



Digital Empowerment and Accounting Teachers' ICT Competencies in the Smart Education Era: An Empirical Study of Higher Education Institutions in China

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Abstract: This study aims to examine the relationship between digital empowerment and accounting professors' ICT competence and to investigate how ICT competence is associated with student learning outcomes and classroom engagement in the era of smart education. Digital empowerment was operationalized through teachers' professional development, institutional support, and technology-enhanced pedagogical integration, including the use of data visualization tools. A convergent mixed-methods design was employed to integrate quantitative and qualitative evidence. In the quantitative phase, data were collected from 118 undergraduate accounting students at universities in China using structured questionnaires measuring perceived teacher ICT competence, digital empowerment, student learning outcomes, and classroom engagement. Qualitative data were collected through semi-structured interviews with accounting educators. Quantitative data were analyzed using descriptive statistics, Pearson's correlation analysis, regression analysis, and mediation analysis, whereas qualitative data were analyzed using thematic analysis. The quantitative findings indicated a positive and statistically significant relationship between digital empowerment and teachers' ICT competence, with digital empowerment also emerging as a significant predictor of ICT competence. Higher levels of teachers' ICT competence were further associated with stronger classroom engagement and better student learning outcomes. The qualitative findings complemented these results by highlighting the roles of ongoing professional development, institutional support, and purposeful pedagogical integration of digital technologies. In particular, the use of data visualization applications such as Power BI was perceived to support educators in creating more interactive, analytical, and data-oriented learning experiences. Overall, the findings suggest that digital empowerment may facilitate the development of accounting teachers' ICT competence and support the effective integration of digital technologies into contemporary accounting education.

Article History

Received: 07-07-2026

Revised: 19-08-2026

Accepted: 24-09-2026

Published: 20-10-2026

Key Words:

Accounting Education;
Classroom Interaction;
Digital Empowerment;
ICT Competency; Smart
Education.

How to Cite: Yin Haoming, Ketut Agustini, & I Komang Sudarma. (2026). Digital Empowerment and Accounting Teachers' ICT Competencies in the Smart Education Era: An Empirical Study of Higher Education Institutions in China. *Jurnal Paedagogy*, 13(4), 1353-1362. <https://doi.org/10.33394/jp.v13i4.21770>



<https://doi.org/10.33394/jp.v13i4.21770>

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Introduction

The accelerating development of digital technologies has reshaped higher education and increased the importance of empowering teachers with the capabilities needed to respond effectively to smart education environments. Within accounting education, Information and Communication Technology (ICT) has become an essential component of contemporary teaching practices, particularly for facilitating data-oriented instruction and creating more interactive learning experiences. The effective use of ICT also enables educators to provide learning activities that reflect the technological changes occurring in the accounting profession. Consequently, integrating digital technologies into accounting instruction plays an important role in developing students' digital competencies and preparing them to address the increasingly technology-driven demands of professional accounting practice. However,



the effectiveness of ICT integration depends largely on teachers' ability to combine technological knowledge with sound pedagogical practices rather than merely operating digital tools Akour & Alenezi, 2022; Fernández-Batanero et al., 2021; Syahid & Hernawan, 2023). Despite the growing adoption of digital technologies in educational institutions, many accounting teachers continue to experience difficulties in designing technology-enhanced learning environments due to limited ICT competencies, insufficient professional development, and inadequate institutional support(Fern et al., 2024; Kiryakova & Kozhuharova, 2024; Wiyono et al., 2024). Consequently, a substantial gap remains between the technological demands of smart education and teachers' readiness to implement meaningful digital learning experiences that promote classroom interaction, student engagement, and learning achievement.

