Knowledge management framework for teacher professional development: Integrating e-learning innovation in economics education

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Abstract

This research aims to develop and validate a comprehensive knowledge management framework to improve teacher professional development and build capacity for introducing innovations to learning economics. The data were collected using quantitative research design with a cross-sectional survey of a sample of 401 secondary school economics teachers and analyzed using SEM-PLS. It is found that when the readiness for digital transformation exists, the knowledge management processes (65.3% and 60.6%) contribute to pedagogical enhancement and knowledge adoption among teachers. The contributions of this study to the literature are as follows: (1) This work involves studying how knowledge management processes mediate the relationship between digital transformation readiness and teacher professional development outcomes, and (2) it validates an integrated framework with good explanatory power and predictive relevance. However, it is found that if the full benefits of e-learning are to be realized, there must be a well-integrated technological infrastructure and organizational support, together with the teachers' digital literacy.

Keywords

E-learning integration, economics education, digital transformation readiness, knowledge management processes, teacher professional development

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Introduction

Integrating e-learning, technology-enhanced learning, and many other topics has become an increasingly accepted issue in teacher professional development (Kiwonde, 2023; Qasem & Viswanathappa, 2016). Digital technologies are increasingly being utilized to rethink teaching and learning methods (Marques & Pombo, 2021; Shonhiwa, 2023). Teachers must have relevant knowledge and skills to implement these innovations (Miranda et al., 2021).

Research has shown some benefits of e-learning and technology-enhanced learning, including accessibility to educational resources, flexible means of delivery, collaborative platforms, and peer-to-peer learning environments (Kiwonde, 2023; Shonhiwa, 2023). Implementations of these methodologies can be practical, but educators need further training, oversight, and help (Rusmawaty et al., 2023; Sakarneh, 2022).

Knowledge management frameworks formalize professional teacher development by integrating technology (Sakarneh, 2022; Shonhiwa, 2023). It stated that modern frameworks use organized, fundamental methods to capture, share, and implement teaching techniques. However, present frameworks typically need explicit guidance for subject-specific curricula, especially in economic education.

While numerous studies have addressed knowledge management in education, a wide gap exists regarding developing frameworks for economics education teachers. Economics education has many unique challenges; connecting theoretical concepts to practical applications and integrating current economic trends requires a specialized knowledge management approach (Prilianti et al., 2022; Xiao et al., 2023). Existing frameworks need to adequately address how to integrate e-learning innovations into the economics teacher's professional development systemically.

This research provides a comprehensive knowledge management approach for efficiently incorporating learning innovations into economics teachers' professional development. The framework provides systematic assistance to record, communicate, and implement the finest economics teaching approaches. This study focuses on economics education to address some of the field's unique challenges, such as aligning university-level economics theory and its practical application and incorporating more current macroeconomic disturbances into the classroom from an economic perspective.

Three fundamental research questions guide this study: (1) What would be the essential components in a knowledge management framework for integrating e-learning into economics teacher professional development? (2) How do the researchers build upon traditional knowledge management practices to meet the demand for economic education? (3) How can mechanisms encourage the selection and adoption of successful knowledge sharing and implementation within the proposed framework?

From a theoretical perspective, this research adds to the knowledge base of knowledge management in advanced educational contexts and regarding the practical application of e-learning developments in economics education. The framework proposed here will offer a structured framework for educational institutions to utilize knowledge management in economics teacher professional development programs and integrate e-learning to improve the quality of professional development.

The remainder of this research is organized as follows. Section 2 presents the theoretical framework and hypothesis development, integrating knowledge management concepts with e-learning innovation in economics education. Section 3 describes the research methodology used in this study. Section 4 presents the results of our analysis. Section 5 discusses the findings and their implications for economics teacher professional development. Finally, Section 6 concludes the research with recommendations and future research directions.

Literature Review

Digital transformation and knowledge management in educational settings

Digital transformation worldwide has radically transformed educational landscapes, including teacher professional development (Mohamed Hashim et al., 2022). This paradigm shifts how educational institutions work and brings value to the stakeholders (Langrafe et al., 2020). What does digital transformation mean in economics education? It is not restricted to technology (Mohamed Hashim et al., 2022). However, it is constantly questioning pedagogical teaching and learning processes.

The meaning of knowledge management in an educational setting is a systematic means of capturing, distributing, and leveraging pedagogical changes (Nonaka et al., 2000). Theoretical constructs for creating and transmitting information in educational organizations are described based on the SECI (Socialization, Externalization, Combination, Internalization) model (Nonaka & Konno, 1998). This is relevant to the teacher's professional development, where tacit and explicit knowledge can improve teaching (Ravanal Moreno et al., 2021).

Teacher professional development and innovation diffusion in educational settings

With digital technologies, teacher professional development is changing in this age (Darling-Hammond, 2017). Efficient, professional teacher development programs to develop teaching skills are developed through traditional and digital methods (Guskey, 2002). Since changes in economic concepts are rapid and constantly occurring (Ertmer & Ottenbreit-Leftwich, 2010). Economics teachers must learn concepts quickly and incorporate instructional innovations.

