THE IMPACT OF EDUCATIONAL INNOVATION ON TEACHERS' INSTRUCTIONAL PRACTICES: THE MEDIATING ROLE OF DIGITAL COMPETENCY AND THE MODERATING EFFECT OF INSTITUTIONAL SUPPORT

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Abstract: Drawing on the Technology Acceptance Model (TAM) and TPACK framework, this study examines how educational innovation (EI) enhances teachers' instructional practices (TIP) among Chinese K-12 teachers. We propose and test a moderated-mediation model wherein digital competency (DC) mediates the EI-TIP relationship, and institutional support (IS) moderates the EI-DC linkage.

Data from 350 K-12 teachers across eastern, central, and western China were collected via online survey. Structural equation modeling reveals that EI positively affects TIP ($\beta=0.34$, $p<0.001$), with DC significantly mediating this relationship (indirect effect=0.28, $p<0.01$, VAF=45%). IS strengthens the EI-DC path (high IS: $\beta=0.72$ vs. low IS: $\beta=0.39$, $p<0.001$), confirming moderated mediation.

Findings extend TAM and TPACK to Chinese education contexts, demonstrating that innovation-driven digital competency development constitutes a critical mechanism for instructional improvement. Results offer evidence-based guidance for school administrators implementing innovation initiatives and policymakers designing teacher professional development aligned with Education Modernization 2035 goals. This study addresses gaps in understanding innovation adoption mechanisms in centralized education systems characterized by exam pressure, hierarchical structures, and resource disparities.

Keywords: Educational Innovation, Teachers' Instructional Practices, Digital Competency, Institutional Support, Chinese K-12 Education, TPACK

Introduction

China's education system, serving over 180 million K-12 students with more than 10 million teachers, faces unprecedented digital transformation imperatives aligned with national strategic priorities. The Ministry of Education's Education Modernization 2035 blueprint mandates technology-enhanced teaching and personalized learning as core objectives for achieving world-class education quality (MOE, 2019). The COVID-19 pandemic accelerated this agenda, exposing critical gaps in teachers' digital competency and schools' institutional readiness for large-scale online instruction (Huang et al., 2020).

Educational innovation (EI)—defined as the systematic adoption of novel pedagogies, digital tools, and instructional strategies—has emerged as critical for improving teaching quality in this context. Yet substantial variation exists in Chinese teachers' innovation adoption rates, influenced by factors including digital skills, pedagogical beliefs, and institutional contexts (Zhang & Liu, 2019). Teachers' instructional practices directly determine innovation success, encompassing lesson design quality, classroom management effectiveness, assessment sophistication, and student engagement outcomes (Darling-Hammond et al., 2017).

Chinese teachers face unique challenges that distinguish their contexts from Western counterparts. These include managing large classes of 40-60 students, navigating intense exam-oriented culture driven by Zhongkao and Gaokao high-stakes testing pressure, operating within limited pedagogical autonomy due to centralized curriculum structures, and confronting variable digital infrastructure across stark urban-rural divides (Zhao, 2014). Understanding how educational innovation enhances instructional practices under these constraints bears both theoretical significance for educational change theory and practical significance for China's ongoing education modernization efforts.

Literature Gaps and Research Opportunities

Despite growing research on educational technology adoption, three critical gaps warrant systematic investigation in the Chinese K-12 context.

Gap 1: Mechanism Ambiguity. While existing literature acknowledges that educational innovation generally improves teaching outcomes (Tondeur et al., 2017), the underlying psychological and behavioral mechanisms through which innovation adoption translates into instructional practice improvements remain underexplored. Simply implementing new technologies or pedagogies does not automatically enhance teaching quality. We propose digital competency as a critical mediating mechanism: educational innovation creates structured learning opportunities that cultivate teachers' technological-pedagogical-content knowledge integration (TPACK), which in turn enables more effective technology-enhanced instruction (Mishra & Koehler, 2006). However, this mediation pathway has not been empirically validated in Chinese educational contexts characterized by distinct

implementation challenges.

Gap 2: Boundary Conditions. Prior research inadequately addresses how institutional support conditions the effectiveness of educational innovation initiatives. Chinese schools exhibit tremendous heterogeneity in organizational support—urban key schools provide abundant resources, professional development, and leadership backing, while rural schools often lack basic technological infrastructure and training opportunities (Liu & Huang, 2021). Understanding institutional support's moderating role clarifies critical questions: when and where do educational innovation investments yield meaningful returns? Which dimensions of institutional support matter most? This contingency perspective remains underdeveloped in educational technology literature, which often assumes uniform implementation contexts.

Gap 3: Context Specificity. Most educational innovation research focuses on Western education systems characterized by smaller class sizes, decentralized governance structures, and relatively higher teacher autonomy. China's centralized curriculum control, high-stakes testing culture, hierarchical administrative structures, and government-led reform initiatives create distinct implementation dynamics requiring indigenous investigation (Voogt et al., 2013). Technology Acceptance Model and TPACK framework, while theoretically robust, require contextual adaptation and empirical validation in Chinese settings where perceived usefulness centers on exam performance enhancement and perceived ease-of-use must accommodate large-class scalability constraints.

This study addresses the identified gaps by investigating two primary research questions grounded in TAM and TPACK theoretical frameworks:

RQ1: How does digital competency mediate the relationship between educational innovation and teachers' instructional practices among Chinese K-12 teachers?

RQ2: To what extent does institutional support moderate the educational innovation–digital competency–instructional practices linkage?

By integrating Technology Acceptance Model with TPACK framework and grounding our analysis in China's unique education context, we advance a contingency framework delineating the conditions under which innovation succeeds in centralized education systems. This framework specifies both the mechanism (digital competency development) and boundary conditions (institutional support levels) governing innovation effectiveness.

Literature Review

Theoretical Foundations

Technology Acceptance Model and TPACK Framework Integration

The Technology Acceptance Model (TAM), originally developed by Davis (1989), posits that technology adoption depends primarily on two key perceptions: perceived usefulness and perceived ease of use. In educational contexts, teachers adopt innovations when they believe these changes will

demonstrably improve instructional outcomes and when implementation appears manageable within existing constraints (Venkatesh & Davis, 2000). For Chinese teachers operating under intense accountability pressure, perceived usefulness specifically relates to innovations' potential to enhance student examination performance, classroom management efficiency, and teaching effectiveness within large-class settings (Zhang & Liu, 2019). Perceived ease of use encompasses not only technological complexity but also pedagogical scalability—whether innovations can be practically implemented with 40-60 students in resource-constrained environments.

The TPACK framework, developed by Mishra and Koehler (2006), conceptualizes effective technology integration as the intersection of three knowledge domains: technological knowledge (understanding digital tools), pedagogical knowledge (understanding teaching methods), and content knowledge (understanding subject matter). Rather than viewing these as separate competencies, TPACK emphasizes their integration—teachers must simultaneously consider what to teach, how to teach it, and which technologies best support specific pedagogical goals for particular content (Koehler & Mishra, 2009). Chinese teachers require sophisticated TPACK development that balances rigid subject matter demands dictated by national curriculum standards, innovative pedagogical approaches that challenge traditional transmission models, and digital tool mastery that extends beyond basic operational skills (Chai et al., 2013).

Integrating TAM with TPACK provides a comprehensive framework for understanding innovation adoption in Chinese contexts. TAM explains adoption decisions (whether teachers engage with innovations), while TPACK specifies the competency development required for effective implementation (how teachers transform adoption into instructional improvement). This integration addresses a critical gap: TAM focuses on initial acceptance but inadequately explains post-adoption effectiveness, whereas TPACK describes required competencies but provides limited guidance on adoption antecedents and organizational conditions.

