

Supplementary Material S4. Full Mapping of Key Success Factors Based on the PPTE Framework

Table S7

Full Mapping of KSFs Based On The PPTE Framework

PPTE Dimension	Secondary Category	KSFs	Measurable Aspects of Factors (Based on Original Text)	Supporting Literature
People	Teacher literacy	Teachers' digital literacy	① Teachers' ability to acquire and effectively utilize digital teaching resources; ② Teachers' ability to participate in teaching and research through the internet; ③ Teachers' ability to use computers and the internet for electronic lesson preparation; ④ Teachers' willingness and ability to integrate theoretical knowledge of information technology into educational practice; ⑤ Teachers' awareness and ability to apply information technology to assist teaching; ⑥ Teachers' proficiency in operating information technology	L01/L02/L04/L05/L06/L08/L11/L16/L18/L19/L20/L21/L24/L25/L26/L28/L29/L32/L33/L34/L36
People	Teacher attitude	Willingness and attitude towards technology adoption	① Perception of the usefulness of educational technology; ② Perception of the ease of use of technology; ③ Intrinsic motivation to use educational technology; ④ Openness to technological change	L02/L04/L08/L16/L17/L18/L20/L21/L24/L25/L26/L28/L29/L34
People	teacher literacy	Support for teachers' professional development	① The school provides regular digital teaching training; ② establishes a teacher learning community to promote experience sharing; ③ provides teachers with personalized and differentiated professional development opportunities; ④ the frequency and duration of teacher participation in training; ⑤ the alignment between training content and teaching practice; ⑥ mobilizes teachers' professional initiative and differentiated care	L02/L04/L05/L08/L15/L20/L23/L25/L28/L29/L32/L36
People	Student literacy	Student information literacy	① Students possess basic information technology operation skills; ② Students can utilize digital resources for autonomous learning; ③ Students have the ability to discern and critically evaluate online information; ④ Students demonstrate proficiency in using smart devices for learning; ⑤ Students show a high level of engagement in learning within a digital environment	L03/L05/L17/L25/L27/L28/L31/L35
People	Student literacy	Development of students' digital competencies	① The degree of improvement in students' digital thinking ability; ② The development of students' collaboration and communication skills; ③ Students' innovative problem-solving abilities; ④ Students' ethical awareness in technology use; ⑤ Students' self-regulated learning abilities; ⑥ Students' active learning behaviors through accessing the learning management system via devices	L03/L06/L12/L17/L19/L22/L31/L32/L33/L35
People	Leadership	Administrator digital leadership	① The principal's ability to formulate a digital vision and strategic planning; ② The principal's ability to coordinate communication and resource integration; ③ The principal's efforts in promoting the construction of digital culture; ④ The principal's support for teachers' digital practices; ⑤ The principal's own digital literacy and learning ability	L01/L02/L03/L04/L05/L07/L08/L09/L10/L13/L14/L15/L16/L22/L23/L24/L26/L29/L30/L31/L34/L36
People	Leadership	CIO system and informatization organization construction	① Establish a specialized information leadership organization in the school; ② Equip with full-time information management personnel; ③ Establish an information work coordination mechanism; ④ Clarify the division of digital responsibilities among various departments; ⑤ Improve the scientific and democratic level of information decision-making (Chief Information Officer (CIO) system)	L01/L02/L05/L07/L13/L15/L23/L30/L36