According to the diffusion of innovation theory, schools adopt new technology and new ways of teaching (Rogers, 2003). Teachers and institutions see relative advantages differently. Therefore, it is wrong because it concerns the complexity of trial and error. Economics education's digital transformation is theoretically unique and poses particular problems, which Moore and Benbasat (1991) discussed.

Theoretical framework

This research examines digital transformation preparation, processes, and consequences, knowledge management activities, and professional teacher development in educational contexts from three theoretical viewpoints. Educational technology study also uses Innovation Diffusion Theory (Adiguzel et al., 2023; Al-Rahmi et al., 2019, Rogers, 2003;

Stefaniak & Carey, 2019). This idea affects educational organizations' technology adoption and performance. This theory has been utilized to study and interpret educational settings, and the results show that it helps analyze digital transformation projects (Anthony et al., 2022; Teo et al., 2019).

The second type of research builds on this starting point and includes the SECI Model of Knowledge Creation (Nonaka et al., 2000), especially as proven in recent educational research. This model shows how endless tacit and explicit knowledge interactions build and exchange organizational knowledge. The concept is used to help teachers generate and exchange pedagogical expertise in digital learning environments (Amhag et al., 2019; O'Dowd et al., 2020; vanOostveen et al., 2019).

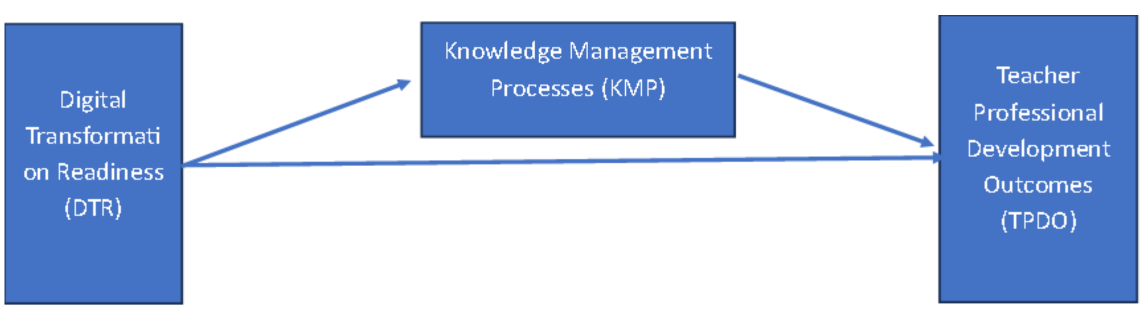
The framework was enhanced using professional development theory, the teacher transformation model (Guskey, 2002), and the Darling-Hammond frameworks (Darling-Hammond, 2017). Studies found extensive content-driven professional development improves teaching (Vasalampi et al., 2021; Yigletu et al., 2023). According to recent studies, digital competencies should be integrated into educators' professional development framework (Amhag et al., 2019; Cabero-Almenara et al., 2020).

The convergence of prior work leads to a well-integrated conceptual model that illustrates the linkages between knowledge management and teacher professional development outcomes through digital transformation preparedness. Studies suggest that these components are interconnected in schooling (Fernández-Batanero et al., 2022; Sancar et al., 2021). These theories are helpful for rapid technological development and for integrating digital competencies in education (Falloon, 2020; Núñez-Canal et al., 2022).

Recent studies have shown its use in educational theories. Teachers' adoption of digital tools has been explained using innovation diffusion theory (Frei-Landau et al., 2022; Uzumcu & Acilmis, 2024). In contrast, the SECI model has been used to analyze the knowledge exchange in an online professional learning group (Wang & Kim, 2023). The recent applications of professional development theory in teacher learning to technological integration (Xiaoyong et al., 2023; Yuan et al., 2023).

It provides a robust theoretical foundation for studying the interaction between digital transformation projects, knowledge management procedures, and educational professional development outcomes. Recent empirical research supports this integrated theoretical approach, especially in describing how digitalization changes teacher professional development and knowledge management systems (Fernández-Batanero et al., 2022).

Figure 1. *Theoretical framework*



Research variables and indicators

Based on the theoretical foundations discussed above, this research examines three primary constructs: Digital Transformation Readiness (DTR), Knowledge Management Processes (KMP), and Teacher Professional Development Outcomes (TPDO). Based on existing literature and theoretical frameworks, specific dimensions and indicators for each construction are operationalized, as shown in Table 1.