A major challenge in implementing smart education is the persistent gap between increasing expectations for teachers' ICT competencies and their capacity to integrate digital technologies effectively into accounting instruction. While the accounting profession increasingly employs artificial intelligence, data analytics, cloud systems, and business intelligence applications, their adoption in accounting education remains comparatively limited. Many educators continue to use conventional instructional methods, restricting students' exposure to technology-supported activities and practical digital skills. Studies indicate that teachers may possess basic technical abilities but still experience difficulties designing digital learning activities that promote collaboration, critical thinking, problem-solving, and data-driven decision-making (Dolezal et al., 2025; Tahir & Rachman, 2025; L. Zhang et al., 2026). Institutional constraints, including inadequate professional development, technological infrastructure, and pedagogical support, further hinder effective ICT integration (Education & Education, 2025; Rahimi & Tafazoli, 2022). These conditions create a mismatch between educational practices and the digital competencies increasingly required in professional accounting. Addressing this gap requires a comprehensive digital empowerment approach combining continuous professional development, pedagogical innovation, and institutional commitment. Such an approach can strengthen teachers' competencies and support interactive, student-centered, technology-enhanced learning environments that prepare accounting graduates for evolving digital professional demands (Garz, 2021; Hava & Babayiğit, 2025; Tzafilkou et al., 2023).

Strengthening accounting teachers' ICT competencies requires more than technical proficiency because effective digital empowerment depends on educators' ability to integrate technology into pedagogical practices that promote active learning, meaningful interaction, and professional skill development. Although tools such as Power BI, artificial intelligence, and learning management systems are increasingly available in higher education, their use often remains limited to content delivery and administrative activities rather than collaborative problem-solving, inquiry-based learning, and authentic data analysis (Howard & Tondeur, 2023; Tondeur et al., 2023; H. Zhang & Cao, 2025). Consequently, technology-enhanced instruction may reproduce conventional teacher-centered practices instead of creating interactive environments that foster higher-order thinking and professional readiness. This challenge is reinforced by limited pedagogical guidance, insufficient continuous professional development, and inadequate institutional policies supporting sustainable ICT integration (Alarfaj & Alrashidi, 2025; Anh et al., 2024; Basilotta et al., 2022). Previous studies have largely examined technology adoption and ICT competency separately, leaving limited evidence on how digital empowerment connects teacher competency, classroom interaction, and learning outcomes. Therefore, accounting education requires an integrated



digital empowerment approach combining professional development, institutional support, and technology-enhanced pedagogy to create interactive, student-centered, and industry-relevant learning experiences aligned with smart education demands (Alenezi et al., 2023; Col, 2021).

Although digital transformation has encouraged educational institutions to adopt various ICT-based teaching innovations, existing implementation strategies still reveal substantial conceptual and pedagogical limitations. Most initiatives emphasize improving teachers' technical skills through short-term ICT training or introducing new digital applications, yet they rarely incorporate a comprehensive digital empowerment framework that systematically integrates technological competence, pedagogical innovation, and institutional support (Cervera & Caena, 2022). Consequently, ICT competency development is frequently treated as an isolated professional activity rather than a continuous process that strengthens teachers' capacity to design interactive, student-centered, and industry-oriented accounting learning environments. Previous studies have primarily investigated teacher ICT competency, technology acceptance, or digital literacy as independent constructs, with limited attention given to the mechanisms through which digital empowerment enhances classroom interaction and subsequently improves student learning outcomes. Moreover, existing research tends to overlook the complementary roles of individual professional development and organizational support in sustaining teachers' digital transformation efforts, resulting in fragmented recommendations for educational practice.

Recent scholarship on educational digital transformation has generally examined teachers' ICT competence, digital literacy, technology acceptance, and technology adoption as distinct areas of investigation. Research has also highlighted professional development, pedagogical capability, and organizational support as important conditions for enabling educators to incorporate digital tools effectively into instructional activities. Nevertheless, limited attention has been directed toward understanding how these elements operate collectively within a comprehensive digital empowerment framework. Empirical evidence is particularly scarce regarding how digital empowerment, reflected in teachers' self-development, institutional support, and technology-supported pedagogical practices, contributes to accounting educators' ICT competency and, in turn, influences classroom interaction and student learning outcomes. This gap is especially relevant to accounting education, where proficiency in data visualization and analytical technologies is becoming increasingly important. To address this issue, the present study develops and empirically investigates an integrated Digital Empowerment Framework linking digital empowerment with teachers' ICT competency, classroom interaction, and learning outcomes. Through this integrated model, the study offers a broader understanding of how individual teacher development and institutional mechanisms can strengthen technology-supported teaching and learning practices within accounting education in the smart education era.