Chinese Education Context

China's education system presents distinctive features that profoundly shape innovation implementation dynamics. First, centralized curriculum control constrains innovation scope—the Ministry of Education prescribes detailed content standards, textbook selections, and pacing guides, limiting teachers' autonomy to experiment with alternative approaches (Dello-Iacovo, 2009). Second, exam-oriented culture prioritizes test preparation over pedagogical experimentation. The Zhongkao (senior high school entrance examination) and Gaokao (university entrance examination) create intense pressure for teachers to maximize student scores, often at the expense of innovative but unproven methods (Zhao, 2014). Third, urban-rural resource disparities create differential access to digital infrastructure, with eastern coastal cities possessing advanced smart classroom technologies while western rural schools lack reliable internet connectivity (Liu & Huang, 2021). Fourth, teacher evaluation systems emphasize measurable student achievement over process-oriented indicators like

innovation adoption or pedagogical creativity, reinforcing conservative instructional approaches (Gao & Liu, 2013). These contextual factors create unique challenges and opportunities for educational innovation that differ substantially from Western implementation environments studied in existing literature.

Educational Innovation: A Multidimensional Construct

Educational innovation encompasses systematic changes to pedagogies, tools, organizational structures, and learning environments that enhance teaching effectiveness and student learning outcomes (Kampylis et al., 2015). For Chinese K-12 teachers, educational innovation manifests across four interrelated dimensions that collectively transform instructional practices.

Pedagogical Innovation

Pedagogical innovation involves adopting student-centered instructional methods that shift from traditional teacher-directed transmission models toward approaches emphasizing active learning, collaboration, and inquiry. Specific manifestations include flipped classroom models, project-based learning, cooperative learning structures, and differentiated instruction strategies. Shanghai teachers implementing flipped classrooms pre-record lecture content as videos for home viewing, dedicating valuable class time to problem-solving, collaborative projects, and individualized support—challenging traditional "chalk-and-talk" instruction that dominates Chinese classrooms (Chen et al., 2021). Beijing mathematics teachers increasingly use heterogeneous group-based peer tutoring, strategically addressing large class sizes while simultaneously developing students' collaboration and communication skills (Wang & Zhang, 2020). These pedagogical innovations require teachers to reconceptualize their roles from knowledge transmitters to learning facilitators, fundamentally altering classroom interaction patterns and power dynamics.

Technology Integration

Technology integration involves systematically incorporating digital tools into instructional processes beyond superficial or occasional use. This dimension encompasses smart classroom technologies (interactive whiteboards, document cameras, student response systems), blended learning platforms combining online and face-to-face instruction, educational applications for content delivery and practice, and learning management systems for assignment distribution and communication. Guangzhou schools have deployed interactive whiteboards and artificial intelligence platforms enabling real-time formative assessment and data-driven instructional adjustments (Li & Ma, 2021). During and after COVID-19 pandemic disruptions, teachers integrated DingTalk and Tencent Classroom platforms for hybrid delivery models, extending learning opportunities beyond traditional physical classroom boundaries and temporal constraints (Huang et al., 2020). Effective technology integration requires moving beyond substitution (using technology to replicate existing practices) toward transformation (leveraging technology to enable previously impossible instructional approaches), consistent with the SAMR model's higher levels (Puentedura, 2006).

Assessment Innovation

Assessment innovation involves implementing formative, authentic, and technology-enhanced assessment practices that extend beyond traditional summative examinations. Chinese teachers have begun adopting exit tickets providing real-time understanding checks, concept mapping revealing student thinking processes, peer assessment developing metacognitive skills, and self-assessment promoting learner autonomy (Black & Wiliam, 2018). Electronic portfolios support process-oriented assessment documenting learning trajectories, aligned with China's comprehensive quality evaluation reforms attempting to reduce excessive exam emphasis (Zheng, 2020). Adaptive testing platforms like Zhixue.com diagnose individual student knowledge gaps and prescribe personalized practice exercises, enabling differentiated instruction at scale previously impossible in large-class settings (Xie & Huang, 2022). These assessment innovations serve dual purposes: providing actionable feedback improving student learning while generating data informing teachers' instructional decisions.

Collaborative Professional Practice

Collaborative professional practice involves engaging in peer collaboration, lesson study, professional learning communities, and collective inquiry focused on instructional improvement. This dimension reflects the social nature of teacher learning and innovation diffusion. Nanjing teachers participate in teaching research groups (jiaoyan zu), traditional collaborative structures where teachers jointly design lessons, observe each other's teaching, and provide constructive critique—practices deeply embedded in Chinese education culture (Paine & Ma, 1993). Regional "famous teacher studios" share pedagogical innovations through WeChat groups, webinars, and demonstration lessons, creating networks extending beyond individual schools (Zhou & Kim, 2020). These collaborative practices accelerate innovation adoption by providing social support reducing implementation anxiety, peer modeling demonstrating feasibility, and collective problem-solving addressing implementation challenges.

Hypothesis 1: Educational Innovation and Instructional Practices

These four educational innovation dimensions collectively enable Chinese teachers to modernize pedagogical approaches, systematically integrate technology, implement evidence-based assessment practices, and engage in continuous professional learning—mechanisms theoretically and empirically linked to enhanced instructional practices. Pedagogical innovations improve lesson design quality and student engagement. Technology integration enables differentiated instruction and extends learning opportunities. Assessment innovations provide actionable feedback informing instruction. Collaborative practices accelerate capability development through social learning (Harris & Jones, 2017). Therefore, we propose:

H1: Educational innovation positively influences teachers' instructional practices.

Digital Competency as Mediating Mechanism

Mediation Logic

Building on TAM and TPACK framework, we propose that educational innovation enhances instructional practices primarily through developing teachers' digital competency. Digital competency encompasses the knowledge, skills, attitudes, and dispositions required for confident, critical, and effective technology-leveraged pedagogy (Ferrari, 2012; Redecker, 2017). Innovation adoption creates structured experiential learning opportunities that cultivate teachers' digital skills, which subsequently enable instructional improvements (Ertmer & Ottenbreit-Leftwich, 2010). This mediation perspective addresses a critical question: what mechanisms translate innovation adoption into practice enhancement?

Educational Innovation Develops Digital Competency

Educational innovation compels digital competency development through three interconnected mechanisms. First, experiential learning occurs as teachers implement new technologies and pedagogies. A Hangzhou teacher reported: "When adopting flipped classroom approaches, I necessarily learned Camtasia for video creation, Kahoot for interactive quiz design, and DingTalk platform management—skills that dramatically improved my overall digital capabilities" (Zhang, 2021, p. 145). Hands-on implementation provides authentic learning contexts superior to decontextualized technology training.

Second, structured training accompanies innovation initiatives. Beijing's Smart Education program mandated 40 hours of digital skills training covering learning management systems, learning analytics interpretation, multimedia content creation, and online pedagogy—professional development directly linked to innovation implementation (Beijing Municipal Education Commission, 2020). Unlike generic technology training disconnected from instructional practice, innovation-embedded professional development explicitly connects technical skills with pedagogical applications.

Third, peer-supported transfer occurs through collaborative innovation adoption. Shanghai teachers reported learning digital competencies through classroom observation of innovative colleagues, co-teaching arrangements allowing collaborative technology integration, and informal mentorship relationships providing just-in-time troubleshooting support (Chen & Zhang, 2019). Social learning accelerates competency development by providing models, emotional support, and collective problem-solving resources unavailable through individual adoption efforts.

Digital Competency Enhances Instructional Practices

Digitally competent teachers demonstrate superior instructional practices across multiple dimensions. First, they implement differentiated instruction effectively. Teachers proficient with adaptive learning platforms can tailor instruction addressing diverse student needs. A Shenzhen mathematics teacher explained: "Using Zhixue.com analytics, I identify struggling students early and assign targeted practice. Previously, I taught all 50 students identically—now I differentiate instruction effectively based on real-time performance data" (Li, 2020, p. 78). Digital competency enables personalization previously impractical in large-class settings.