Table 1. *Operational variables*

Variable	Dimension	Indicators
Digital Transformation Readiness (DTR)	Technology Infrastructure (TI)	• TI1: Opportunity to use a wide range of technological resources • TI2: Internet access, connection, and bandwidth • TI3: Technical support systems • TI4: Digital resource accessibility
	Individual Competence (IC)	• IC1: Proficiency with technology tools • IC2: Teaching competencies for online instruction • IC3: Digital content creation and management • IC4: Technology integration for problem-solving
	Organizational Support (OS)	• OS1: Administrative support for digital initiatives • OS2: Variety of training opportunities • OS3: Professional development training • OS4: Resource allocation for digital transformation
Knowledge Management Processes (KMP)	Knowledge Sharing (KS)	• KS1: Teamwork and collaborative learning • KS2: Group practices and team tutoring • KS3: Analysis of teaching practices • KS4: Exchange of teaching experiences and learning aids
	Knowledge Integration (KI)	• KI1: Integration of IT products and procedures • KI2: Integration of teaching practices • KI3: Implementation of best practices • KI4: Adaptation of teaching-learning processes
Teacher Professional Development Outcomes (TPDO)	Pedagogical Enhancement (PE)	• PE1: Enhanced teaching and learning delivery • PE2: Increased student engagement • PE3: Improved assessment methods • PE4: Enhanced facilitation and instruction
	Digital Integration (DI)	• DI1: Classroom technology implementation • DI2: Online learning implementation • DI3: Digital assessment utilization • DI4: Virtual collaboration practices
	Professional Growth (PG)	• PG1: Career advancement opportunities • PG2: Professional network development • PG3: Research and publication activities • PG4: Digital transformation leadership

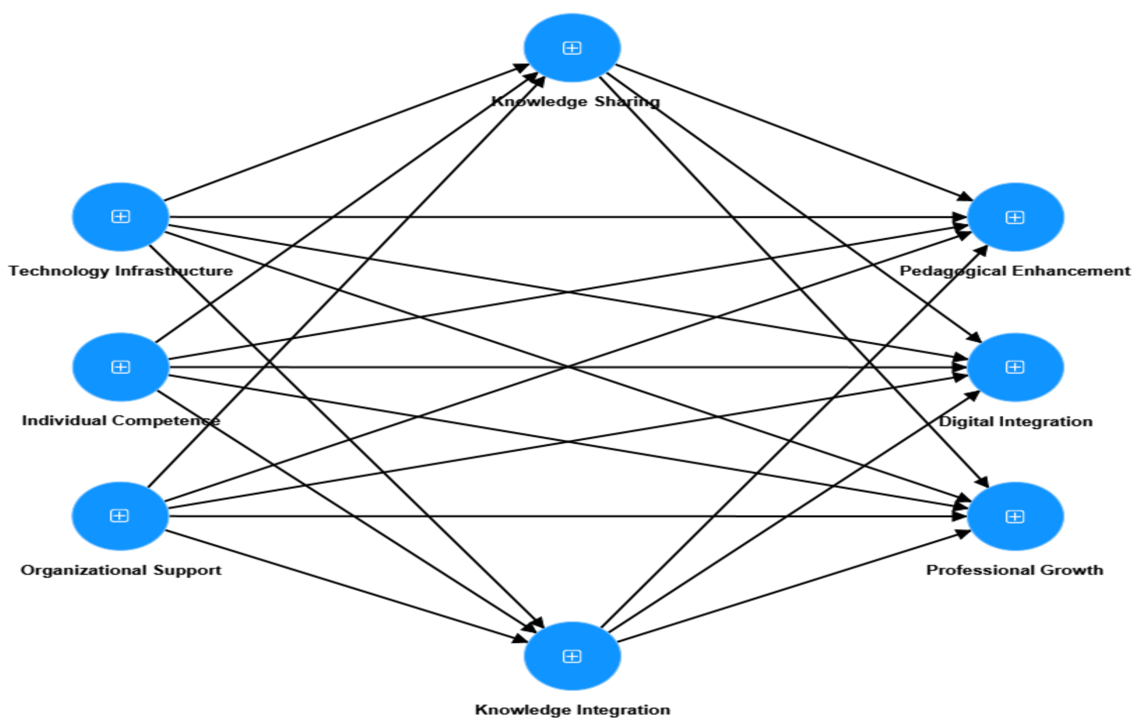
Conceptual model and hypotheses development

Considering the theoretical framework and the variables that have been discussed above, this research develops a conceptual model that hypothesizes the interaction between Digital Transformation Readiness (DTR), Knowledge Management Processes (KMP), and the outcomes of Teacher Professional Development (TPDO). The theoretical framework of the model is based on the Innovation Diffusion Theory and the SECI Model.

Conceptual model

The conceptual model views digital transformation readiness as an exogenous second-order property that affects teacher professional development outcomes throughout knowledge management processes. Previous research shows that technological readiness and organizational support systems affect professional development outcomes (Darling-Hammond, 2017), while knowledge management processes mediate those effects.

Figure 2. *Conceptual framework*



Hypothesis development

Hypothesis 1: Digital transformation readiness positively and significantly impacts knowledge management processes.

Hypothesis 2: Knowledge management processes have been discovered to enhance teacher professional development outcomes.

Hypothesis 3: Digital technology readiness is found to directly affect the outcomes of teacher professional development.

Hypothesis 4: Knowledge management process moderates the relationship between digital transformation readiness and teacher professional development outcomes.