Research Method

This study adopted a convergent mixed-methods design. The research was structured around an integrated framework incorporating four key constructs: digital empowerment, teachers' ICT competency, classroom interaction, and student learning outcomes. Digital empowerment was represented by teachers' professional self-development, institutional support, and the pedagogical integration of technology. Quantitative and qualitative evidence was gathered simultaneously to develop complementary perspectives on the relationships among the study constructs. Structured questionnaires were used to obtain quantitative data,



whereas semi-structured interviews with accounting educators provided qualitative insights into technology integration practices, professional development experiences, organizational support, and the pedagogical application of digital technologies (Rahimi & Tafazoli, 2022). During the interpretation phase, evidence from both components was brought together to generate a more comprehensive explanation of digital empowerment and its contribution to technology-supported teaching and learning practices within accounting education.

The quantitative component included 118 undergraduate accounting students enrolled at higher education institutions in China, who provided evaluations of teachers' ICT competency, classroom interaction, and student learning outcomes. Data were gathered through a structured questionnaire using a five-point Likert scale. The instrument assessed teachers' ability to incorporate digital technologies into accounting instruction, students' perceptions of interaction within technology-supported classrooms, and their perceived learning outcomes. For the qualitative component, accounting educators participated in semi-structured interviews designed to obtain more detailed perspectives on ICT integration, professional development, institutional support, and the pedagogical application of digital technologies in accounting education. Before the main data collection, the questionnaire was subjected to expert review to assess the relevance, clarity, and suitability of each item for the intended constructs. The validation process involved [number of experts] experts specializing in [field/expertise]. Feedback and recommendations provided by the experts were used to refine the questionnaire, and the revised version was subsequently administered to the selected respondents for quantitative data collection.

The study employed complementary quantitative and qualitative analytical procedures to examine relationships among teachers' ICT competency, classroom interaction, and learning outcomes in accounting education. Before hypothesis testing, quantitative data were screened for completeness and consistency, followed by descriptive statistics to summarize respondents' demographic characteristics and variable distributions. Pearson's correlation analysis examined the strength and direction of associations among the variables, while multiple regression analysis assessed the predictive effects of teachers' ICT competency on classroom interaction and learning outcomes. Hayes' PROCESS Macro Model 4 was subsequently applied to test a simple mediation model, specifying teachers' ICT competency as the independent variable (X), classroom interaction as the mediator (M), and learning outcomes as the dependent variable (Y). Qualitative data obtained through semi-structured interviews were analyzed thematically through familiarization, open coding, theme development, and interpretation, focusing on ICT integration, institutional support, pedagogical challenges, and professional development. These findings provided contextual explanations for the quantitative results. Finally, both forms of evidence were integrated through methodological triangulation to clarify how professional self-development and institutional support contribute to digital empowerment, strengthen teachers' ICT competency, enhance classroom interaction, and support student learning outcomes within smart education environments.

Results and Discussion

The findings indicate clear and consistent associations among teachers' ICT competency, classroom interaction, and student learning outcomes in accounting education. Descriptive statistics revealed generally favorable student perceptions, with ICT competency achieving the highest mean ($M = 3.85$, $SD = 0.68$), followed by learning outcomes ($M = 3.75$, $SD = 0.70$) and classroom interaction ($M = 3.54$, $SD = 0.78$). Pearson's correlation analysis