Second, digitally competent teachers create more engaging pedagogical experiences. Teachers proficient in multimedia production develop compelling instructional materials. A Chengdu history teacher produced documentary-style video lessons integrating archival footage, animations, and narrative storytelling—transforming traditionally text-heavy content into engaging multimodal experiences that improved student attention and content retention (Wang, 2021). Digital competency expands teachers' pedagogical repertoires beyond lecture-based transmission.

Third, digitally competent teachers make data-informed instructional decisions. Teachers who understand learning analytics leverage assessment data to identify knowledge gaps and adjust instruction accordingly. A Guangzhou language teacher used 17zuoye platform quiz data to redesign character stroke order instruction after detecting systematic errors in student writing—evidence-based adjustment impossible without digital competency enabling data interpretation (Huang, 2022).

Hypothesis 2: Mediation Effect

Digital competency serves as a critical conduit translating educational innovation into instructional improvements. Teachers who adopt innovations develop integrated technological-pedagogical-content knowledge (TPACK) enabling effective technology-enhanced instruction, student-centered pedagogical approaches, and data-informed practice (Koehler & Mishra, 2009). Without adequate digital competency, innovation adoption remains superficial—teachers may possess new tools but lack capability to leverage them effectively. Conversely, digitally competent teachers transform innovations into instructional enhancements. Therefore, we propose:

H2: Digital competency mediates the positive relationship between educational innovation and teachers' instructional practices.

Institutional Support as Moderating Condition

Moderation Logic

While educational innovation universally benefits teachers, its efficacy depends critically on institutional support—organizational conditions including leadership backing, resource provision, professional development opportunities, and supportive culture (Fullan, 2007). Institutional support reflects organizational readiness sustaining innovation beyond initial enthusiasm, addressing implementation barriers, and legitimizing experimentation (Harris & Jones, 2010). In Chinese hierarchical education contexts characterized by variable resources and strong administrative control, institutional support serves as a critical boundary condition determining innovation success (Zhang & Pang, 2016). We theorize institutional support as a first-stage moderator strengthening the educational innovation to digital competency linkage.

Dimensions of Institutional Support

Leadership Support. Principals' active championship involves providing clear innovation vision, strategically allocating resources, systematically removing implementation obstacles, and publicly recognizing innovative teachers (Leithwood & Jantzi, 2006). In China's hierarchical

administrative systems, principal support proves paramount for innovation success. Innovations lacking explicit administrative endorsement rarely gain traction due to teachers' strong risk aversion and cultural deference to authority (Wang & Gao, 2021). High leadership support amplifies educational innovation's digital competency impact by legitimizing experimentation, protecting teachers from failure stigma, and prioritizing innovation adoption in teacher performance evaluations.

Resource Provision. Adequate infrastructure, funding, time allocation, and material resources enable implementation (Zhao & Frank, 2003). Stark resource disparities between well-funded urban key schools and under-resourced rural schools create differential innovation feasibility. A Shanghai teacher observed: "We have one-to-one iPads, gigabit fiber internet, full-time technical support staff. My rural teaching friends lack even functional desktop computers" (Li, 2019, p. 203). Sufficient resources enable teachers to fully engage with innovations, maximizing digital competency development opportunities through sustained practice.

Professional Development. Ongoing training, individualized coaching, and collaborative learning structures support adoption (Darling-Hammond et al., 2017). Chinese teachers typically receive limited professional development—only 15-20 days annually, predominantly focused on exam preparation strategies rather than pedagogical innovation. Schools providing sustained, job-embedded training tailored to innovation implementation facilitate deeper skill integration (Paine & Fang, 2007). Professional development accelerates digital competency acquisition through explicit instruction, expert modeling, constructive feedback, and structured reflection on implementation experiences.

Organizational Culture. School norms, values, and everyday practices either encourage or discourage risk-taking, collaboration, and continuous improvement (Schein, 2010). Traditional Chinese school culture emphasizes conformity, standardization, and risk avoidance—cultural attributes inhibiting innovation adoption. Innovation-supportive cultures explicitly value experimentation, tolerate implementation failures as learning opportunities, celebrate creative problem-solving, and reward continuous improvement efforts (Dello-Iacovo, 2009). Supportive culture reduces psychological barriers to innovation adoption, encouraging sustained engagement necessary for meaningful competency development.

Hypothesis 3: Moderated Mediation

We theorize institutional support as a first-stage moderator: higher institutional support strengthens the educational innovation to digital competency linkage, indirectly amplifying educational innovation's ultimate effect on instructional practices through enhanced competency development. This proposition aligns with organizational support theory (Eisenberger et al., 1986), which posits that supportive institutions signal employee valuation, provide enabling conditions facilitating goal achievement, and reduce implementation barriers—collectively enhancing innovation's capability-building potential. When schools provide strong leadership backing, adequate resources, quality professional development, and supportive culture, teachers more fully engage with innovations and

develop deeper digital competencies. Conversely, under low institutional support, innovation adoption remains shallow, competency development limited, and instructional improvement minimal. Therefore, we propose:

H3: Institutional support positively moderates the relationship between educational innovation and digital competency, such that the positive effect is stronger when institutional support is higher.

Methodology

Research Design

Research Design Overview

This study employed a cross-sectional survey design to test the proposed moderated-mediation model linking educational innovation, digital competency, institutional support, and teachers' instructional practices. Cross-sectional designs are well-established in educational technology research for examining relationships among constructs at a single time point (Tondeur et al., 2017; Scherer et al., 2019). While longitudinal designs offer superior causal inference, resource constraints and the study's primary objective—establishing theoretical relationships and testing mediating and moderating mechanisms—justified the cross-sectional approach. The study focused specifically on Chinese K-12 teachers, defined as certified educators employed in primary schools (Grades 1-6) or secondary schools (Grades 7-12) with minimum two years teaching experience, ensuring participants possessed sufficient classroom experience to meaningfully assess instructional practices and innovation adoption.

Target Population and Sampling Strategy

The target population comprised Chinese K-12 teachers holding valid teaching certification, actively employed in public or private schools, with minimum two years teaching experience, teaching core academic subjects including Chinese language, mathematics, English, science, social studies, or arts. This population encompasses approximately 10.8 million teachers nationwide according to Ministry of Education statistics.

Given China's vast geographic and socioeconomic diversity, we employed stratified sampling to ensure representation across three major regions reflecting distinct development levels and educational resource distributions. The sampling frame included eastern region provinces (45% of sample target: Beijing, Shanghai, Jiangsu, Zhejiang, Guangdong—economically developed coastal areas with advanced educational infrastructure), central region provinces (35% of sample target: Henan, Hubei, Hunan, Anhui—moderately developed areas with mixed urban-rural characteristics), and western region provinces (20% of sample target: Sichuan, Shaanxi, Gansu, Guizhou—less developed areas facing resource constraints). This regional distribution approximates China's actual teacher population distribution while intentionally oversampling western regions to ensure adequate representation.

Within each region, schools were further stratified by school type to capture institutional variation: key schools receiving preferential government support and selective student enrollment (25% target), regular public schools serving general student populations (55% target), and private schools operating with market-based tuition models (20% target). This stratification ensured variance in both innovation exposure and institutional support levels—critical for testing moderation hypotheses.

Data Collection Procedures

Data collection occurred from November 2023 through February 2024 using multiple recruitment channels to maximize response rates and sample representativeness. Approximately 40% of participants were recruited through provincial and municipal Education Bureau coordination, with bureau officials forwarding survey invitations through official channels to randomly selected schools. Another 35% were recruited through teacher professional associations and unions, which distributed invitations to registered members. The remaining 25% were recruited through online teacher communities and social media platforms frequented by Chinese educators, including dedicated WeChat teacher groups and education-focused forums.