PPTE Dimension	Secondary Category	KSFs	Measurable Aspects of Factors (Based on Original Text)	Supporting Literature
Process	Strategic planning	Digital strategy and planning formulation	① Schools should formulate clear visions and goals for digital transformation; ② develop phased implementation plans and roadmaps; ③ clarify key tasks and resource allocation for each stage; ④ plan the degree of alignment with regional education informatization policies; ⑤ formulate and implement informatization development plans and annual semester plans, with dynamic adjustments and optimizations; ⑥ deeply understand the major policies of the Party and the state regarding digital transformation.	L01/L02/L03/L04/L05/L07/L08/L09/L10/L11/L13/L15/L16/L22/L23/L26/L29/L36
Process	Strategic planning	Phase division and task decomposition	① Clarify the short-term, medium-term, and long-term goals of the transformation; ② Identify the key points, difficulties, and promotion strategies for each stage; ③ Establish a stage evaluation and feedback mechanism; ④ Breakdown tasks to specific responsible individuals and departments; ⑤ Iterative design method (develop prototype, evaluate, expand, and re-evaluate in stages)	L02/L05/L15/L23/L34/L36
Process	Project management	Project management and schedule control	① Establish project management systems and processes; ② Develop detailed project timelines and milestones; ③ Regularly monitor and evaluate project progress; ④ Timely identify and respond to project risks; ⑤ Rationally allocate and utilize project resources	L02/L05/L13/L15/L23/L26/L29/L36
Process	Quality assurance	Quality assurance and continuous improvement	① Establish a digital teaching application assessment and evaluation mechanism; ② Conduct regular digital teaching effectiveness assessments; ③ Establish a problem diagnosis and feedback improvement mechanism; ④ Reward teachers who actively participate in digital practices; ⑤ Refine and promote excellent digital teaching cases; ⑥ Iteratively improve application quality through multiple rounds of assessments (expert review, user testing, heuristic evaluation)	L02/L04/L05/L07/L08/L11/L13/L15/L23/L26/L29/L36
Process	Teaching Application	Course integration and teaching application	① The degree of deep integration between digital technology and subject teaching; ② The diversity and innovation of digital teaching activities; ③ The frequency with which teachers integrate technology into daily teaching; ④ The enhancement of students' learning outcomes through digital teaching;	L01/L03/L05/L06/L08/L13/L16/L18/L19/L21/L24/L25/L29/L32/L33/L34/L35/L36
Process	Teaching Application	Teaching model innovation	① Implementing new teaching models such as flipped classrooms and blended learning; ② Implementing personalized learning and adaptive teaching; ③ Offering cutting-edge courses such as maker education and STEAM education; ④ Utilizing data to drive teaching decisions; ⑤ Creating an online and offline integrated teaching environment that promotes regional collaboration; ⑥ Offering interdisciplinary project-based learning courses	L01/L03/L05/L07/L17/L21/L24/L27/L32/L33/L34/L35
Process	Cultural development	Digital cultural construction	① Create a digital work environment that supports innovation; ② Establish an incentive mechanism for digital teaching innovation; ③ Foster a data-driven decision-making culture; ④ Promote the sharing of digital experiences among teachers; ⑤ Form a digital value system recognized by the entire school; ⑥ Cultivate a collaborative cultural atmosphere; ⑦ Cultivate a data culture."	L01/L02/L04/L07/L08/L09/L10/L11/L14/L16/L26/L30

PPTE Dimension	Secondary Category	KSFs	Measurable Aspects of Factors (Based on Original Text)	Supporting Literature
Process	Data governance	Data-driven decision-making	① Establish a data collection and integration mechanism; ② Monitor teaching quality using data; ③ Implement personalized teaching interventions based on data; ④ Support management decision-making through data visualization; ⑤ Establish data governance standards and process construction; ⑥ Monitor digital business	L03/L05/L06/L07/L13/L16/L22/L23/L26/L29/L36
Technology	Infrastructure	Infrastructure coverage level	① Campus network coverage and bandwidth level; ② Multimedia classroom/smart classroom equipment rate; ③ Teacher-student terminal equipment ratio (student-computer ratio, teacher-computer ratio); ④ Full coverage of campus wireless network; ⑤ Information-based classroom construction (smart classroom); ⑥ New infrastructure construction of the school"	L01/L02/L05/L07/L11/L12/L13/L19/L23/L25/L26/L28/L29/L30/L31/L32/L33/L34/L35/L36
Technology	Infrastructure	Technology selection and platform integration	① Applicability and stability of digital teaching platforms; ② Interconnection and data sharing of various systems; ③ Construction of high-quality digital teaching resource libraries; ④ Matching degree between platform functions and teaching needs; ⑤ Adaptability of technical solutions to the actual situation of schools; ⑥ Resource coverage and applicability of national/regional smart education cloud platforms; ⑦ Adoption of intensive and lightweight digital project construction models	L01/L02/L03/L04/L05/L07/L08/L09/L10/L13/L16/L23/L26/L29
Technology	System quality	System usability and accessibility	① The system interface is simple and aesthetically pleasing, with convenient operation; ② The system can be used without time and space constraints; ③ The system boasts fast response speed and stability; ④ The system has low learning cost and is easy to get started; ⑤ The system is user-friendly for different user groups	L04/L05/L07/L08/L13/L23/L25/L26/L28/L29/L32/L33/L34/L35/L36
Technology	System quality	Child-friendliness focus	① The interface design conforms to children's cognitive characteristics; ② The font, graphics, and sounds are suitable for the target age group; ③ The interaction design takes into account children's operating habits and preferred styles of their age group; ④ The difficulty of the content matches the developmental level of children; ⑤ Provides guidance suitable for children's use	L25/L30
Technology	System quality	Data security and privacy protection	① Establish a data security management system; ② Ensure the personal information security of teachers and students; ③ Regulate the ethics and legality of online behavior; ④ Implement a data access control mechanism; ⑤ Strengthen network security and data protection	L03/L07/L15/L22
Technology	Resource construction	Digital resource construction	① Construction of digital educational resources and platforms (school-based resource repository, digital library, campus website); ② Scientificity and accuracy of resource content; ③ Alignment of resources with curriculum standards; ④ Resource update and maintenance mechanism	L03/L04/L05/L07/L08/L13/L15/L19/L23/L25/L30/L31/L32/L33/L34/L35/L36
Ecosystem	Policy environment	Policy and regulatory support	① Guidance from national/local educational informatization policies; ② Formulation of regional educational informatization development plans; ③ Institutional guarantees for digital transformation; ④ Coherence and consistency in policy implementation; ⑤ Policy evaluation and feedback mechanisms	L01/L02/L03/L05/L07/L11/L15/L16/L23/L25/L26/L29/L30/L31/L36

