standard. Therefore, this measurement model has met the standards of convergent validity and reliability, as shown below.

Table 2: Reliability and validity analyses for the measurement model

Construct	Cronbach alpha	Composite reliability	Average variance extracted
University digital leadership	0.899	0.943	0.804
Teacher digital competency	0.913	0.941	0.797
Teacher technology behavior	0.882	0.901	0.769

Discriminant validity was evaluated using the heterotrait-monotrait (HTMT) ratio of correlations. According to Gold et al. (2001), discriminant validity is deemed acceptable if the HTMT ratio values are below 0.90. As illustrated in Table 3, the HTMT ratio values for the constructs in this study were all below this threshold, indicating satisfactory discriminant validity.

Table 3: HTMT discriminant analysis for the measurement model

Construct	University digital leadership	Teacher digital competency	Teacher technology behavior
University digital leadership	1.00		
Teacher digital competency	0.862	1.00	
Teacher technology behavior	0.751	0.817	1.00

4.2.2 Assessment of the structural model

The assessment of the structural model involves several procedures, including collinearity analysis, the coefficient of determination (R2), effect size (f2), predictive relevance (Q2), and hypothesis testing.

Collinearity analysis

Prior to the subsequent analysis stage, an assessment of collinearity among the variables was conducted. The Variance Inflation Factor (VIF) was calculated for each variable, as presented in Table 4. According to Hair et al. (2019), VIF values below four indicate that there are no issues with collinearity.

Table 4: VIF values

Construct	University digital leadership	Teacher digital competency	Teacher technology behavior
University digital leadership	-		
Teacher digital competency	1.000	-	
Teacher technology behavior	2.962	2.962	-

The coefficient of determination (R^2)

Ascertaining the R2 value is a critical step in the assessment of the structural model, as it is used to evaluate the extent to which the independent variables predict the dependent variable. Specifically, a higher R^2 value indicates a greater predictive accuracy. The R2 value for this study was tested through the algorithmic program in SmartPLS; the result is shown in Table 5. The R2 value of 0.591 indicates that teacher technology behavior accounts for 59.1 percent of the variance in the observation. According to Chin (1998), this means that the model proposed in this study is moderate.

Table 5: R^2 value

Construct	R^2	Result
Teacher technology behavior	0.591	Moderate

Assessment of the effect size (f^2)

The f2 value represents the percentage of variance in the dependent variables that is explained by the independent variables. Thus, a higher f2 value signifies the greater explanatory power of the model with regard to the independent variables. Table 6 presents the f2 values for this research. According to the threshold recommended by Cohen (1988), the effect of university digital leadership on teacher digital competency is strong, while the effect of teacher digital competency on teacher technology behavior is moderate. The influence of university digital leadership on teacher technology behavior falls into the weak category.

Table 6: f^2 effect size

Path	f^2	Effect size
University digital leadership to teacher digital competency	0.665	Strong effect
Teacher digital competency to teacher technology behavior	0.286	Moderate effect
University digital leadership to teacher technology behavior	0.044	Weak effect

Assessment of the predictive relevance (Q^2)

Q2 value serves as a measure of the path model's predictive capability for the original observed values (Hair et al., 2019). The Q^2 values of 0.02, 0.15, and 0.35 correspond to weak, moderate, and strong effect sizes, respectively (Hair et al., 2019). In this study, the Q^2 analysis was conducted using the "Blindfolding" technique with a distance parameter of seven in SmartPLS. As illustrated in Table 7, the predictive relevance Q2 values for teacher digital competency and teacher technology behavior are 0.523 and 0.450. These values suggest that the model possesses substantial predictive relevance.