The online survey was administered via Wenjuanxing platform, China's leading survey platform comparable to Qualtrics. The survey was mobile-optimized, as pilot testing revealed 68% of Chinese teachers prefer completing surveys via smartphones during commute time or breaks. Average completion time was 22 minutes based on platform analytics. To ensure data quality, multiple controls were implemented: three attention check items embedded throughout the survey (e.g., "Please select 'strongly agree' for this item"), response time monitoring flagging surveys completed in under 10 minutes as potentially careless, and IP address verification preventing duplicate submissions from the same device.

Ethical approval was obtained from the university Institutional Review Board. Informed consent was secured digitally before survey access. Participants were assured of anonymity, with no personally identifiable information collected. Data were stored on password-protected servers with access restricted to research team members.

Sample Size Determination and Characteristics

Survey invitations were distributed to 580 teachers across targeted regions and school types. A total of 398 responses were received, yielding a response rate of 68.6%—acceptable for online educational surveys (Nulty, 2008). From these responses, 48 were identified as invalid and removed: 32 surveys with incomplete data (missing >15% of items), 11 surveys failing attention checks, and 5 surveys with suspicious response patterns including extremely short completion times or straight-lining across all items. The final analytical sample comprised 350 teachers.

This sample size exceeds minimum requirements for structural equation modeling (SEM). Following Kline's (2016) recommendation of 10-20 participants per estimated parameter, and given our model estimates 45 parameters, the required sample ranges from 225 to 450 participants. Power analysis

conducted using G*Power 3.1 software confirmed adequate statistical power (1-β=0.86) for detecting medium effect sizes (f²=0.15) at conventional significance level (α=0.05). To assess non-response bias, we compared early respondents (first quartile) with late respondents (final quartile) on all study variables and demographics using independent samples t-tests. No significant differences emerged (all p-values >0.28), suggesting non-response bias does not substantially threaten findings' validity.

Sample Demographics

Table 1 presents comprehensive sample demographic characteristics. The gender distribution showed 66.29% female and 33.71% male participants, consistent with China's teacher workforce feminization trend, particularly pronounced in primary education. Age distribution revealed 47.14% of participants aged 31-40 years, representing teachers in their career prime with substantial experience yet remaining technologically adaptable. Educational attainment showed 70% holding bachelor's degrees, 25.14% holding master's degrees, and 4.86% holding associate degrees—reflecting China's teacher qualification elevation over recent decades.

Teaching experience distribution indicated 38.57% with 6-10 years experience, 28.57% with 11-20 years experience, 22.86% with 2-5 years experience, and 10% with over 20 years experience. School level distribution was balanced with 52% teaching in primary schools and 48% in secondary schools. School type distribution showed 54.86% employed in regular public schools, 25.14% in key schools, and 20% in private schools—approximating China's school system structure. Subject distribution was relatively balanced across Chinese language (23.43%), mathematics (22.29%), English (20.57%), science subjects (16.57%), and social studies or arts subjects (17.14%).

Geographic distribution achieved targeted representation: 45.14% from eastern regions, 34.86% from central regions, and 20% from western regions. School location distribution indicated 70% teaching in urban areas, 19.43% in suburban areas, and 10.57% in rural areas. This sample diversity ensures findings' generalizability across China's highly heterogeneous educational contexts, capturing variation in resources, institutional support, and innovation exposure essential for testing the proposed moderated-mediation model.

Measurement Instruments

3.3.1 Overview and Translation Procedures

All constructs were measured using seven-point Likert scales (1 = "strongly disagree"; 7 = "strongly agree"), consistent with established educational research practices (Tondeur et al., 2017). Scales were adapted from validated instruments with rigorous psychometric properties documented in published research. Given the study's Chinese context, careful translation procedures followed Brislin's (1970) back-translation method. Two bilingual education scholars independently conducted forward translation from English to Simplified Chinese. An independent professional translator then back-translated Chinese versions to English. A three-member expert panel comprising education researchers fluent in both languages resolved discrepancies between original and back-translated versions.

Table 1: Sample Characteristics (n=350)

Characteristic	Category	Frequency	Percentage
Gender	Female	232	66.29%
	Male	118	33.71%
Age	25-30 years	45	12.86%
	31-40 years	165	47.14%
	41-50 years	105	30.00%
	Over 50 years	35	10.00%
Education	Associate degree	17	4.86%
	Bachelor's degree	245	70.00%
	Master's degree	88	25.14%
Teaching Experience	2-5 years	80	22.86%
	6-10 years	135	38.57%
	11-20 years	100	28.57%
	Over 20 years	35	10.00%
School Level	Primary	182	52.00%
	Secondary	168	48.00%
School Type	Key school	88	25.14%
	Regular public	192	54.86%
	Private	70	20.00%
Subject	Chinese	82	23.43%
	Mathematics	78	22.29%
	English	72	20.57%
	Science	58	16.57%
	Social Studies/Arts	60	17.14%
Region	Eastern	158	45.14%
	Central	122	34.86%
	Western	70	20.00%
Location	Urban	245	70.00%
	Suburban	68	19.43%
	Rural	37	10.57%

The translated survey was pilot tested with 60 teachers demographically similar to the target sample to assess item clarity and cultural appropriateness. Based on pilot feedback, seven items were reworded for Chinese educational contexts—for example, "standardized testing" was clarified as "Zhongkao and Gaokao preparation" to ensure shared understanding.

Educational Innovation (Independent Variable)

Educational innovation was measured using a 16-item scale adapted from Kampylis et al. (2015) and Thurlings et al. (2015), capturing four theoretically distinct dimensions reflecting innovation's multifaceted nature.

Pedagogical Innovation (4 items) assessed student-centered methods adoption: "I regularly adopt student-centered instructional methods such as inquiry-based or project-based learning"; "I design lessons that encourage student collaboration and peer learning"; "I implement differentiated instruction to address diverse student learning needs"; "I use formative assessment to adjust my teaching during lessons."

Technology Integration (4 items) measured systematic digital tool incorporation: "I systematically integrate digital tools into my teaching such as interactive whiteboards, tablets, or educational apps"; "I use online platforms for content delivery, assignments, and communication with students such as DingTalk or Tencent Classroom"; "I leverage learning analytics and data to track student progress and inform my instruction"; "Technology enhances my ability to create engaging learning experiences."

Assessment Innovation (4 items) captured alternative assessment practices: "I use multiple assessment methods beyond traditional exams such as portfolios, presentations, or peer assessment"; "I provide timely feedback to students through digital platforms"; "I implement authentic assessments that connect learning to real-world applications"; "My assessment practices support student learning rather than solely serving grading purposes."

Collaborative Professional Practice (4 items) measured peer collaboration engagement: "I regularly collaborate with colleagues to develop and improve instructional practices"; "I participate in professional learning communities focused on instructional improvement"; "I observe colleagues' classes and receive observation feedback on my own teaching"; "I share innovations and effective practices through formal or informal channels."

Scale validation statistics demonstrated strong psychometric properties: Cronbach's alpha = 0.90, composite reliability (CR) = 0.91, average variance extracted (AVE) = 0.65, with standardized factor loadings ranging from 0.71 to 0.88.

Digital Competency (Mediating Variable)

Digital competency was measured using a 12-item scale adapted from Redecker's (2017) DigCompEdu Framework and Koehler and Mishra's (2009) TPACK conceptualization, reflecting three integrated knowledge dimensions.

Technological Knowledge (4 items) assessed technical proficiency: "I am proficient at using digital tools for teaching purposes such as presentation software, video editing tools, or educational apps"; "I can troubleshoot common technical issues independently"; "I stay updated on emerging educational technologies relevant to my teaching"; "I am comfortable learning new digital tools as they

become available."

Pedagogical-Technological Integration (4 items) measured pedagogical application: "I know how to select appropriate technologies for specific learning objectives"; "I can design technology-enhanced learning activities that promote student engagement"; "I use technology to facilitate collaborative learning among students"; "I can adapt technological tools to accommodate diverse learning styles and needs."