PPTE Dimension	Secondary Category	KSFs	Measurable Aspects of Factors (Based on Original Text)	Supporting Literature
Ecosystem	Resource guarantee	Funds and resource guarantee	① Special funding and guarantee for educational informatization; ② Funding guarantee for equipment maintenance and renewal; ③ Funding support for teacher training; ④ Funding for digital resource procurement; ⑤ Equipment and network support for vulnerable groups	L01/L03/L05/L07/L11/L12/L23/L30/L32/L36
Ecosystem	Resource guarantee	Funds and resource guarantee	① Special funding and guarantee for educational informatization; ② Funding guarantee for equipment maintenance and renewal; ③ Funding support for teacher training; ④ Funding for digital resource procurement; ⑤ Equipment and network support for vulnerable groups	L01/L03/L05/L07/L11/L12/L23/L30/L32/L36
Ecosystem	Society and culture	Sociocultural and value orientation	① Social awareness and acceptance of digitalization in education; ② Widespread recognition of the value of digitalization in education; ③ Digital cultural differences between urban and rural areas/regions; ④ Social atmosphere surrounding digital learning; ⑤ Social emphasis on digital literacy	L01/L02/L03/L05/L07/L11/L19/L23/L30/L31/L32/L36
Ecosystem	Home-School Collaboration	Parental digital literacy and participation	① Parents' support for their children's digital learning; ② Parents' own digital literacy level; ③ Parents' frequency of participating in school digital activities; ④ Construction of digital communication channels between home and school; ⑤ Parents' cognition and attitude towards digital education; ⑥ Parents' tutoring of their children's studies (educational participation)	L03/L04/L07/L08/L23/L30
Ecosystem	Collaborative network	Multi-party collaboration network	① Coordination and collaboration between schools and competent departments; ② Cooperation between schools and universities, research institutions; ③ Technical cooperation between schools and enterprises; ④ Inter-school alliances and experience sharing; ⑤ Home-school-community collaborative education mechanism; ⑥ Recommendation by teachers from other schools, enterprise promotion, lectures by university experts, and appeals from parents	L02/L05/L07/L15/L22/L23/L25/L26/L29/L30/L31/L36
Ecosystem	Collaborative network	Enterprise technical support and services	① Enterprises provide software and hardware products along with accompanying services; ② Technical experts provide guidance in schools; ③ Continuous technical support and maintenance; ④ Customized services tailored to the needs of schools; ⑤ Technical training and consulting services	L02/L05/L07/L22/L25/L26/L36

Table S8

31 Validated Paths from 36 Studies

Path_ID	Source_KSF	Relationship type	Target KSF Outcome	Mediator moderator	Effect size evidence	Empirical method	Literature ID	PPTE dimension path
P01	Policy and regulation support	Chain path	Curriculum integration and teaching application	Administrator digital leadership→Technology selection and platform integration→Willingness and attitude towards tech adoption	$\beta = 0.585/0.531/0.662/0.490^{***}$	Multilevel SEM	L16	Ecosystem→People→Technology
P02	Administrator digital leadership	Direct	Technology selection and platform integration		$\beta = 0.531^{***}$	SEM	L16	People→Technology
P03	Administrator digital leadership	Full mediation	School effectiveness/platform outcomes	Digital culture construction (organizational commitment)	Bootstrap significant	SEM mediation	L14	People→Process (culture construction)→Outcome
P04	Teacher digital literacy	Chain	Curriculum integration and teaching application	Willingness and attitude towards tech adoption→Adaptive use	PLS significant chain	PLS-SEM	L18	People→Process
P05	Teacher digital literacy (data literacy)	Mediation	Student digital competency development	Curriculum integration (digital teaching competence)	Full/partial mediation	SEM	L06	People→Process→Outcome
P06	Technology selection and platform integration (platform service)	Direct	Willingness and attitude towards tech adoption		$\beta = 0.439^{***}$	SEM	L08	Technology→People
P07	Willingness and attitude towards tech adoption	Mediation	Transformation application behavior/implementation success		$\beta = 0.202^{***}$	SEM	L08	People→Outcome
P08	Teacher professional development support (facilitating conditions)	Direct	Transformation application behavior		$\beta = 0.151^{***}$	SEM	L08	People→Outcome
P09	Digital resource construction (content quality)	Direct	Platform satisfaction/implementation effectiveness outcome		$\beta = 0.113^{***}$; 7/8 configuration core	SEM+fsQCA	L04	Technology→Outcome
P10	Technology selection and platform integration (platform quality)	Direct	Platform satisfaction outcome		$\beta = 0.218^{***}$	SEM	L04	Technology→Outcome
P11	Social culture and value orientation (contextual dynamics)	Chain mediation	Transformation implementation effectiveness outcome	Project management→Quality assurance and continuous improvement (trigger→enablement)	Indirect 90.06%	SEM+Bootstrap	L02	Ecosystem→Process→Outcome
P12	Quality assurance and continuous improvement (enabling dynamics)	Direct	Transformation intention/behavior/effectiveness outcome		$\beta = 0.893^{***}$	SEM	L02	Process→Outcome
P13	Curriculum integration and teaching application	Direct	Student digital competency development		$\beta = 0.262^{**}$	Regression	L19	Process→People
P14	Infrastructure coverage level	No significant direct effect	Student digital competency development		Not significant	Regression	L19	Technology→People
P15	Willingness and attitude towards tech adoption (performance expectancy)	Direct	Teaching implementation effectiveness outcome		$\beta = 0.567^{**}$	Regression	L21	People→Outcome