Methodology

Research design, site, and sampling

This research employed a quantitative research design with a cross-sectional survey design to establish the relationship between digital transformation readiness and knowledge management processes, and the relationship between teacher and professional development outcomes. Based on a positive paradigm, the research qualifies it for objective measurement and allows for systemic analysis of the causality of relationships between variables. Moreover, it is very good at testing the theoretical framework proposed by Innovation Diffusion Theory and the SECI Model in economics education.

The research population was all junior high school economics teachers in North Sulawesi, Indonesia. Power and complexity analysis determined the minimum sample size required for the SEM-PLS model to ensure sufficient power to detect latent variables. Cluster sampling was employed for sample selection, first by categorizing schools into public and private and then randomly selecting respondents within each cluster.

Data collection and analysis

Data collection was systematized, starting with instrument development and grounded on validated scales from previous studies. Based on this approach, the questionnaire was reviewed by an expert panel and piloted with a representative sample of economics teachers. This research collected primary data using online and paper-based survey administration to maximize response rates. The online questionnaire data were collected for three months (September–November 2024) from 500 Indonesian junior high school economics teachers. An online survey introduced automated validation, progress saving, and mobile optimization. Multiple items of the construction were measured with a five (5) point Likert scale, strongly disagree (1) to strongly agree (5). Attention-check questions and timestamp analysis prevented data quality issues—our 82.4% response rate (412 responses from 500 disseminated surveys and 401 valid respondents). To impute missing data (< 3%), the researchers used the Full Information Maximum Likelihood technique (FIML). Early and late respondents were compared to estimate non-response bias (Armstrong & Overton, 1977), and then Harman assessed standard method bias, single-factor test, and marker variable methodology (Howard et al., 2024).

The analysis is made using SEM-PLS using SmartPLS 4.0. The researchers screened missing values, outliers, and normality assumptions first. Then, the reliability (Cronbach's alpha, composite reliability) and the validity (convergent, discriminant) of the measurement model and the path coefficients, R-square values, and effect sizes of the structural model were tested. Indirect effects were tested in mediation analysis and bootstrapping (5000 resamples), and direct and indirect correlations of the variables were analyzed for comprehensively testing hypothesized relationships. Hair et al. (2022) performed a two-stage analysis using Smart PSLs 4.0 (Hair & Alamer, 2022).

Indicator reliability (loadings > 0.70), internal consistency reliability (composite reliability > 0.70), convergent validity (AVE > 0.50), and discriminant validity (HTMT < 0.85) were applied to evaluate the measurement model. The path coefficients with t-statistics, p-values, and 95% confidence intervals from the structural model were calculated using bootstrapping. The predictive strength of the model was compared using R^2 values along with additional quality measures such as the effect size (f^2) and predictive relevance (Q^2). Zhao et al. (2010) proposed testing and bootstrapped confidence intervals of specific indirect effects to test for mediating effects.

Data preparation and screening

Comprehensive data preparation and screening procedures formed the initial data analysis. Consequently, appropriate techniques were utilized to examine and handle missing data patterns based on the nature and extent of missingness. Outlier detection was done through Mahalanobis distance analysis, and data normality was tested through skewness and kurtosis tests (Mark & Workman, 2018). To test the quality and reliability of our dataset, the researchers evaluated standard method bias using Harman's single-factor test.

Descriptive analysis

The first analysis of the preliminary data includes a demographic description of the respondents and a descriptive analysis of all measurement variables. The essential characteristics of our data were calculated according to means, standard deviations, and frequency distributions. Also, correlation analysis was conducted to determine potential patterns and relationships of study variables for the initial assessment of variable relationships.

Validity and reliability

A validity and reliability assessment were performed during the research process. Content validity was established through an expert review and an extensive literature analysis. Construct validity was measured using confirmatory factor analysis, convergent validity was checked through factor loadings more significant than 0.70 and AVE bigger than 0.50, and discriminant validity was tested through cross-loading using the Fornell-Larcker criterion and HTMT ratio. Reliability was evaluated by Cronbach's alpha and composite reliability with threshold values of 0.70.

Validation was achieved using both traditional and digital reliability metrics. Content validity was verified by an expert team of eight educational technology and economics educators. Confirmatory factor analysis was used to investigate construct validity in digital competency assessments. Digital tool usability and online survey functionality were pilottested (n=30). The researchers then wrung the scale dry to ensure measurement invariance across digital proficiency levels. Internal consistency was verified with technology-mediated response patterns, composite reliability, and Cronbach's alpha.

Measurement model and structural model assessment

The measurement model evaluation followed a systematic approach focusing on three key aspects. First, the researchers assessed internal consistency reliability through Cronbach's alpha and composite reliability measures, with threshold values set at 0.70, complemented by rho_A reliability coefficients. Second, convergent validity was examined through indicator loadings (threshold > 0.70) and Average Variance Extracted (AVE > 0.50). Third, discriminant validity was assessed using the Fornell-Larcker criterion, cross-loading examination, and Heterotrait-Monotrait ratio analysis (HTMT < 0.85).

Structural models were evaluated regarding collinearity using VIF values to keep values below 5. Bootstrapping with 5000 resamples generated and statistically adjudicated path coefficients. The predictive potential of the model was assessed using Q^2 scores from blindfolding procedures and by R^2 values for endogenous factors. SRMR and NFI examined model fit.