Table 7: Q^2 value

Endogenous construct	Q^2	Effect size
Teacher digital competency	0.523	Strong effect
Teacher technology behavior	0.450	Strong effect

4.2.3 Hypothesis testing

The hypotheses were tested using Bootstrapping in SmartPLS, which is a resampling technique that provides robust estimates of path coefficients, observed T-statistics, and P-values. As presented in Table 8, the analysis revealed that all of the hypothesized paths exhibited statistical significance, thereby supporting all hypotheses. Collectively, these findings support all of the proposed hypotheses, demonstrating that the relationships among digital leadership, teacher digital competency, and teacher technology behavior are both statistically significant and consistent with the theoretical framework.

Table 8: Path coefficients, observed T-statistics, and significance level for all hypothesized paths

Hypothesized path	Path coefficients	Observed T-statistics	P-value	Result
UDL-->TDC	0.814	40.222	0.00	Accepted
UDL-->TTB	0.231	3.733	0.00	Accepted
TDC-->TTB	0.569	9.630	0.00	Accepted
UDL-->TDC-->TTB	0.463	9.988	0.00	Accepted

Note: UDL=university digital leadership; TDC=teacher digital competency; TTB=teacher technology behavior

5. Discussion

5.1 The Levels of Three Key Variables

The results indicate that digital leadership, teacher digital competency, and teacher technology behavior are all at high levels. These findings are consistent with those of Liesa-Orus et al. (2023), who indicated that a majority of university teachers possess sufficient digital competency to enhance technology behavior. Many universities have recognized the importance of digital leadership in navigating the challenges and opportunities presented by technological advancements (Cunha et al., 2020). However, in contrast, Li and Xue (2022) reporting that digital leadership has not yet been comprehensively implemented; many scholars have also suggested that the cultural factor should be taken into account when discussing digital leadership. The high level of teacher technology behavior is supported by Marcelo-Martínez et al. (2024), who reported that teachers in universities have a higher frequency of technology. Furthermore, this finding is also aligned with a study by Akram et al. (2022), who reported that teacher digital competency is at a high level. Notably, teacher technology behavior is higher than university digital leadership and teacher digital competency. This discrepancy may be explained by the fact that many teachers in universities in Jilin Province are digital natives. Additionally, since the onset of the COVID-19 pandemic, teachers have been required to utilize technology to ensure the continuity of the teaching and learning process.

5.2 The Relationship between Digital Leadership and Teacher Technology Behavior

The results obtained from this study demonstrated that there is a substantial association between digital leadership and technology behavior. This finding is in line with the findings of Ismail et al. (2021), who found a positive correlation between technology leadership and teacher technology behavior. High levels of digital leadership prevent teachers from deviating towards negative outcomes (Laufer et al., 2021). Similarly, lower levels of digital leadership correlate with weaknesses in providing instruction and decision-making (Zeike et al., 2019). The positive relationships identified in the current study can be explained by the fact that universities exhibit strong digital leadership to facilitate professional development opportunities designed to enhance teachers' digital skills and confidence, thereby increasing their willingness and ability to use technology effectively (Pratiwi et al., 2022). Conversely, insufficient support and unclear guidance from leaders can lead to uncertainty and resistance towards technology use. However, some researchers have reported a contrasting view that top

managerial support has no significant direct effect on the frequency of teacher technology behavior (Dong et al., 2020). These inconsistent results may be attributed to different educational stages and cultural backgrounds, as digital leadership can yield different outcomes across various countries.

5.3 The Relationship between Digital Leadership and Teacher Digital Competency

The results showed that digital leadership positively affects teacher digital competency. These findings affirm prior research and extend it to a very different sociocultural context (Yuting et al., 2022). The result is supported by Rui et al. (2024), who assert that leadership positively influences the digital competency of university faculties. Teachers play a crucial role in setting the vision and strategic direction for digital competency enhancement. Effective digital leaders provide ongoing professional development opportunities that are essential for teachers to remain up-to-date with the latest technological advancements. Moreover, digital leaders can foster a supportive community that encourages knowledge sharing and collaboration among teachers. This can lead to the development of a robust professional learning network, whereby teachers can exchange best practices, share resources, and support each other along their digital journey. However, some empirical research suggests that digital leadership has no substantial influence on teacher digital competency (Chong et al., 2022; Guillén-Gámez & Mayorga-Fernández, 2020). This may be because the role of digital leadership in influencing teacher digital competency necessitates a multifaceted effort that includes training, support, communication, and the provision of the necessary resources to create a positive learning environment that motivates teachers to improve their digital competency (Kubrushko et al., 2020).