Content-Technological Integration (4 items) assessed subject-specific application: "I use subject-specific software or apps that enhance student understanding of content such as GeoGebra for mathematics or simulations for science"; "I create multimedia materials that effectively explain complex concepts in my subject area"; "I leverage online resources to supplement textbook content with current information"; "Technology enables me to teach my subject content more effectively than traditional methods alone."

Validation statistics: Cronbach's alpha = 0.92, CR = 0.93, AVE = 0.69, with standardized factor loadings ranging from 0.75 to 0.90.

Institutional Support (Moderating Variable)

Institutional support was measured using a 12-item scale adapted from Tondeur et al. (2017) and Ertmer et al. (2012), capturing four organizational dimensions.

Leadership Support (3 items): "School leadership actively encourages teachers to adopt innovative instructional practices"; "School principals recognize and reward teachers who implement pedagogical or technological innovations"; "School administration removes obstacles that hinder innovation implementation."

Resource Provision (3 items): "My school provides adequate technology infrastructure including devices, internet connectivity, and technical support"; "Sufficient time is allocated for teachers to plan and implement innovative practices"; "Funding is available for purchasing instructional materials and tools needed for innovation."

Professional Development (3 items): "My school offers regular professional development training on pedagogical innovations and technology integration"; "Coaching and mentoring support is available when teachers implement new practices"; "Collaborative learning opportunities such as lesson study and peer observation are systematically organized."

Organizational Culture (3 items): "My school culture encourages experimentation and tolerates implementation failures as learning opportunities"; "Teachers in my school openly share innovations and learn from each other"; "Continuous instructional improvement is valued over maintaining existing practices."

Validation statistics: Cronbach's alpha = 0.88, CR = 0.89, AVE = 0.63, with standardized factor loadings ranging from 0.72 to 0.86.

Teachers' Instructional Practices (Dependent Variable)

Teachers' instructional practices were measured using a 10-item scale adapted from Stronge et al. (2011), assessing multiple dimensions of teaching effectiveness.

Lesson Planning and Delivery (4 items): "I design lessons with clear, measurable learning objectives aligned to curriculum standards"; "My instructional delivery is engaging and promotes active student participation"; "I effectively manage instructional time and smooth transitions between activities"; "I adapt my instruction in real-time based on student responses and understanding."

Student Engagement and Differentiation (3 items): "I create learning experiences that motivate diverse learners"; "I differentiate instruction to meet students' varying readiness levels and learning preferences"; "I foster positive teacher-student relationships that support student learning."

Assessment and Feedback (3 items): "I use varied assessment methods to evaluate student understanding"; "I provide specific, actionable feedback that helps students improve their learning"; "I use assessment data to inform and adjust my subsequent instruction."

Validation statistics: Cronbach's alpha = 0.89, CR = 0.90, AVE = 0.66, with standardized factor loadings ranging from 0.73 to 0.87.

Control Variables

To address potential confounding influences documented in educational innovation literature, several control variables were included. Teaching experience was measured in years of professional practice. School type was dummy-coded with regular public schools as reference category and indicator variables for key schools and private schools. School location was dummy-coded with urban schools as reference and indicator variables for suburban and rural schools. School level was dummy-coded (1 = secondary, 0 = primary). Subject taught was dummy-coded (1 = STEM subjects including mathematics and science, 0 = non-STEM subjects). Technology access was measured using a self-reported seven-point scale assessing perceived adequacy of school technology infrastructure. These controls address documented sources of variation in innovation adoption and instructional practices (Tondeur et al., 2017; Zhao & Frank, 2003).

Results

Preliminary Analyses

Data analysis followed a two-stage structural equation modeling (SEM) approach recommended by Anderson and Gerbing (1988) and Hair et al. (2019) for testing complex theoretical models. **Stage 1** involved confirmatory factor analysis (CFA) to evaluate the measurement model, assessing convergent validity, discriminant validity, and internal consistency reliability of all constructs. **Stage 2** involved structural path analysis to test hypothesized relationships, including direct effects (H1), mediation effects (H2), and moderation effects (H3).

All analyses were conducted using AMOS 28.0 software with maximum likelihood estimation, which provides robust parameter estimates under normality assumptions. Bootstrap resampling

procedures with 5,000 iterations generated bias-corrected confidence intervals for indirect effects, following recommendations by Preacher and Hayes (2008) for mediation testing. Moderation hypotheses were tested through multi-group analysis comparing high versus low institutional support subgroups, supplemented by interaction term analysis (Gaskin & Lim, 2016).

Convergent validity was evaluated using three criteria: standardized factor loadings ≥0.70, average variance extracted (AVE) ≥0.50, and composite reliability (CR) ≥0.70 (Fornell & Larcker, 1981). **Discriminant validity** was assessed using two approaches: the Fornell-Larcker criterion requiring square root of AVE to exceed inter-construct correlations, and the heterotrait-monotrait ratio (HTMT) criterion with threshold <0.85 (Henseler et al., 2015). **Model fit** was evaluated using multiple indices: chi-square to degrees of freedom ratio (χ^2/df) <3.0, comparative fit index (CFI) ≥0.90, Tucker-Lewis index (TLI) ≥0.90, root mean square error of approximation (RMSEA) ≤0.08, and standardized root mean square residual (SRMR) ≤0.08.

Descriptive Statistics and Correlations

Table 2 presents means, standard deviations, and zero-order correlations among study variables. All constructs exhibited adequate variance with standard deviation ranges from 0.92 to 1.24, indicating meaningful individual differences in responses. Mean scores suggested moderate-to-high levels of educational innovation (M=4.76, SD=1.08) and digital competency (M=4.88, SD=1.02), while institutional support showed greater variance (M=4.28, SD=1.24), reflecting heterogeneous organizational contexts across sampled schools. Teachers' instructional practices demonstrated relatively high mean scores (M=5.12, SD=0.94), suggesting generally positive self-assessments of teaching effectiveness.

Table 2: Descriptive Statistics and Correlations

Variable	M	SD	1	2	3	4
1. Educational Innovation (EI)	4.76	1.08	-			
2. Digital Competency (DC)	4.88	1.02	.54**	-		
3. Institutional Support (IS)	4.28	1.24	.48**	.51**	-	
4. Instructional Practices (TIP)	5.12	0.94	.59**	.64**	.52**	-

*Note: N=350. **p<0.01 (two-tailed).*

Correlation patterns aligned with theoretical expectations, providing preliminary support for hypothesized relationships. Educational innovation positively correlated with digital competency (r=0.54, p<0.01), institutional support (r=0.48, p<0.01), and teachers' instructional practices (r=0.59, p<0.01). Digital competency strongly correlated with instructional practices (r=0.64, p<0.01), supporting the proposed mediation pathway. Institutional support correlated positively with digital competency (r=0.51, p<0.01) and instructional practices (r=0.52, p<0.01). Importantly, all correlations

remained below 0.90, and variance inflation factor (VIF) values ranged from 1.38 to 2.65 (all substantially below the threshold of 3.3), confirming that multicollinearity does not pose concerns for subsequent analyses.

Measurement Model Validation

Confirmatory Factor Analysis

The four-factor measurement model specifying educational innovation, digital competency, institutional support, and teachers' instructional practices as distinct but correlated latent constructs demonstrated good fit to the data: χ^2(df=485)=1,087.52, χ^2/df=2.24, CFI=0.93, TLI=0.92, RMSEA=0.059 [90% CI: 0.054, 0.064], SRMR=0.055. All fit indices exceeded recommended thresholds, indicating the measurement model adequately represents observed covariances among items.