Path_ID	Source_KSF	Relationship type	Target KSF Outcome	Mediator moderator	Effect size evidence	Empirical method	Literature ID	PPTE dimension path
P16	Teacher digital literacy x organizational governance x digital culture construction	Configurational	High-quality development outcome		H1-H2 consistency >0.95	fsQCA	L01	People x Process x Process→ Outcome
P17	Curriculum integration x digital culture construction	Configurational	High-quality development outcome		H3 environment-advantage type	fsQCA	L01	Process x Process→ Outcome
P18	Infrastructure x strategic planning	Configurational	High-quality development outcome		H4 strategy-led type	fsQCA	L01	Technology x Process→ Outcome
P19	Strategic planning x data-driven decision making	Configurational	Smart education innovation		Top-level design type	fsQCA	L07	Process x Process
P20	Multi-party collaboration x technology selection	Configurational	Smart education innovation		Internal-external linkage type	fsQCA	L07	Ecosystem x Technology
P21	Technology adoption x digital resources x system quality	Configurational	Platform satisfaction		User-platform dominant type	fsQCA	L04	People x Technology
P22	School level/region/school type	Moderation	Technology adoption→ application behavior		$\beta = -0.025 \sim -.098^*$	SEM	L08	Ecosystem moderation
P23	School level	Moderation	Administrator leadership→ ICT transformation		Cross-level interaction	Multilevel SEM	L16	Ecosystem moderation
P24	Willingness and attitude towards tech adoption	Sequential	Use behavior	Attitude stage	Attitude→ intention→ behavior	GT+SEM	L20	People→ Outcome
P25	Policy and regulation support	Path	Student digital competency development	Learning space/evaluation/teaching/resources	Path analysis p<0.05	Path analysis	L03	People (leadership source)→ multiple factors
P26	Administrator digital leadership	Descriptive association	Teacher digital literacy		Only 46.81% agree leadership is strong	Questionnaire	L36	People→People (non-causal)
P27	Digital strategy and planning formulation	Descriptive association	Project management and progress control		83.67% have plans but slow implementation	Questionnaire	L36	Within Process
P28	Digital resource construction (appropriateness)	Descriptive association	Curriculum integration and teaching application		34.1% resources unsuitable; low application competence	Questionnaire	L36	Technology→Process
P29	Policy and funding support + multi-party collaboration	Recommended path	Teacher digital literacy improvement		High-level promotion + collaboration + path dependency dissolution	Policy recommendation	L36	Ecosystem→ People
P30	Digital culture construction	Mediation	School remote teaching effectiveness	Organizational commitment	Full mediation	SEM	L14	Process (culture construction)→ Outcome
P31	Teacher digital literacy	Path effect	Student IT learning application outcome		Teacher IT application competence → student IT learning application $\beta = 0.261^{**}$, $t=2.143$, $R^2=0.575$	SEM	L05	People→ Outcome