5.4 The Relationship between Teacher Digital Competency and Technology Behavior

Additionally, the current study also demonstrates a positive correlation between teacher digital competency and technology behavior. The positive relationship suggests that enhancing digital skills is critical for effective technology integration in teaching. These findings are supported by Amhag et al. (2019), who highlighted that teachers with higher ICT competency find it easier to create digital learning environments. This is due to the fact that digital competency influences teachers' confidence and attitudes towards using technology. Also, as Ayub et al. (2015) noted, among teacher digital competency, school environment, digital infrastructure, top management support, and years of classroom teaching experience, teacher digital competency is most strongly positively correlated with teacher attitudes toward technology behavior. As digital learning environments become more prevalent, teachers must continuously update and refine their digital skills in order for their teaching to remain both relevant and effective (Kryshtanovych et al., 2023). Such ongoing professional development is crucial for maintaining a high level of digital competency, which, in turn, supports sustained technology behavior.

5.5 The Mediating Role of Teacher Digital Competency

The results also indicate a mediating effect of teacher digital competency on the relationship between digital leadership and teacher technology behavior. Prior studies (Abdullah & Kadir, 2023) have pointed out that enhancing the level of teacher digital competency can effectively increase the positive impact of digital leadership on technology behavior, emphasizing the important mediating role of digital competency in facilitating the integration of educational technology integration. This finding not only expands our understanding of the mechanisms of digital leadership but also indicates targeted strategies that can effectively enhance the promotion of digital leadership in using educational technology by providing training to enhance teacher digital competency. Institutions should prioritize the development of comprehensive training programs that not only improve teachers' technical skills but also foster a deeper understanding of the ways in which technology can be successfully integrated into pedagogical practices.

6. Conclusion

In summary, the current study adds to the knowledge of how digital leadership affects teacher technology behavior in universities. More precisely, it focuses on the effect of digital leadership on teacher digital competency and teacher technology behavior. This study therefore contributes to the body of knowledge in this field as the theorized linkages between digital leadership, teacher digital competency, and teacher technology behavior have been affirmed empirically in the context of universities in China. Moreover, this study provides insights concerning digital leadership and its correlation with teacher digital competency and teacher technology behavior that will be valuable to both education administrators and practitioners. By adding empirical evidence on the relationships among digital leadership, teacher digital competency, and technology behavior in the context of Chinese universities, this study makes an effective contribution to the existing literature. Furthermore, the results of this study can be strengthened by integrating theories on digital leadership in the context of educational transformation, which emphasize the multidimensional nature of digital leadership in fostering teacher technology behavior.

In practical terms, this study provides targeted recommendations for various stakeholders, including government agencies and higher education institutions (HEIs), based on the research findings. Specifically, the findings highlight the urgent need to improve teacher digital competency levels. Therefore, educational institutions and policymakers should collaborate to develop programs and provide professional development opportunities to enhance teacher digital competency, aimed at increasing teacher technology behavior. Such collaboration between educational institutions and policymakers provides a forward-looking perspective; similarly, it is recommended that future research could explore specific strategies for implementing digital leadership initiatives. Furthermore, this study emphasizes the role of China's local and national environment and culture in shaping the outcomes, suggesting that digital leadership practices in China need to be adapted to the unique cultural and political contexts of Chinese higher education institutions.