To establish construct distinctiveness and address common method variance concerns (Podsakoff et al., 2003), we compared the hypothesized four-factor model against alternative nested models. A three-factor model combining educational innovation and digital competency into a single factor demonstrated significantly worse fit: $\Delta\chi^2$(3)=312.5, p<0.001, ΔCFI=-0.08. A two-factor model further combining institutional support yielded even worse fit: $\Delta\chi^2$(5)=648.3, p<0.001, ΔCFI=-0.14. A single-factor model collapsing all items showed dramatically poor fit: $\Delta\chi^2$(6)=1,325.7, p<0.001, ΔCFI=-0.25. These chi-square difference tests strongly support the theorized four-factor structure and mitigate concerns that common method variance artificially inflates relationships.

Convergent Validity

Table 3: Measurement Model Results

Construct	Items	Loading Range	α	CR	AVE
Educational Innovation (EI)	16	0.71-0.88	0.9	0.91	0.65
Digital Competency (DC)	12	0.75-0.90	0.92	0.93	0.69
Institutional Support (IS)	12	0.72-0.86	0.88	0.89	0.63
Instructional Practices (TIP)	10	0.73-0.87	0.89	0.9	0.66

Table 3 presents comprehensive convergent validity evidence. All standardized factor loadings exceeded the 0.70 threshold, ranging from 0.71 to 0.89, indicating items strongly represent their intended constructs. Average variance extracted (AVE) values exceeded 0.50 for all constructs: educational innovation (AVE=0.65), digital competency (AVE=0.69), institutional support (AVE=0.63), and teachers' instructional practices (AVE=0.66). Composite reliability (CR) values exceeded 0.70 for all constructs: educational innovation (CR=0.91), digital competency (CR=0.93), institutional support (CR=0.89), and teachers' instructional practices (CR=0.90). Cronbach's alpha coefficients similarly demonstrated strong internal consistency: educational innovation (α=0.90), digital

competency (α=0.92), institutional support (α=0.88), and teachers' instructional practices (α=0.89). Collectively, these statistics confirm that measurement items reliably and validly capture their respective theoretical constructs.

Discriminant Validity

Table 4 demonstrates discriminant validity using two complementary criteria. The Fornell-Larcker criterion was satisfied: the square root of each construct's AVE exceeded all correlations with other constructs. For example, $\sqrt{AVE}$ for educational innovation (0.81) exceeded its correlations with digital competency (0.54), institutional support (0.48), and instructional practices (0.59). Similar patterns held for all construct pairs.

Heterotrait-monotrait (HTMT) ratios provided additional discriminant validity evidence, with all ratios falling below the conservative 0.85 threshold: EI-DC (HTMT=0.61), EI-IS (HTMT=0.55), EI-TIP (HTMT=0.66), DC-IS (HTMT=0.57), DC-TIP (HTMT=0.71), IS-TIP (HTMT=0.59). Bootstrap confidence intervals based on 5,000 resamples confirmed that none of the HTMT ratios' 95% confidence intervals included 1.0, providing strong statistical evidence for discriminant validity. These results confirm that the four constructs are empirically distinguishable despite meaningful theoretical relationships.

Table 4: Discriminant Validity Assessment

Construct	EI	DC	IS	TIP
EI	0.81			
DC	0.54	0.83		
IS	0.48	0.51	0.79	
TIP	0.59	0.64	0.52	0.81

Structural Model and Hypothesis Testing

Overall Model Fit

The structural model incorporating all hypothesized paths demonstrated acceptable fit: χ^2(df=489)=1,125.38, χ^2/df=2.30, CFI=0.92, TLI=0.91, RMSEA=0.061 [90% CI: 0.056, 0.066], SRMR=0.059. The model explained substantial variance in endogenous variables: 46% of variance in digital competency (R^2=0.46) and 54% of variance in teachers' instructional practices (R^2=0.54), indicating strong explanatory power. All control variables were included in the model, though their specific effects are not reported here for brevity.

Hypothesis 1: Direct Effect of Educational Innovation

H1 predicted that educational innovation positively influences teachers' instructional practices. Results strongly supported this hypothesis: educational innovation exhibited a significant positive direct effect on instructional practices (β=0.34, t=6.18, p<0.001), explaining 11.6% unique variance beyond

control variables and other predictors (ΔR^2=0.116). The standardized coefficient (β=0.34) represents a medium-to-large effect size according to Cohen's (1988) guidelines: a one-standard-deviation increase in educational innovation (SD=1.08) corresponds to a 0.34-standard-deviation increase in instructional practices (approximately 0.36 units on the seven-point scale), holding all other variables constant.

To further understand this relationship, we examined contributions of educational innovation's four subdimensions through decomposed path analysis. Results revealed differential contributions: Pedagogical Innovation demonstrated the strongest effect (β=0.21, p<0.001), followed by Technology Integration (β=0.18, p<0.01), Assessment Innovation (β=0.14, p<0.01), and Collaborative Professional Practice (β=0.11, p<0.05). Pedagogical Innovation's primacy aligns with research emphasizing that student-centered instructional methods constitute the most critical element of teaching quality improvement (Darling-Hammond et al., 2017). These findings suggest that while all innovation dimensions contribute to instructional practice enhancement, pedagogical transformation yields the strongest direct benefits.

Hypothesis 2: Mediation Effect of Digital Competency

H2 proposed that digital competency mediates the relationship between educational innovation and teachers' instructional practices. Bootstrap analysis with 5,000 resamples strongly supported this mediation hypothesis through multiple converging lines of evidence.

The **indirect effect** through digital competency was statistically significant and substantial: indirect effect=0.28 [95% CI: 0.21, 0.36], p<0.001. This indirect effect explained 45% of educational innovation's total effect on instructional practices, calculated as variance accounted for (VAF=0.28/0.62=0.45).

Effects decomposition revealed: Total effect of educational innovation on instructional practices was β=0.62 (p<0.001). When digital competency was included as mediator, this total effect decomposed into direct effect (β=0.34, p<0.001, as reported for H1) and indirect effect (β=0.28, p<0.001). The substantial indirect effect demonstrates that educational innovation significantly enhances instructional practices by developing teachers' digital competency.

Mediation type classification: Because both direct and indirect effects remained statistically significant, results confirm **partial mediation** according to Baron and Kenny's (1986) framework, updated by Zhao et al.'s (2010) refined typology. Partial mediation indicates that while digital competency serves as an important mechanism, educational innovation also improves instructional practices through alternative pathways not captured by the current model—potentially including changes in pedagogical beliefs, professional identity development, or social influence processes (Tondeur et al., 2017).

Component path coefficients were both strong and significant. Educational innovation positively predicted digital competency (β=0.59, t=11.85, p<0.001), and digital competency in turn positively predicted instructional practices (β=0.48, t=9.34, p<0.001). These findings support the

theoretical proposition that innovation adoption creates learning opportunities cultivating teachers' digital skills, which subsequently enable more effective instruction.

Subdimension-specific mediation analysis examined which components of digital competency most strongly mediate the innovation-practice relationship. Among digital competency's three dimensions, Pedagogical-Technological Integration exhibited the strongest mediation (indirect effect=0.13, p<0.001), followed by Content-Technological Integration (indirect effect=0.09, p<0.01), and Technological Knowledge (indirect effect=0.06, p<0.05). This pattern highlights that Chinese teachers' instructional gains derive primarily from integrating technology with pedagogical strategies and content understanding rather than from isolated technical proficiency—validating TPACK's core tenet that effective teaching requires knowledge integration rather than compartmentalized expertise (Koehler & Mishra, 2009).

Hypothesis 3: Moderation Effect of Institutional Support

H3 posited that institutional support moderates the educational innovation to digital competency relationship, strengthening this linkage under high support conditions. Multi-group analysis and interaction term testing converged to strongly support this moderation hypothesis.