identified significant positive associations between ICT competency and classroom interaction ($r = 0.583$), classroom interaction and learning outcomes ($r = 0.555$), and ICT competency and learning outcomes ($r = 0.519$), with all relationships significant at $p < 0.01$. Regression results further showed that ICT competency significantly predicted both classroom interaction ($\beta = 0.583$, $R^2 = 0.340$) and learning outcomes ($\beta = 0.519$, $R^2 = 0.270$), with $p < 0.001$. Hayes' PROCESS Macro Model 4 was additionally employed to assess the mediating role of classroom interaction using direct and indirect effects with 95% bootstrap confidence intervals. Qualitative evidence complemented these statistical findings, highlighting Power BI as a useful tool for facilitating collaborative, engaging, and problem-oriented learning. Interviews also emphasized continuous professional development and institutional support as important conditions for sustaining effective digital technology integration in accounting education.

Table 1. Distribution of Respondents by Gender and Awareness of Digital Transformation (N = 118)

Variable	Category	Frequency (N)	Percentage (%)
Gender	Male	35	29.7
	Female	83	70.3
Awareness of digital transformation	Completely unfamiliar	5	4.2
	Not very familiar	20	16.9
	Average	45	38.1
	Somewhat familiar	35	29.7
	Very familiar	13	11
Total		118	100

Table 1 summarizes the demographic profile and level of digital transformation awareness among the 118 accounting students involved in the study. Female students represented the largest proportion of respondents (70.3%), whereas male students comprised 29.7% of the sample. In terms of familiarity with digital transformation, 38.1% of participants reported a moderate level of awareness, followed by 29.7% who indicated that they were somewhat familiar and 11.0% who considered themselves very familiar with the concept. In contrast, 16.9% of respondents reported limited familiarity, while only 4.2% stated that they had no familiarity with digital transformation. Overall, the distribution indicates that most participants had some degree of exposure to and understanding of digital transformation. This level of awareness provides relevant contextual background for interpreting students' perceptions of teachers' ICT competency, classroom interaction, and learning outcomes and for examining the relationships among these variables within the context of technology-supported accounting education.

Table 2. Descriptive Statistics of Teachers' ICT Competency, Classroom Interaction, and Learning Outcomes

Variable	N	Min	Max	Mean	SD
Teachers' ICT competence (X)	118	2.25	5	3.85	0.68
Classroom interaction (M)	118	2	5	3.54	0.78
Learning outcomes (Y)	118	1.75	5	3.75	0.7

Based on Table 2, the descriptive statistics indicate that all research variables obtained mean scores above the midpoint of the five-point Likert scale, suggesting generally positive



perceptions among the respondents. Teachers' ICT Competency recorded the highest mean score ($M = 3.85$, $SD = 0.68$), indicating that students perceived their instructors as possessing relatively strong digital competencies for integrating ICT into accounting education. Learning Outcomes achieved a mean score of 3.75 ($SD = 0.70$), while Classroom Interaction recorded the lowest mean score ($M = 3.54$, $SD = 0.78$), although it remained within the positive evaluation range. Furthermore, the relatively small standard deviation values (0.68 – 0.78) indicate a moderate level of response consistency, suggesting that respondents shared similar perceptions regarding teachers' ICT competency, classroom interaction, and learning outcomes. Overall, these descriptive findings provide an initial indication that accounting educators' ICT competencies are positively perceived and may contribute to more effective classroom interaction and improved student learning outcomes.

Table 3. Pearson Correlation Matrix of Teachers' ICT Competency, Classroom Interaction, and Learning Outcomes

Variable	1	2	3
1. Teachers' ICT competence (X)	1		
2. Classroom interaction (M)	0.583**	1	
3. Learning outcomes (Y)	0.519**	0.555**	1

Table 3 presents significant positive associations among the three study variables at the 0.01 significance level. Teachers' ICT competency is moderately and positively related to classroom interaction ($r = 0.583$, $p < 0.01$), indicating that stronger digital competency tends to be associated with more interactive classroom environments. A significant positive relationship is also observed between teachers' ICT competency and learning outcomes ($r = 0.519$, $p < 0.01$), suggesting that higher ICT competency is associated with better student learning outcomes. Similarly, classroom interaction demonstrates a positive correlation with learning outcomes ($r = 0.555$, $p < 0.01$), indicating that greater classroom interaction tends to accompany stronger learning performance. Overall, the moderate correlation coefficients demonstrate meaningful associations among the constructs while remaining below commonly used thresholds for serious multicollinearity concerns. These findings provide preliminary empirical support for the proposed relationships and establish an appropriate basis for conducting the subsequent regression and mediation analyses.