Mediation analysis

Mediation analysis occurred in a comprehensive examination of direct, indirect, and total effects. I first established baseline relationships of the direct impact between the variables. The researchers examined specific indirect effects in initial bootstrapping procedures and then calculated total indirect effects. To investigate the strength of mediation e, the researchers computed the Variance Accounted For (VAF).

Ethical considerations

All subjects provided informed consent, and all studies were conducted according to institutional ethics. Data was protected from a privacy standpoint, and electronic and physical protection was provided from data corruption and theft. The research protocols were reviewed by institutional ethics committees, which provided participants with the right to withdraw their participation.

The issues related to digital research ethics were discussed. Thus, electronic consent was used to create rebound consent solutions, and precise data use methods were used for survey responses and research data in the cloud. Internet privacy was maintained using secure data transmission, and responses were anonymous. Participants were informed of their rights regarding preserving and removing data collected from them. All techniques had passed the GDPR and digital research requirements.

Results

Descriptive statistics

This section describes the descriptive statistics according to indicators, mean, standard deviation, excess kurtosis, and skewness (Table 2). Each measure had mean values between 2.975 and 3.03, near moderate on the 5-point Likert scale. All measuring items' standard deviations were 1.211 and 1.235, indicating adequate response dispersion. Skewness scores range from -0.035 to 0.032; the score distribution is near zero. Response excess kurtosis values were negative (-1.011 to -0.979), indicating a flatter and lighter tail distribution. These statistics verify that the value is social science-related and that the data is correct for statistical analysis.

Table 2. *Descriptive statistics*

Indicators	Mean	Standard deviation	Excess kurtosis	Skewness
TI1	3.030	1.221	-0.994	-0.016
TI2	2.975	1.235	-1.004	0.032
TI3	3.000	1.211	-0.979	0.000
TI4	3.015	1.231	-1.011	0.004
IC1	3.010	1.225	-1.003	-0.035
IC2	3.035	1.231	-0.994	-0.042
IC3	2.998	1.218	-0.991	0.005
IC4	2.995	1.211	-0.951	0.010
OS1	3.012	1.230	-1.004	-0.024
OS2	2.958	1.238	-1.025	0.002
OS3	3.012	1.222	-0.973	-0.016
OS4	3.022	1.224	-0.984	-0.018
KS1	3.007	1.246	-1.028	-0.006
KS2	3.005	1.233	-1.008	-0.002
KS3	3.035	1.219	-0.999	-0.001
KS4	3.012	1.236	-1.024	-0.016
KI1	3.000	1.233	-1.008	-0.008
KI2	3.010	1.235	-1.006	-0.003
KI3	3.002	1.226	-0.996	0.003
KI4	2.990	1.231	-1.010	0.003
PE1	2.975	1.239	-1.014	0.024
PE2	3.035	1.235	-1.018	-0.027
PE3	3.007	1.238	-1.010	0.009
PE4	3.007	1.230	-1.005	-0.014
DI1	3.010	1.225	-0.990	-0.011
DI2	3.027	1.236	-1.023	-0.028
DI3	2.998	1.224	-0.985	-0.003
DI4	3.025	1.231	-0.997	-0.007
PG1	3.027	1.234	-1.014	-0.012
PG2	2.985	1.231	-1.010	0.012
PG3	2.993	1.250	-1.037	-0.001
PG4	3.035	1.229	-0.999	-0.018

Measurement model analysis

The reliability and validity of the constructions on which the research is based are assessed through measurement model analysis. However, this testing also includes convergent validity, discriminant validity, and reliability. Construct indicators have a high correlation in convergent validity, while constructions are distinctly lying apart in discriminant validity. Reliability tests of constructs (Cronbach's Alpha and Composite Reliability) were conducted to assess the internal consistency measures of constructs (Table 2).

Table 3. *Summary of measurement model analysis*

Indicators	Outer Loading	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
DI1	0.876	0.898	0.898	0.929	0.766
DI2	0.869				
DI3	0.869				
DI4	0.886				
IC1	0.920	0.932	0.932	0.951	0.83
IC2	0.905				
IC3	0.906				
IC4	0.915				
KI1	0.914	0.928	0.928	0.949	0.822
KI2	0.894				
KI3	0.921				
KI4	0.897				
KS1	0.903	0.932	0.932	0.952	0.831
KS2	0.919				
KS3	0.906				
KS4	0.919				
OS1	0.915	0.931	0.934	0.951	0.829
OS2	0.909				
OS3	0.908				
OS4	0.909				
PE1	0.899	0.926	0.926	0.948	0.819
PE2	0.908				
PE3	0.902				
PE4	0.911				
PG1	0.859	0.891	0.892	0.924	0.753
PG2	0.865				
PG3	0.875				
PG4	0.873				
TI1	0.886	0.923	0.924	0.945	0.811
TI2	0.897				
TI3	0.915				
TI4	0.905				

Table 3 demonstrates that all structures' Cronbach's Alpha is above 0.7 and over 0.89, indicating good internal consistency. Each composite's CR is greater than 0.92 and higher than the recommended 0.7, showing good construct reliability. The average variation extracted (second threshold) exceeds the minimum threshold of 0.5 and shows that latent components explain more than 76% of indicator variation, proving convergent validity. For convergent validity, all outside loadings should exceed 0.86. Valid and trustworthy measurement models underpin structural model analysis.