Table S9

Information of 36 Included Studies

No.	Article Title	Author	Year	Country	Research Method	Sample Characteristics	Core Theoretical Model
L01	Research on Configuration Pathways for Digital Transformation Empowering High-Quality Development in Primary and Secondary Schools	Liang Y. Z., Xu Ch. Ch. & Wang Y.	2025	China	Quantitative research (utilising questionnaire surveys and fsQCA quantitative analysis)	Sample Size : 600valid questionnaires . Research Subjects: Primary and secondary school administrators (principals, vice-principals, etc.). Educational Stages: Covering primary schools (71.5%)	
L02	Research on the Driving Mechanisms and Implementation Pathways for Digital Transformation in School Education	Hou Ch. X.	2024	China	Mixed methods (quantitative: questionnaire surveys, structural equation modelling; qualitative: interviews, case studies, grounded text analysis).	Sample Size: Questionnaire I (Current Status Survey):13,168 valid responses. Questionnaire II (Driving Mechanism Survey):1,077 valid responses.	Theoretical Model Foundation: Organisational Change Theory (Greenwood & Hinings' Tripartite Mechanism Model of Organisational Change)
L03	Research on Factors Influencing the Transformation of Basic Education through Educational Informatisation	Huang R. h., et al.	2016	China	Qualitative: Literature review, Delphi method Quantitative: Case scoring, path analysis	Sample size : 40 schools (case studies) Research subjects: Schools (as organisational units) Educational stages: Primary, lower secondary, upper secondary (full basic education spectrum) School types: Unspecified	Integrated three international school informatisation evaluation frameworks: Intel ICTMonitoring Framework UK School E-Learning Self-Assessment Framework
L04	Configurational Path Analysis of Factors Influencing Satisfaction with the National Smart Education Platform for Primary and Secondary Schools	Dong T. Q., Chen R. L., & Xu Zh. G.	2025	China	Quantitative research (employing structural equation modelling (SEM) and fuzzy set qualitative comparative analysis(fsQCA) to analyse scale data)	Sample Size: 1,456valid questionnaires . Research Participants: Primary and secondary schoolteachers. Educational Stage: Not explicitly differentiated between primary and secondary schoolteachers; collectively termed "primary and secondary school teachers".	Theoretical Model Foundation: This study integrates three theories to construct a hypothetical model: Perceived Value Theory: Distinguishes utilitarian value (perceived usefulness) and
L05	Research on the Systemic Driving Mechanisms for High-Quality and Balanced Development of Information Technology in Compulsory Education	Zhang H.,Y.,& LianY. d.	2024	China	Quantitative research (data collected via questionnaire surveys, employing quantitative analytical methods including entropy analysis and system dynamics simulation)	As stated on page 5of thepaper: "This study targeted primary and secondary school teachers in a western region, employing stratified sampling to distribute260 questionnaires, yielding 227validresponses."	Theoretical Model Foundation: System Dynamics Theory. The article explicitly states "utilising system dynamics methodology" (Abstract andPage 2), and constructs upon this theory
L06	Does teacher's data literacy and digital teaching competence influence empowering students in the classroom? Evidence from China	Lin R.Y, Yang J.F., Jiang F. , & Lij. P.	2022	China	Quantitative research (usingSPSSand AMOS for structural equation modelling analysis).	Sample size:629 teachers. Research subjects:K-9 teachers (basic education teachers). Educational stages: Kindergarten, primary school, secondary school (K-9).	
L07	The Configuration Pathways for Innovative Development of Smart Education in Primary and Secondary Schools in Western China-A Qualitative Comparative Analysis Based on TOE Theory	Liu M., Guo Sh, Liu Errun	2025	China	Qualitative Comparative Analysis (QCA), specifically Fuzzy Set Qualitative Comparative Analysis (fsQCA). This method combines	32 school cases in western China	Theoretical Model Foundation: Core Theoretical Framework:Technology- Organisation- Environment (TOE) Theory. Methodological Foundation: Fuzzy Set Qualitative Analysis