7. Limitations

Although this study makes an important contribution to the literature, it also has several limitations. A key limitation is the study's reliance on self-reported surveys. As noted by Podsakoff et al. (2003), such surveys can lead to inflated or understated responses, increasing the risk of common method biases. To mitigate these issues, future studies might use alternative data collection methods, such as interviews or multi-rater assessments, to minimize self-reporting biases. Additionally, the sample selection was limited to a single province in China and employed a convenience sampling method. This may limit the generalizability of the findings to other regions or countries. Future research should therefore consider expanding the sample to include multiple provinces or use a random sampling method to enhance generalizability. Furthermore, this study did not account for demographic variables such as age, gender, or years of experience, which can significantly impact technology behavior and digital competency. Demographic factors may influence the way in which teachers engage with technology and their perceptions of digital leadership. Consequently, future research should consider including demographic variables to explore how these factors might interact with digital leadership and technology behavior.

8. References

Abdullah, N. S., & Kadir, S. A. (2023). Relationship between principals' digital leadership and teachers' digital competency in Klang district secondary schools. *Asian Journal of Vocational Education and Humanities, 4*(2), 1–14. https://doi.org/10.53797/ajvah.v4i2.1.2023

Akram, H., Abdelrady, A. H., Al-Adwan, A. S., & Ramzan, M. (2022). Teachers' perceptions of technology integration in teaching-learning practices: A systematic review. *Frontiers in Psychology, 13*, Article 920317. https://doi.org/10.3389/fpsyg.2022.920317

AlAjmi, M. K. (2022). The impact of digital leadership on teachers' technology integration during the COVID-19 pandemic in Kuwait. *International Journal of Educational Research, 112*, Article 101928. https://doi.org/10.1016/j.ijer.2022.101928

Alexandro, R., & Basrowi. (2024). Measuring the effectiveness of smart digital organizations on digital technology adoption: An empirical study of educational organizations in Indonesia. *International Journal of Data and Network Science, 8*(1), 139–150. https://doi.org/10.5267/j.ijdns.2023.10.009

Amhag, L., Hellström, L., & Stigmar, M. (2019). Teacher educators' use of digital tools and needs for digital competence in higher education. *Journal of Digital Learning in Teacher Education, 35*(4), 203–220. https://doi.org/10.1080/21532974.2019.1646169

Antonopoulou, H., Halkiopoulos, C., Barlou, O., & Beligiannis, G. N. (2020). Leadership types and digital leadership in higher education: Behavioural data analysis from University of Patras in Greece. *International Journal of Learning, Teaching and Educational Research, 19*(4), 110–129. https://doi.org/10.26803/ijlter.18.9.13

Asante, K., & Novak, P. (2024). When the push and pull factors in digital educational resources backfire: The role of digital leader in digital educational resources usage. *Education and Information Technologies, 29*(6), 6553–6578. https://doi.org/10.1007/s10639-023-12095-8

Ayub, A. F. M., Bakar, K. A., & Ismail, R. (2015). Factors predicting teachers' attitudes towards the use of ICT in teaching and learning. *AIP Conference Proceedings, 1682*(1), Article 030010. https://doi.org/10.1063/1.4932473

Chin, W. W. (1998). The partial least squares approach to structural equation modeling. *Modern Methods for Business Research,* 295(2), 295‑336. https://doi.org/10.1016/B978-012685900-6/50019-3

Chong, K. M., Ating, R., Separa, L. A. C., Widyatama, A., Palmares-Cruz, M. R. M. J., & Buluran, M. J. C. (2022). Teaching competency in the digital era in Indonesia, Malaysia and the Philippines. *Environment-Behaviour Proceedings Journal, 7*(22), 23−32. https://doi.org/10.21834/ebpj.v7i22.4155

Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd ed.). *Lawrence Erlbaum Associates*. https://doi.org/10.4324/9780203771587

Cunha, M. N., Chuchu, T., & Maziriri, E. (2020). Threats, challenges, and opportunities for open universities and massive online open courses in the digital revolution. *International Journal of Emerging Technologies in Learning (iJET), 15*(12), 191–204. https://www.learntechlib.org/p/217551/