Table 4. *Discriminant validity*

Heterotrait-monotrait ratio								
Indicators	DI	IC	KI	KS	OS	PE	PG	TI
DI								
IC	0.426							
KI	0.753	0.541						
KS	0.681	0.54	0.851					
OS	0.248	0.051	0.323	0.502				
PE	0.734	0.459	0.834	0.809	0.347			
PG	0.683	0.335	0.643	0.598	0.256	0.707		
TI	0.53	0.052	0.617	0.573	0.088	0.574	0.454	
Fornell-Lacker Criterion								
Indicators	DI	IC	KI	KS	OS	PE	PG	TI
DI	0.875							
IC	0.39	0.911						
KI	0.687	0.503	0.907					
KS	0.623	0.503	0.792	0.911				
OS	0.228	0.045	0.302	0.469	0.91			
PE	0.669	0.427	0.773	0.752	0.323	0.905		
PG	0.611	0.306	0.585	0.545	0.235	0.643	0.868	
TI	0.483	0.049	0.572	0.533	0.082	0.532	0.413	0.901

Legend

DI =	Digital Integration	OS =	Organizational Support
IC =	Individual Competence	PE =	Pedagogical Enhancement
KI =	Knowledge Implementation	PG =	Professional Growth
KS =	Knowledge Sharing	TI =	Technology Infrastructure

As shown in Table 3, the HTMT (Heterotrait-Monotrait Ratio) criterion was used to determine the discriminant validity. The thresholds of 0.85 are satisfied for all construct pairs, thus proving that the constructions do not overlap significantly. This shows that the measurement model has sufficient discriminant validity. It also presents the Fornell-Larcker criterion, which consists of the correlations between constructs and the square root of each construct's AVE. The fact that the off-diagonal values are correlations suggests they should all be lower than the diagonal values (square root of AVE), resulting in even further discriminant validity. The findings demonstrate that these constructions are well-defined and different, and that the measurement model satisfies the discriminant validity.

Structural model analysis

The structural model analysis examines the relationship between constructions, such as direct and indirect effects (media), and how well the model predicts. Path coefficients, R-square values, hypothesis testing, and mediation effects are included in this analysis.

R-square analysis

The explanatory power of the model for an endogenous construct is its R-square. The power of explanation in this analysis is strong across major model constructs. Its predictors explain over two-thirds (67.6%) of its variance. R-square values of 65.3% for pedagogical enhancement and 60.6% for knowledge implementation are significant percentage variation values that do not affect the adequacy of the model. Professional growth comprises 35.9%, followed by digital integration 49.5% (Table 4). Finally, the model fits very well in predicting knowledge-related outcomes and dependent variables.

Table 5. *R-square*

Variables	R-square	R-square adjusted
Digital Integration	0.502	0.495
Knowledge Implementation	0.609	0.606
Knowledge Sharing	0.678	0.676
Pedagogical Enhancement	0.657	0.653
Professional Growth	0.367	0.359

Hypothesis testing

This analysis presents hypothesis testing based on the research framework, with structured sub-hypothesis numbering.

Table 6. *Hypothesis testing*

Hypothesis 1	Path	Path coefficient (β)	T-statistics	P-values	Decision
H1a	TI → KS	0.477	15.884	0.000	Supported
H1b	OS → KS	0.409	13.738	0.000	Supported
H1c	IC → KS	0.461	15.986	0.000	Supported
H1d	TI → KI	0.530	17.059	0.000	Supported
H1e	OS → KI	0.237	7.353	0.000	Supported
H1f	IC → KI	0.467	15.647	0.000	Supported
Hypothesis 2					
H2a	KS → PE	0.311	4.884	0.000	Supported
H2b	KS → DI	0.150	2.103	0.018	Supported