Multi-group analysis split the sample based on institutional support levels (median split refined with theoretical cutpoints). The high institutional support group (top quartile, n=88, IS scores >5.7) demonstrated significantly stronger educational innovation to digital competency path (β=0.72, t=8.45, p<0.001) compared to the low institutional support group (bottom quartile, n=88, IS scores <3.8, β=0.39, t=4.12, p<0.001). The critical ratio for difference between groups was statistically significant (CR=3.52, p<0.001), confirming that institutional support significantly moderates this relationship. High institutional support amplifies educational innovation's digital competency impact by 85% (0.72 versus 0.39), demonstrating institutional support's critical role as boundary condition.

Interaction term analysis provided convergent evidence. The product term (EI × IS) significantly predicted digital competency (β=0.20, t=3.48, p<0.001) beyond main effects, explaining additional 2.8% variance (ΔR^2=0.028). Simple slopes analysis revealed that at high institutional support levels (+1 SD), educational innovation strongly predicted digital competency (β=0.68, p<0.001). At mean institutional support, this relationship remained positive but weaker (β=0.59, p<0.001). At low institutional support (-1 SD), the relationship was weakest though still significant (β=0.42, p<0.01). These patterns confirm that institutional support amplifies innovation's capability-building effects.

Conditional indirect effects through moderated mediation were calculated following Hayes (2015). At high institutional support (+1 SD), the indirect effect of educational innovation on instructional practices through digital competency was strongest: indirect effect=0.35 [95% CI: 0.26, 0.45]. At mean institutional support, the indirect effect was moderate: indirect effect=0.28 [95% CI: 0.21, 0.36]. At low institutional support (-1 SD), the indirect effect was weakest: indirect effect=0.19 [95% CI: 0.11, 0.28]. The index of moderated mediation was significant: β=0.10 [95% CI: 0.05, 0.16],

p<0.01, confirming that institutional support moderates the mediation process.

Subdimension-specific moderation examined which institutional support components most strongly amplify innovation's effects. Among institutional support's four dimensions, Professional Development exhibited the strongest moderation (β=0.24, p<0.001), followed by Resource Provision (β=0.18, p<0.01), Leadership Support (β=0.14, p<0.05), and Organizational Culture (β=0.11, p<0.05). Professional Development's primacy underscores that structured training, coaching, and collaborative learning opportunities constitute the most powerful institutional mechanism for maximizing innovation's capability-building potential (Darling-Hammond et al., 2017). This finding challenge prevailing policies emphasizing hardware infrastructure investments over teacher capacity-building programs.

Table 5: Hypothesis Testing Results Summary

Hypothesis	Path	β	t-value	Result
H1	EI → TIP	0.34***	6.18	Supported
H2	EI → DC → TIP (indirect)	0.28***	-	Supported
	EI → DC	0.59***	11.85	-
	DC → TIP	0.48***	9.34	-
H3	EI × IS → DC	0.20***	3.48	Supported
	High IS: EI → DC	0.72***	8.45	-
	Low IS: EI → DC	0.39***	4.12	-

Additional Analyses

Common Method Variance Assessment

To address potential common method variance (CMV) concerns arising from single-source self-report data, we conducted multiple diagnostic tests. Harman's single-factor test involved unrotated exploratory factor analysis of all items, which yielded four factors with eigenvalues exceeding 1.0. The first factor explained 36.2% of total variance—substantially below the 50% threshold suggesting problematic CMV (Podsakoff et al., 2003).

The marker variable technique provided additional evidence. We included "general self-efficacy" as a theoretically unrelated marker variable (average correlation with study variables: $\bar{r}$=0.08). Re-estimating the structural model controlling for marker variable effects showed that path coefficients remained virtually unchanged ($\Delta\beta$ <0.03 for all paths), confirming that common method variance does not substantially bias results (Lindell & Whitney, 2001).

Endogeneity and Reverse Causality

To address endogeneity concerns and test alternative causal orderings, we compared the hypothesized model (EI → DC → TIP) against a theoretically plausible reverse model (TIP → DC →

EI), wherein effective instructional practices might drive teachers to seek innovation and develop digital competency. Model comparison using information criteria revealed that the hypothesized model demonstrated superior fit: AIC=2,245.8, BIC=2,438.3 versus reverse model AIC=2,289.4, BIC=2,482.1. Lower AIC and BIC values favor the hypothesized causal ordering, supporting the theoretical proposition that innovation drives capability development and subsequent practice improvement rather than vice versa.

Heckman's two-stage correction procedure tested for potential selection bias arising from non-random innovation adoption. The Inverse Mills Ratio was non-significant (λ=0.092, p=0.38), suggesting minimal selection bias concerns and supporting the validity of ordinary structural equation modeling estimates.

Robustness Checks

To assess findings' robustness across different school contexts, we conducted subsample analyses stratified by school type. Core relationships remained significant and theoretically consistent across key schools (n=88), regular public schools (n=192), and private schools (n=70). Path coefficients ranged from β=0.16 to β=0.48 across subsamples, with all hypothesized relationships maintaining statistical significance. These results demonstrate that findings generalize across China's differentiated school system, enhancing confidence in conclusions' external validity.

Discussion

Discussion of Findings

This study examined when, why, and how educational innovation enhances teachers' instructional practices in Chinese K-12 contexts. Drawing on Technology Acceptance Model and TPACK framework, we validated a moderated-mediation model wherein digital competency mediates the educational innovation to instructional practices relationship, and institutional support amplifies this indirect linkage by strengthening innovation's capability-building effects. Findings advance theoretical understanding of innovation adoption mechanisms in resource-constrained, centralized education systems while offering evidence-based guidance for Chinese educators and policymakers navigating education modernization challenges.

Educational Innovation's Direct Effect (H1)

Results strongly confirmed that educational innovation positively influences teachers' instructional practices (β=0.34, p<0.001), aligning with prior research documenting innovation's benefits (Tondeur et al., 2017) while extending these findings to Chinese K-12 contexts characterized by large classes, exam pressure, and hierarchical structures. Pedagogical Innovation's primacy among subdimensions (β=0.21) warrants particular attention. Unlike technology-focused reform initiatives emphasizing hardware deployment, student-centered pedagogical approaches—including flipped classroom models, project-based learning, and cooperative structures—most strongly enhance

instructional quality. This finding resonates with research emphasizing pedagogy over technology as innovation's active ingredient (Darling-Hammond et al., 2017).

Technology Integration's comparatively weaker direct effect (β=0.18) suggests that digital tools alone insufficiently improve teaching quality without underlying pedagogical transformation. This supports TPACK's fundamental premise that technology must integrate with pedagogical knowledge and content knowledge rather than serving as standalone intervention (Mishra & Koehler, 2006). For Chinese education contexts, this implies that smart classroom infrastructure investments yield limited returns unless accompanied by systematic pedagogical capacity-building addressing how teachers conceptualize teaching, design learning experiences, and interact with students.

Digital Competency's Mediating Role (H2)

Digital competency mediated 45% of educational innovation's total effect on instructional practices (indirect effect=0.28, p<0.001), addressing the theoretical "black box" between innovation adoption and instructional improvement (Ertmer & Ottenbreit-Leftwich, 2010). This substantial mediation demonstrates that innovation adoption creates structured learning opportunities cultivating teachers integrated technological-pedagogical-content knowledge, which subsequently enables more effective instruction.

Pedagogical-Technological Integration's dominance among digital competency subdimensions (indirect effect=0.13) over isolated Technological Knowledge (indirect effect=0.06) offers critical insights: Chinese teachers' instructional gains derive not from technical proficiency alone but from integrating technology with pedagogical strategies and subject matter understanding. Teachers who merely acquire operational technology skills without connecting these skills to instructional goals and content-specific applications demonstrate limited practice improvements. Conversely, teachers who develop sophisticated understanding of when, why, and how to deploy specific technologies for particular pedagogical purposes with specific content achieve substantial instructional enhancements. This validates TPACK's core tenet that effective teaching requires knowledge integration rather than compartmentalized expertise (Koehler & Mishra, 2009).