Dong, Y., Xu, C., Chai, C. S., & Zhai, X. (2020). Exploring the structural relationship among teachers' technostress, technological pedagogical content knowledge (TPACK), computer self-efficacy and school support. *The Asia-Pacific Education Researcher, 29*, 147–157. https://doi.org/10.1007/s40299-019-00461-5

Ghavifekr, S., & Wong, S. Y. (2022). Technology leadership in Malaysian schools: The way forward to Education 4.0–ICT utilization and digital transformation. *International Journal of Asian Business and Information Management (IJABIM), 13*(2), 1–18. https://doi.org/10.4018/ijabim.20220701.oa3

Gold, A. H., Malhotra, A., & Segars, A. H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185–214. https://doi.org/10.1080/07421222.2001.11045669

Guillén-Gámez, F. D., Lugones, A., Mayorga-Fernández, M. J., & Wang, S. (2019). ICT use by pre-service foreign languages teachers according to gender, age and motivation. *Cogent Education, 6*(1), Article 1574693. https://doi.org/10.1080/2331186x.2019.1574693

Guillén-Gámez, F. D., & Mayorga-Fernández, M. J. (2020). Identification of variables that predict teachers' attitudes toward ICT in higher education for teaching and research: A study with regression. *Sustainability, 12*(4), Article 1312. https://doi.org/10.3390/su12041312

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *European Business Review, 31*(1), 2–24. https://doi.org/10.1108/EBR-11-2018-0203

Hamzah, N. H., Nasir, M. K. M., & Wahab, J. A. (2021). The effects of principals' digital leadership on teachers' digital teaching during the COVID-19 pandemic in Malaysia. *Journal of Education and e-Learning Research, 8*(2), 216–221. https://doi.org/10.20448/journal.509.2021.82.216.221

Ismail, S. N., Omar, M. N., & Raman, A. (2021). The authority of principals' technology leadership in empowering teachers' self-efficacy towards ICT use. *International Journal of Evaluation and Research in Education, 10*(3), 878–885. https://doi.org/10.11591/ijere.v10i3.21816

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement, 30*(3), 607–610. https://doi.org/10.1177/001316447003000308

Kryshtanovych, S., Lapychak, I., Sydorko, O., Ostrovskyy, M., & Petryna, R. (2023). Modeling the impact of the creative industry on national sustainable educational development in France. *International Journal of Sustainable Development & Planning, 18*(9), 2933–2939. https://doi.org/10.18280/ijsdp.180931

Kubrushko, P. F., Alipichev, A. Y., Kozlenkova, E. N., Nazarova, L. I., & Siman, A. S. (2020). Digital competence as the basis of a lecturer's readiness for innovative

pedagogical activity. *Journal of Physics: Conference Series, 1691,* Article 012116. https://doi.org/10.1088/1742-6596/1691/1/012116

Laufer, M., Leiser, A., Deacon, B., Perrin de Brichambaut, P., Fecher, B., Kobsda, C., & Hesse, F. (2021). Digital higher education: A divider or bridge builder? Leadership perspectives on edtech in a COVID-19 reality. *International Journal of Educational Technology in Higher Education, 18*, Article 51. https://doi.org/10.1186/s41239-021-00287-6

Li, J., & Xue, E. (2022). A social networking analysis of education policies of creating world-class universities for higher education sustainability in China. *Sustainability, 14*(16), Article 10243. https://doi.org/10.3390/su141610243

Liesa-Orus, M., Lozano Blasco, R., & Arce-Romeral, L. (2023). Digital competence in university lecturers: A meta-analysis of teaching challenges. *Education Sciences, 13*(5), Article 508. https://doi.org/10.3390/educsci13050508

Love, M. L., Simpson, L. A., Golloher, A., Gadus, B., & Dorwin, J. (2020). Professional development to increase teacher capacity for the use of new technologies. *Intervention in School and Clinic, 56*(2), 115–118. https://doi.org/10.1177/1053451220914886

Luo, W., He, H., & Li, H. (2024). Chinese model of digital leadership in early childhood settings: A grounded theory study. *Early Education and Development, 35*(1), 42–56. https://doi.org/10.1080/10409289.2023.2203614