H2c	KS → PG	0.162	2.182	0.015	Supported
H2d	KI → PE	0.422	7.726	0.000	Supported
H2e	KI → DI	0.437	7.257	0.000	Supported
H2f	KI → PG	0.363	4.985	0.000	Supported
Hypothesis 3					
H3a	TI → PE	0.119	2.685	0.004	Supported
H3b	TI → DI	0.149	2.863	0.002	Supported
H3c	TI → PG	0.114	2.123	0.017	Supported
H3d	OS → PE	0.038	1.028	0.152	Not Supported
H3e	OS → DI	0.010	0.225	0.411	Not Supported
H3f	OS → PG	0.038	0.771	0.221	Not Supported
H3g	IC → PE	0.050	1.228	0.110	Not Supported
H3h	IC → DI	0.087	1.795	0.036	Not Supported
H3i	IC → PG	0.035	0.614	0.270	Not Supported
Hypothesis 4					
H4a	TI → KI → PE	0.224	6.89	0.000	Supported
H4b	TI → KI → DI	0.231	6.608	0.000	Supported
H4c	TI → KI → PG	0.192	4.762	0.000	Supported
H4d	TI → KS → PE	0.148	4.771	0.000	Supported
H4e	TI → KS → DI	0.072	2.106	0.018	Supported
H4f	TI → KS → PG	0.077	2.190	0.014	Supported
H4g	OS → KI → PE	0.100	5.058	0.000	Supported
H4h	OS → KI → DI	0.104	5.061	0.000	Supported
H4i	OS → KI → PG	0.086	3.934	0.000	Supported
H4j	OS → KS → PE	0.127	4.599	0.000	Supported
H4k	OS → KS → DI	0.062	2.061	0.020	Supported
H4l	OS → KS → PG	0.066	2.133	0.017	Supported
H4m	IC → KI → PE	0.197	7.012	0.000	Supported
H4n	IC → KI → DI	0.204	6.522	0.000	Supported

H4o	IC → KI → PG	0.169	4.782	0.000	Supported
H4p	IC → KS → PE	0.144	4.651	0.000	Supported
H4q	IC → KS → DI	0.069	2.085	0.019	Supported
H4r	IC → KS → PG	0.075	2.145	0.016	Supported

Note: Significance levels - * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$
Decision criteria: Supported if $p < 0.05$ and t-statistics > 1.96

Table 5 shows that digital transformation readiness positively and significantly affects knowledge management processes (H1a-H1f) and teacher professional development outcomes (H2a-H2f). Meanwhile, technology infrastructure shows significant direct effects on teacher professional development outcomes (H3a-H3c), organizational support (H3d-H3f) and individual competence (H3g-H3i) exhibit limited direct effects. Furthermore, knowledge management processes significantly mediate the relationship between digital transformation readiness and teacher professional development outcomes, as evidenced by statistically supported mediation paths (H4a-H4r).

SEM-PLS model evaluation analysis

Examining the SEM-PLS Model Evaluation Analysis in detail is essential to substantiate and verify the obtained results. This analysis's essential findings are the effect size (f^2), the predictive relevance Q^2, the model fit index PLS - predict consequences, and the Cross-validated Prediction Accuracy Test (CVPAT). Therefore, if the researchers invest in the indicated dimensions methodically, their models' validity, efficiency, and relevance for advancing the body of knowledge can be ensured.

Table 7. *Comprehensive model evaluation results*

Evaluation Criteria	**Metric**	**Value**	**Assessment**
Model Fit	SRMR (Saturated)	0.031	Excellent (< 0.08)
	SRMR (Estimated)	0.059	Good (< 0.08)
	NFI	0.906	Excellent (> 0.90)
Effect Size (f^2)	TI → KI	0.712	Large effect (> 0.35)
	IC → KS	0.659	Large effect (> 0.35)
	OS → KS	0.516	Large effect (> 0.35)
	KI → PE	0.160	Medium effect (> 0.15)
Predictive Relevance (Q^2)	Knowledge Sharing	0.676	Strong (> 0.35)
	Knowledge Implementation	0.647	Strong (> 0.35)
	Pedagogical Enhancement	0.659	Strong (> 0.35)
	Professional Growth	0.553	Strong (> 0.35)
PLS-Predict (Q^2predict)	Knowledge Sharing	0.547-0.571	High predictive power

	Knowledge Implementation	0.463-0.524	Good predictive power
	Pedagogical Enhancement	0.395-0.427	Moderate predictive power
	Professional Growth	0.181-0.238	Acceptable predictive power

The whole SEM-PLS model evaluation in Table 6 shows strong performance across many categories. The analysis examines model fitness, effect size, predictive relevance, and power. The saturated model has SRMR values of 0.031, and the estimated model has 0.059, far below the 0.08 threshold, indicating a good fit. The model's NFI is 0.906, over 0.90, indicating an acceptable fit. The model's F-squared analysis finds substantial links. Technology Infrastructure has the highest impact on knowledge implementation ($f^2 = 0.712$), followed by individual competence (0.659) and organizational support (0.516) on knowledge sharing. practical significance is proven by effect sizes >0.35.

Knowledge Implementation moderately affects Pedagogical Enhancement ($f^2 = 0.160$). The Q^2 values of 0.553 to 0.676 suggest significant predictive power for all endogenous components. Knowledge sharing ($Q^2 = 0.676$) is the most predictive, followed by pedagogical enhancement (0.659) and knowledge implementation (0.647). The model's high values show prediction power. PLS-Predict validates the model's prediction. Knowledge Sharing indicators have the highest predictive value (Q^2predict: 0.547-0.571), followed by knowledge implementation (0.463-0.524). Despite Cross v, validated Cross-validated

lower Q-predict values (0.181-0.238), professional growth has strong predictive power across all constructs.