L08	How to Enhance the Application Effectiveness of the National Smart Education Platform for Primary and Secondary Schools? -An Analysis Based on a Nationwide Survey	Wang, D. M., Jiang Sh. Sh., Guo J., Pan Ch. Ch., Zhu J.Y.	2025	China	Quantitative research (primarily employing Structural EquationModelling-SEMand Fuzzy Set Qualitative ComparativeAnalysis-fsQCA).	Sample Size: 10,359valid teacher questionnaires . Research Participants: Primary and secondary schoolteachers. Educational Stages: Primary (49.1%),LowerSecondary (30.9%), Upper Secondary	Theoretical Model Foundation: This study integrates the Technology Acceptance and Usage Integration Model and the Information Systems Success Model to construct a "Technology-Cognition-Behaviour" framework.
L09	Research on Constructing a Five-Element Model of Digital Transformation Leadership for Primary and Secondary School Principals	Li, Sh. Sh., LinY., Wu &X. M.	2025	China	Qualitative research (employing literature review and interview dataanalysis/qualitative coding).	Interviewed principals fromsix primary and secondary schoolsin Beijing . Research Subjects: Primary and secondary school principals (administrators). Educational Stage: Primary and secondary education stage (Primary	Theoretical Model Foundation:Connectivismlearning theory. This theory emphasises establishing connections between network nodes in the digital age
L10	Construction and Interpretation of a Digital Leadership Model for Primary and Secondary School Principals	Qi, J. Y., Shao, S.C, Ge, Y., Chen N., &Zhao K. Y.	2025	China	A combination of qualitative and quantitative approaches. Qualitative methods included grounded theory (three-level coding) and the Delphi method (expert assessment); quantitative	Sample size: Questionnaires for confirmatory factor analysis were distributed toprimary and secondary school principals across multiple regions in Province S (the article does not explicitly state the absolute number of valid responses, but mentions the questionnairecomprised 5	Theoretical Model Foundations: Grounded Theory: Employed for core element extraction. Organisational Change Theory (particularly Lewin's Change Model): Utilised to define
L11	Has Online Teaching Exacerbated Educational Inequality?An Empirical StudyBasedon13,176 Primary and Secondary School Questionnaires in Jiangsu Province	Wang, Y.J., Bai, Y., Ding, B. R.	2020	China	Quantitative research (questionnaire survey employing multiple linear regression models)	Sample size:13,176 valid questionnaires. Research subjects: Primary and secondary school students (and their families). Educational stage: Primary, junior secondary, and senior secondary levels covered (the model in the text categorises primary and secondary as lower secondary)	Theoretical Framework: Primarily grounded in maximised inequality theory and cultural reproduction theory. The research framework reveals a pathway: "social class → family support (
L12	How Does School IT Hardware Investment Affect Student Performance? An Empirical Study Based on Junior High Schools in Nanjing	Tian,Y.H., Yao,J. J, &Ding J.	2020	China	Quantitative research (based on large-scale monitoring data, employing hierarchical linearmodelling HLM for statistical analysis)	Sample size School level:128 junior secondary schools Student level:16,530 Year 8 pupils Research subjects: Year 8 (second year of junior secondary) pupils	Theories of educational resource allocation and educational equity. The research methodology employs hierarchical linear modelling (HLM) to address the nested data structure of students within schools.

L13	Analysis of Factors Influencing Digital Campus Management Levels in Primary and Secondary Schools:A Questionnaire Survey of 16 Municipalitiesin Province X	Zhang, Y., et al.	2013	China	Quantitative Research (Questionnaire Survey + Multiple Linear Regression + Structural Equation Modelling)	Sample Size 795 valid questionnaires (representing 795 schools) Research Subjects Primary and secondary schools (including teaching points, ordinary primary schools, junior high schools, senior high schools) Educational Stages Primary, Junior High Sample size:380Research subjects: Teachers	No single theoretical model is explicitly referenced in the text, but the indicator system construction drew upon: • Malaysia's Smart School Quality Assessment Star Rating Indicators • U
L14	Principals' digital transformational leadership, teachers' commitment, and school effectiveness	Berkovich,I., & Hassan, T.	2025	Bahrain	Quantitative	Educational stage: Primary (31.3%) and secondary (including junior and senior high) School type: No clear distinction between	
L15	Research on Pathways for Digital Transformation to Empower High-Quality Development in Basic Education:A Case Study of National-Level Information-Based Teaching Experimental Zones	Zhou, Q.	2022	China	Qualitative Research (Case Analysis, Policy Analysis)	Research Subjects: Centred on basic education organisations, explicitly encompassing: Schools: Primary and secondary schools within the experimental zones (covering primary, junior secondary, and senior secondary levels). Teachers: As key agents of digital transformation	The article references Zhu Zhitang et al.'s theoretical framework on educational digital transformation and independently constructs a digital transformation framework centred on the core concept of "continuous iteration".
L16	How does principal e-leadership affect ICT transformation across different school stagesin K-12 education Perspectives from teacher	Wu,B., Yu,X.,& Hu,Y .	2019	China	Quantitative	Sample size:2,894 valid questionnaire participants. Research subjects: Teachers. Educational stage: Covering primary, lower secondary, and upper secondary levels. School type: Not specified in the text	
L17	Factors Influencing Primary and Secondary Students' Acceptance of Smart Classrooms	Wei, W.,Zhang X. R,Chen M. Y., &Ding X.	2024	China	Quantitative Research (Questionnaire Survey Method, Descriptive Statistics,Independent Samplet-Test, One-Way ANOVA, Correlation Analysis, Regression	Sample size:3,078 primary and secondary school students (formal survey). Research subjects: Primary and secondary school students.	Theoretical Model Foundation: Unified Theory of Acceptance and Use of Technology (UTAUT): Serving as the core theoretical framework, it retains the
L18	The Path From Digital Competence to Adaptive Use: An Empirical Analysis of 9,726 Primary and Secondary School Teachers	Y Li, X Zhang, M Chen	2025	China	Quantitative	Sample size:9,726 teachers (valid questionnaires) Research subjects: In-service primary and secondary schoolteachers Educational stage: Primary and secondary	
L19	Can Technology Empower Students' Digital Literacy? –A Large-Scale Survey on Digital Learning Status in Primary and Secondary Schools	Pu, S.,& Cao, P. J.	2025	China	Quantitative research (large-scale questionnaire survey, descriptive statistical analysis, multiple linear regression analysis).	Sample Size: Valid sample size of 23,178 responses (covering12 provinces nationwide). Research Participants: Primary and	
L20	A Grounded Theory Perspective on Factors Influencing the Development of Information Technology Competence Among Primary School Teachers in Rural Western China	Zhang, R. H., Wang, P. H.	2023	China	Qualitative research (specifically employing interviews and grounded theory)	SampleSize: Research Subjects: Rural primary schoolteachers in western China (specifically "expert-level teachers") Educational Stage: Primary education School Type: Rural primary schools	Model Foundation: Grounded Theory. The article explicitly states "the application of grounded theory for theoretical modelling" (Abstract) and "the use of grounded theory for model construction" (