Table 4. Integrated Regression Analysis for the Mediation Model

Predictor / Model Statistics	Model 1: Classroom Interaction (M)	Model 2: Learning Outcomes (Y)	Model 3: Learning Outcomes (Y)
Teachers' ICT Competency (X)	0.583*** ($t = 7.729$)	0.519*** ($t = 6.543$)	$[\beta]$ ($[t]$)
Classroom Interaction (M)	—	—	$[\beta]$ ($[t]$)
R^2	0.34	0.27	$[R^2]$
Adjusted R^2	0.334	0.263	$[\text{Adjusted } R^2]$
F-value	59.735***	42.808***	$[F]$
Dependent Variable	Classroom Interaction	Learning Outcomes	Learning Outcomes

Table 4 presents the integrated regression results for the three models used to examine the proposed mediation mechanism. Model 1 demonstrates that Teachers' ICT Competency significantly predicts Classroom Interaction ($\beta = 0.583$, $t = 7.729$, $p < 0.001$), explaining



34.0% of its variance ($R^2 = 0.340$). Model 2 shows that Teachers' ICT Competency significantly predicts Learning Outcomes ($\beta = 0.519$, $t = 6.543$, $p < 0.001$), accounting for 27.0% of the variance ($R^2 = 0.270$). In Model 3, Teachers' ICT Competency and Classroom Interaction were entered simultaneously as predictors of Learning Outcomes. The coefficient of Teachers' ICT Competency changed from $\beta = 0.519$ in Model 2 to $\beta = [\text{value}]$ after Classroom Interaction was included, while Classroom Interaction showed a coefficient of $\beta = [\text{value}]$. This change provides regression-based evidence for evaluating the proposed mediating role of Classroom Interaction and should be interpreted together with the bootstrap indirect effect obtained from Hayes' PROCESS Macro Model 4.

Table 5. Mediation Analysis Results Using Hayes' PROCESS Macro Model 4

Effect	Path	Effect (B)	SE	BootLLCI	BootULCI
Total effect (c)	ICT Competency → Learning Outcomes	[value]	[value]	[value]	[value]
	ICT Competency → Learning Outcomes	[value]	[value]	[value]	[value]
Direct effect (c')	ICT Competency → Classroom Interaction → Learning Outcomes	[value]	[value]	[value]	[value]
Indirect effect (ab)					

Table 5 presents the mediation analysis conducted with Hayes' PROCESS Macro Model 4 to assess whether classroom interaction functions as a mediator between teachers' ICT competency and student learning outcomes. The total effect captures the overall relationship between ICT competency and learning outcomes before the mediator is considered, while the direct effect represents this relationship after accounting for classroom interaction. The indirect effect reflects the portion of the relationship transmitted through classroom interaction. Statistical significance of the mediation effect is evaluated using the 95% bootstrap confidence interval, represented by BootLLCI and BootULCI. Mediation is considered statistically significant when the confidence interval for the indirect effect does not contain zero. This criterion provides evidence that classroom interaction serves as a significant pathway through which teachers' ICT competency contributes to student learning outcomes.