Discussion

This research discusses the impact of a knowledge management framework on teacher professional development in economics education and e-learning innovation. The respondents are a diverse group of educators embracing various education levels, genders, and locations, and hence, the results could be subjected to descriptive and inferential statistics (Backfisch et al., 2020; Gondwe, 2021). Cronbach's alpha, composite reliability, and AVE are above the measurement model analysis levels, as indicated by Gondwe (2021).

The analysis of the structural model demonstrates that predictors indicate a large proportion of endogenous components – 67.6%, with the priority given to pedagogical improvement, which is 65.3%, and knowledge implementation, 60.6% (Gomez et al., 2021; Mokotjo, 2023). The hypothesis testing reveals that knowledge management processes affect technology infrastructure, organizational support, and individual competency in enhancing teacher professional development concerns.

The findings of this research contribute to the existing literature on knowledge management in teacher professional development and technology-enhanced teaching and learning. As with literature, technology infrastructure, organizational support, and individual capabilities are also relevant to knowledge management and positive educational outcomes (Hairunisya et al., 2019; Korriku & Tartaraj, 2023).

The implications of the findings presented in this research support the prior scholarly work, and this research adds knowledge to the literature by showing how the identified factors affect teacher professional development. These results overlaid the moderating role of KMP, coherent with the prior studies on optimal technology utilization and PD, and knowledge sharing and application (Filippova et al., 2021; Gillani et al., 2018). This highlights the need for, as opposed to just providing the technology, forming an integrated approach to knowledge transfer and orientated implementation.

Theoretical contributions

The research advances technology integration in teaching and learning theory with its complete knowledge management framework. Three theoretical contributions of the research: This research first adds digital transformation readiness as a prerequisite to knowledge management methods. This growth emphasizes the role of technology in instructional knowledge management (Paneru & Adhikari, 2019; Viphanova et al., 2021). The research strengthens the theoretical framework for digital transformation in education by incorporating technology infrastructure, organizational support, and personal competence as knowledge management antecedents.

Second, knowledge management processes mediate the benefits of digital transformation preparedness into increased teacher professional development. This clarifies how technology integration and organizational factors affect teaching and learning (Yasir & Khalifa, 2018). According to the findings, knowledge management methods link organizational capabilities and educational outcomes.

Third, the framework's strong explanatory power, model fit, and predictive relevance validate the theoretical integration of the key constructs and lay the groundwork for future research in this field. This validation applies TAM and Knowledge Management Theory to teacher professional development and e-learning integration.

This research emphasizes this significance for legislators, administrators, and teacher professional development program developers. Integrated learning becomes effective when teachers invest in technology infrastructure and dependable digital tools (Gondwe, 2021). Knowledge sharing and its implementation need organizational support (Backfisch et al., 2020). Teachers should include digital literacy and pedagogical skills in their professional development, making them technology specialists in the classroom (Anyanwu, 2015; Melash et al., 2020).

It is insightful but has drawbacks. This complicates inferences of causal correlations from cross-sectional data and strongly suggests the need for longitudinal research to observe components' dynamic interactions over time. However, the findings are conducted in Indonesian economics education and may be unsuitable for other educational fields or cultures. Future research replication of the findings in different applications is needed. The framework's success may be seen in moderating factors such as institutional traits, leadership styles, and teacher demographics. Adding student learning outcomes or organizational-level performance measurements to the framework will help you to analyze its impact better.

A thorough framework is presented for studying digital-era teacher professional development variables. The research systematically integrates learning difficulties by linking technical infrastructure, organizational support, and individual competence with knowledge management methods. This research stresses how evidence-based teacher professional development initiatives are needed to improve educational outcomes and use digital innovation in teaching.

Conclusion

Knowledge management frameworks affect economic teacher professional development and e-learning innovation in this research. Respondents supply robust descriptive and inferential data across educational levels, genders, and locales. The measurement model is reliable and valid with Cronbach's alpha, composite reliability, and AVE above the criteria. The variance in endogenous components, particularly pedagogical improvement (65.3%) and knowledge implementation (60.6%), is explained by structural model analysis. Hypothesis testing shows how knowledge management procedures affect technology infrastructure, organizational support, and individual competency to improve teacher professional development, including pedagogy, digital integration, and growth.

The research adds to knowledge management in teacher professional development and technology-enhanced education literature. It supports previous findings that technology infrastructure, organizational support, and human abilities improve educational outcomes. It expands the research by explaining how knowledge management procedures mediate digital transformation preparedness into improved professional development results. The requirement for an integrated strategy for knowledge transmission and execution goes beyond providing technological tools.

This research contributes to theoretical understanding by adding digital transformation readiness as a prerequisite of knowledge management processes that reflect the importance of technology in the instructional knowledge management process. Moreover, the mediating function of knowledge management processes in linking organizational capabilities and educational outcomes is further represented in how technology integration and certain organizational factors assimilate with teaching and learning. The applicability of the Technology Acceptance Model (TAM) and Knowledge Management Theory to teach professional development and e-learning integration is also extended by this research while confirming the framework's strength with a sound explanatory power and model fit.

Disclosure Statement

No potential conflict of interest was reported by the authors.

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