L21	Returning to the Classroom: A Study on the Sense of Efficacy in Smart Classroom Teaching and Its Influencing Factors	Ye, F. zh., &Wang W.	2023	China	Quantitative research	Sample Size:299 valid questionnaires Research Participants: Primary and secondary schoolteachers Educational Stage: Primary and secondary schools (no explicit distinction between	Theoretical Model Foundations: Bandura's Triadic Interaction Theory Technology Acceptance Model (TAM)
L22	Research on the Construction and Development of a Model for Headteachers' Digital Leadership	Tian A.L., Gao W. X., &Xiao, M. et al.	2024	China	Mixed Methods (primarily qualitative research, including case studies and grounded theory analysis; supplemented by	Sample Size:Approximately 50schools (the text mentions "case studiesconducted by the research teamacrossnearly 50schoolsnationwide," referring to the qualitative research sample size. The	Theoretical Model Foundation: Grounded Theory: Employed for coding analysis of qualitative case data to extract
L23	Analysis and Countermeasures for Regional Basic Education Informatisation under a Balanced Development Perspective:A Surveyof14 Regionsin Gansu Province	Hao, Zh., &Bao, L.	2022	China	Mixed-methods approach, survey research methodology (questionnaires, in-depth interviews, field observations).	Sample Size: Survey coverage across 14 cities (prefectures) in Gansu Province , with 41,313 teacher questionnaires and 75,103 student questionnaires distributed.	Theoretical Model Foundation: Theory of Balanced Educational Development, Education Informatisation 2.0 Framework.
L24	An analysis of causal factors of blended learning in Thailand	W Diteeyont, B Plangsorn, SE Pramono, B Isdaryanti, &AP Wijaya	2024	Thailand	Quantitative	Sample size Total 236 Research subjects School administrators (n=48), teachers (n=86), students (n=102)Educational stage	Technology Acceptance Model (TAM)
L25	Appropriation of adaptive literacy games into the German elementary school...	N Pflaumer, N Knorr, &K Berkling	2021	Germany	Qualitative (semi-structured interviews + thematic analysis)	Sample size:21 teachers (from 9 schools) Research subjects: Primary schoolteachers Educational stage: Primary school (Years 1-4) School types: State and independent, urban and rural	TPACK model (Technology-Pedagogy-Content Knowledge)UTAUT model (Unified Theory of Acceptance and Use of Technology)
L26	Assessing Digital Technologies' Adoption in Romanian Secondary Schools	Vărzaru & Ghiță,	2025	Romania	Quantitative	Sample size:430Research subjects: Secondary schoolteachers Educational stage:Secondary educationSchool type: Not specified	The Technology Acceptance Model (TAM) has been extended to incorporate perceived quality as
L27	Differences in K-12 School Students' Online Learning Outcomes from the ...	Zhu et al.,	2025	China	Quantitative	Samplesize: Validsample of 13,225 students. Research subjects:K-12 school students. Educational stage:Primary school	Pedagogical-Societal-TechnologicalFramework (PSTFramework)
L28	The unique effects of Covid-19-A qualitative study of the factors that influence teachers' acceptance and usage of digital tools	O Wohlfart, T Trumler, I Wagner	2021	Germany	Qualitative (interview-based qualitative content analysis)	Sample size:15 secondary schoolteachers Research subjects:Secondary school teachersEducational stage:Secondary education	Technology Acceptance Model(TAM)
L29	Understanding factors affecting fundamental schoolteachers' use of technology in Luxembourg through a survey study	K Ivanishchenko, G Busana, RAP Reuter	2024	Luxembourg	Quantitative	Sample size: 159 teachers. Research subjects: Practising teachers in Luxembourg's fundamental schools (primary schools), including regular teachers, trainee teachers, non-certified teachers, substitute teachers, and educational	Technology Acceptance Model(TAM) Theory of Planned Behaviour (TPB)