Marcelo-Martínez, P., Yot-Domínguez, C., & Marcelo, C. (2024). How and why teachers use social networks for professional learning. *Teacher Development, 28*(3), 317–329. https://doi.org/10.1080/13664530.2023.2296611

Nawawi, W., Nor, M. Y. M., & Alias, B. S. (2022). Principal's leadership and technology leadership practices and its relationship with integration of technology in teachers' teaching at school: Evidence through PLS-SEM and IPMA analysis. *Resmilitaris, 12*(4), 1915–1929. https://doi.org/10.1016/j.compedu.2022.103967

Perienen, A. (2020). Frameworks for ICT integration in mathematics education: A teacher's perspective. *Eurasia Journal of Mathematics, Science and Technology Education, 16*(6), em1845. https://doi.org/10.29333/ejmste/7803

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Pratiwi, R., Putra, Y. D., & Iswati, I. (2022). The adaptive learning effects in developing coercive digital leadership: Efforts to improve lecturer performance in Central Java province through integration of transformational leadership, power and digital intellectuality. *Quantitative Economics and Management Studies, 3*(3), 426−434. https://doi.org/10.35877/454RI.qems974

Raman, A., Thannimalai, R., & Ismail, S. N. (2019). Principals' technology leadership and its effect on teachers' technology integration in 21st century classrooms. *International Journal of Instruction, 12*(4), 423–442. https://doi.org/10.29333/iji.2019.12428a

Rui, Z., Alias, B. S., Hamzah, M. I. M., & Wahab, J. A. (2024). The impact of president digital leadership on lecturer technology usage: The mediating role of lecturer digital competence. *Educational Administration: Theory and Practice, 30*(4), 10210–10220. https://doi.org/10.53555/kuey.v30i4.6195

Simsek, O. (2016). Education Technology Standards Self-Efficacy (ETSSE) Scale: A validity and reliability study. *Eurasian Journal of Educational Research, 63*, 311–334. http://dx.doi.org/10.14689/ejer.2016.63.18

Sterrett, W. L., & Richardson, J. W. (2023). Innovation beyond the pandemic: The powerful potential of digital principal leadership. *Development and Learning in Organizations: An International Journal, 37*(2), 14–17. https://doi.org/10.1108/DLO-03-2022-0059

Suárez-Rodríguez, J., Almerich, G., Orellana, N., & Díaz-García, I. (2018). A basic model of integration of ICT by teachers: Competence and use. *Educational Technology Research and Development, 66*(5), 1165–1187. https://doi.org/10.1007/s11423-018-9591-0

Ter Beek, M., Wopereis, I., & Schildkamp, K. (2022). Don't wait, innovate! Preparing students and lecturers in higher education for the future labor market. *Education Sciences, 12*(9), Article 620. https://doi.org/10.3390/educsci12090620

Yuan, F., & Khan, M. S. (2024). Investigating the impact of digital leadership on innovation performance of public universities in Yunnan, China. *Journal of Infrastructure, Policy and Development, 8*(9), Article 7663. https://doi.org/10.24294/jipd.v8i9.7663

Yuting, Z., Adams, D., & Lee, K. C. S. (2022). The relationship between technology leadership and teacher ICT competency in higher education. *Education and Information Technologies, 27*(7), 10285–10307. https://doi.org/10.1007/s10639-022-11037-0

Zeike, S., Bradbury, K., Lindert, L., & Pfaff, H. (2019). Digital leadership skills and associations with psychological well-being. *International Journal of Environmental Research and Public Health, 16*(14), Article 2628. https://doi.org/10.3390/ijerph16142628

Zhao, Y., Pinto Llorente, A. M., & Sánchez Gómez, M. C. (2021). Digital competence in higher education research: A systematic literature review. *Computers & Education, 168*, Article 104212. https://doi.org/10.1016/j.compedu.2021.104212