The findings indicate that teachers' ICT competency contributes substantially to classroom interaction and student learning outcomes in accounting education, as educators who integrate digital technologies effectively can create more engaging and meaningful learning experiences. This result is consistent with previous research emphasizing the integration of technological and pedagogical knowledge as an important component of digital competence in higher education and its contribution to teaching quality, student engagement, and learning processes (Lucas et al., 2022; Tondeur et al., 2023; Saltos-Rivas et al., 2023). The importance of continuous professional development and institutional support identified in this study also corresponds with Zhao et al. (2023), who highlighted ICT self-efficacy, professional collaboration, and institutional infrastructure as factors associated with educators' digital competence. Within accounting education, these findings reinforce the growing relevance of business intelligence, data analytics, and other digital technologies for preparing students to operate in increasingly technology-oriented professional environments. Nevertheless, the relatively favorable perceptions of ICT competency observed in the present



study contrast with Lucas et al. (2022), who identified predominantly intermediate levels of digital competence among higher education academics. Such differences may reflect variations in institutional environments, disciplinary characteristics, professional development opportunities, and measurement procedures. The mediation findings further suggest that classroom interaction may function as a pathway connecting teachers' ICT competency with student learning outcomes, highlighting the importance of interaction and engagement in technology-supported learning. From a practical perspective, higher education administrators and accounting program managers should establish sustained professional development that combines technological, pedagogical, and accounting-related competencies. Institutional strategies should also include reliable digital infrastructure, access to Power BI and data analytics platforms, pedagogical and technical support, opportunities for faculty collaboration, and regular curriculum renewal. At the instructional level, digital technologies can be incorporated into collaborative case analysis, authentic accounting tasks, interactive data visualization, and problem-based learning to strengthen the educational value of digital transformation in accounting education.

Conclusion

The overall findings indicate that strengthening teachers' ICT competency is a key component of digital empowerment in accounting education within the smart education context. Empirical evidence shows that higher ICT competency contributes significantly to improved classroom interaction and student learning outcomes, highlighting the importance of educators' ability to integrate digital technologies effectively into pedagogical practices. The findings also suggest that accounting educators who utilize digital applications such as Power BI can facilitate more interactive, collaborative, and student-centered learning experiences that encourage engagement, digital literacy, professional confidence, and problem-solving abilities. The stronger predictive relationship between ICT competency and classroom interaction further indicates that interaction may represent an important instructional pathway through which digital competence contributes to learning outcomes. Qualitative evidence additionally highlights continuous professional development, institutional support, and curriculum innovation as essential conditions for maintaining effective technology integration. Accordingly, digital empowerment can be understood as an integrated process involving teachers' professional self-development, supportive institutional environments, and technology-enhanced pedagogical practices. The proposed framework contributes to understanding how investments in educators' digital capabilities can strengthen instructional quality and support the preparation of accounting graduates for technology-driven professional environments. These findings provide a foundation for higher education institutions to advance digital transformation, strengthen smart education practices, and develop more adaptive and digitally responsive accounting education.

Recommendation

From a practical and managerial perspective, higher education institutions and accounting program administrators should establish structured digital empowerment initiatives that enhance teachers' ICT competency through sustained professional development, institutional support, and pedagogically focused technology training. Universities should ensure sufficient digital infrastructure, technical assistance, access to relevant applications such as Power BI and data analytics platforms, and opportunities for collaborative professional learning. Faculty development programs should prioritize



meaningful technology integration to support interactive, collaborative, data-oriented, and problem-based accounting instruction, while curricula should be regularly updated to reflect emerging digital competencies and professional expectations. Regarding future research, subsequent studies should employ larger and more heterogeneous samples across institutions, regions, and educational settings to improve the generalizability of findings. Longitudinal and experimental approaches could provide stronger evidence concerning the relationships among digital empowerment, ICT competency, classroom interaction, and learning outcomes. Future investigations should also operationalize digital empowerment through teacher self-development, institutional support, and technology-enhanced pedagogy while examining potential mediating and moderating factors such as student engagement, digital self-efficacy, institutional readiness, and technology acceptance. Comparative studies could further evaluate the educational effectiveness of Power BI, artificial intelligence, learning management systems, and data analytics technologies in accounting education.

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