L30	Unheard voices: Identifying aspects for an inclusive digital education through the lens of low-income contexts schools	J Castaño-Muñoz, C Moreno-Morilla, M Reina-Parrado, I Lopez-Cobo	2025	Spain	Qualitative (semi-structured interviews, focus groups, participatory visual methods (priority ladder, digital traffic lights) and document analysis)	Sample size: Total of 70 participants. Including 8 headteachers, 30 teachers, 32 Year 6 pupils. Research subjects: Headteachers, teachers, pupils. Educational stage: Pre-school	
L31	Investigating ICT-led engagement with content in science and basic computing subjects of lower secondary schools in Rwanda	O Habimana, M Nduwingoma, I Ndayambaje, JF Maniraho, A Kaleeba, D Kamuhanda	2025	Rwanda	Qualitative	Sample size: 394 participants in total. Research subjects: Deputy headteachers: Teachers: 40 (teaching science and ICT subjects) Students: 344	
L32	A slightly digital learning environment in the hands of a rural teacher: modern-day teaching and its impact on student engagement and subject learning outcomes	G Zhang	2025	China	Quantitative	Sample size: 245 secondary school pupils Research subjects: Pupils Educational stage: Middle school School type: Rural state school (unspecified)	
L33	Use of Computing Devices as Sensors to Measure Their Impact on Primary...	Fernández-Soriano et al.,	2019	Spain	Quantitative	Sample size: 1,938 pupils Research subjects: Pupils (primary, lower secondary, upper secondary) Educational stage: Primary (9–10 years old), lower secondary, upper secondary (17–18 years old)	Technology Acceptance Model (TAM)
L34	Iteratively Digitising an Analogue Syllable-Based Reading Intervention	A Riedmann, P Schaper, M Donnermann, M Lein, SC Steinhäusser, P Karageorgos	2022	Germany	Hybrid	Sample size: 17 children. Participants: Year 2 primary school pupils. Educational stage: Primary School. School type: Not specified	
L35	Integrating Executive Function Activities Into a Computerized Cognitive Training to Enhance Reading Comprehension in Primary Students	C Ruffini, E Pizzigallo, C Pecini, L Bertolo, B Carretti	2025	Sweden	Quantitative	Sample size: 92 ; Research subjects: Primary school teachers; Educational stage: Primary School School type: Not explicitly stated, but research	
L36	Examining the Current Status of Educational Informatisation in Promoting High-Quality Development of Basic Education in Tibet. An Analysis Based on a Survey of 3,134 Teachers Regarding Factors Influencing Digital Education Literacy	Xiao, L., Zheng, Zh., & Song N. Q.	2023	China	Quantitative research (questionnaire survey, descriptive statistics, t-tests/ANOVA, regression analysis).	Sample Size: Valid samples 3,134 ; Research Subjects: Primary and secondary school teachers. Educational Stages: Primary, junior secondary, senior secondary (encompassing the entire basic education stage).	

Table S10

Subgroup comparison of PPTE key success factors: number of supporting studies in Chinese (n = 25) versus non-Chinese (n = 11) subgroups.

PPTE dimension	Key success factor	China (n=25)	Non-China (n=11)	Cross-context status
People	Teachers' digital literacy	14	7	Both
	Willingness/attitude toward adoption	8	6	Both
	Teacher professional development	9	3	Both
	Student information literacy	4	4	Both
	Student digital competency	7	3	Both
	Administrator digital leadership	15	7	Both
	CIO / IT organization	8	1	Both
	Digital strategy and planning	16	2	Both
Process	Phase division and task decomposition	5	1	Both
	Project management and control	6	2	Both
	Quality assurance and improvement	10	2	Both
	Course-technology integration	12	6	Both
	Teaching model innovation	8	4	Both
	Digital cultural construction	9	3	Both
	Data-driven decision-making	9	2	Both
	Infrastructure coverage	11	9	Both
Technology	Technology selection / platform	12	2	Both
	System usability and accessibility	8	7	Both
	Child-friendliness focus	0	2	Non-China only
	Data security and privacy protection	4	0	China only
	Digital resource construction	11	6	Both
	Policy and regulatory support	10	5	Both
	Funds and resource guarantee	9	1	Both
	Sociocultural and value orientation	10	2	Both
Ecosystem	Parental digital literacy	5	1	Both
	Multi-party collaboration network	7	5	Both
	Enterprise technical support	5	2	Both

Note. Counts denote the number of included studies whose extracted evidence supports each factor, based on the supporting-literature mapping in Table S4-1 and the country classification in Table S4-3. Counts are not mutually exclusive across factors, as a single study may support multiple factors. “Both” = supported in both subgroups (candidate cross-context factor); “China only” / “Non-China only” = supported in only one subgroup and, given the small subsets, best read as untested in the other context rather than as confirmed context-specific.