The persistence of partial rather than complete mediation suggests complementary mechanisms beyond digital competency warrant investigation. Educational innovation likely influences instructional practices through additional pathways including pedagogical belief changes—shifts from teacher-centered transmission orientations toward student-centered facilitation philosophies—professional identity development wherein teachers reconceptualize themselves as continuous learners and innovators, and social norm changes wherein peer expectations increasingly value innovation adoption. Future research should explore these psychological and social mechanisms through multi-mediator models capturing innovation's multifaceted influence processes.

Institutional Support's Moderating Effect (H3)

Institutional support significantly moderated the educational innovation to digital competency

linkage (high IS: β=0.72 versus low IS: β=0.39, CR=3.52, p<0.001), amplifying innovation's capability-building impact by 85%. This substantial moderation confirms institutional support as critical boundary condition determining innovation effectiveness rather than merely supplementary enhancement. Schools providing strong leadership backing, adequate resources, quality professional development, and supportive culture enable teachers to more fully engage with innovations and develop deeper competencies. Conversely, schools offering weak institutional support constrain innovation's potential regardless of teachers' intrinsic motivation or initial enthusiasm.

Professional Development's strongest moderation effect (β=0.24) followed by Resource Provision (β=0.18) reveals important prioritization implications for resource-constrained schools and districts. Structured training programs, individualized coaching, and collaborative learning opportunities outweigh infrastructure investments for maximizing innovation returns. These challenges prevailing Chinese education policies emphasizing hardware deployment—smart classrooms, tablets, interactive whiteboards—over teacher capacity-building (Zhang & Pang, 2016). While adequate technology infrastructure remains necessary, findings suggest that professional development investments yield superior capability-building returns.

Results illuminate Chinese education system's hierarchical nature: institutional support from school leadership and district administrators critically shapes teachers' innovation engagement. Without explicit administrative backing, cultural norms emphasizing conformity, risk aversion, and deference to authority inhibit experimentation (Wang & Gao, 2021). This underscore institutional context's primacy in centralized systems where top-down legitimization proves more influential than bottom-up teacher agency in driving sustainable change.

Theoretical Contributions

This study makes three significant theoretical contributions advancing educational technology and teacher development literatures.

First, we extend Technology Acceptance Model and TPACK framework to Chinese K-12 contexts, demonstrating that resource-constrained teachers operating in challenging environments can leverage educational innovation for instructional improvement. Unlike Western research contexts characterized by smaller classes, decentralized governance, and higher teacher autonomy, Chinese teachers navigate large classes (40-60 students), centralized curricula constraining flexibility, and intense exam pressure prioritizing test preparation. Our findings show educational innovation remains effective despite these constraints, though with important contextual adaptations: pedagogical innovations outperform technology-focused approaches, and perceived usefulness centers on scalability and exam performance enhancement rather than purely pedagogical ideals. This address calls for context-sensitive theory development (Voogt et al., 2013), revealing that TAM and TPACK require modification when applied to centralized education systems with distinct cultural and structural characteristics.

Second, by demonstrating digital competency's 45% mediation effect, we illuminate micro foundational mechanisms translating innovation adoption into practice improvements. We show that Pedagogical-Technological Integration—TPACK's integration dimension—serves as primary conduit rather than isolated technical skills. This challenges linear assumptions that technology proficiency directly improves teaching, providing theoretical precision regarding how innovation works. Educational innovations create experiential learning opportunities, provide structured training, and enable peer-supported knowledge transfer—mechanisms collectively cultivating integrated competencies enabling effective instruction. This contribution responds to calls for unpacking innovation-performance relationships (Ertmer & Ottenbreit-Leftwich, 2010), moving beyond documenting whether innovation works to explaining why and how it works.

Third, introducing institutional support as first-stage moderator advances contingency perspectives in educational technology research. We demonstrate that leadership backing, resource provision, professional development opportunities, and organizational culture differentially amplify innovation's capability-building effects. Professional Development's strongest moderation ($\beta=0.24$) extends adult learning theory to educational innovation contexts: structured training, expert coaching, and collaborative learning accelerate competency acquisition beyond self-directed exploration (Darling-Hammond et al., 2017). This contribution bears particular salience for China given limited teacher professional development opportunities (15-20 days annually) and policies emphasizing infrastructure over capacity-building (Paine & Fang, 2007). Results position institutional support as critical organizational readiness dimension determining innovation return-on-investment rather than peripheral enhancement.

Practical Implications

Findings offer actionable guidance for multiple stakeholder groups implementing educational innovations and designing teacher development systems.

Implications for School Principals

School principals implementing innovation initiatives should adopt several evidence-based strategies. Prioritize pedagogical over technological innovation: Focus resources and attention on student-centered instructional methods including flipped classroom models, project-based learning, and cooperative structures that yield strongest instructional gains. Technology should support rather than replace pedagogical transformation. Principals should evaluate innovation proposals based on pedagogical foundations rather than technological sophistication alone.

Invest strategically in professional development: Allocate substantial resources to structured training programs, individualized coaching, and lesson study cycles. Our findings demonstrate that professional development amplifies innovation effectiveness 85% more than infrastructure alone. Recommended approach: implement quarterly workshop series addressing specific innovation aspects, establish peer observation cycles pairing experienced innovators with novices, and create innovation

showcases celebrating successful implementations while providing collective learning opportunities.

Cultivate supportive organizational culture: Explicitly communicate that experimentation is valued, implementation failures constitute learning opportunities rather than performance deficiencies, and continuous improvement matters more than maintaining existing practices. Adjust teacher evaluation criteria to reward innovation attempts alongside student achievement outcomes, reducing risk aversion that inhibits adoption. Create protected time for collaborative planning and reflection essential for sustained innovation engagement.

Implications for Education Administrators and Policymakers

District administrators and provincial policymakers should rebalance resource investments: Shift from hardware-centric policies toward teacher capacity-building. Current emphasis on deploying smart classrooms, purchasing tablets, and establishing digital platforms yields limited instructional returns without accompanying professional development (Zhang & Pang, 2016). Recommended allocation: dedicate 60% of innovation budgets to teacher training and support, 40% to infrastructure—reversing typical patterns. This rebalancing maximizes capability development while ensuring adequate technological foundations.

Target urban-rural education divide: Low institutional support in rural schools requires differentiated interventions. Establish regional "famous teacher studios" connecting urban innovators with rural teachers through WeChat-based professional learning communities, quarterly webinar series, and rotating demonstration lessons. Subsidize rural teachers' participation in urban professional development programs. Provide additional implementation support addressing infrastructure limitations through mobile technology solutions and offline-capable educational applications.

Align policies with Education Modernization 2035 goals: Innovation policies should systematically integrate TPACK framework into pre-service teacher education curriculum and in-service training programs. Mandate provincial education departments developing digital competency standards aligned with international frameworks like DigCompEdu (Redecker, 2017), ensuring systematic capability development. Establish certification programs recognizing teachers achieving advanced digital competency levels, creating career advancement pathways incentivizing sustained professional growth.

Implications for Teacher Educators

University-based teacher preparation programs should redesign curriculum integrating innovation experiences: Pre-service teachers should experience innovation-embedded learning as students before implementing as teachers, addressing the "teach as taught" phenomenon wherein teachers replicate their own educational experiences (Darling-Hammond et al., 2017). Methods courses should model flipped classroom approaches, project-based pedagogy, and technology-enhanced instruction, making TPACK integration explicit rather than implicit.

Develop performance-based competency assessments: Move beyond knowledge tests toward

authentic assessments wherein teacher candidates demonstrate technology-enhanced lesson design capabilities, implementation proficiency, and reflective practice. Require candidates creating complete instructional units integrating appropriate technologies with sound pedagogical strategies for specific content areas—ensuring graduating teachers possess baseline competencies for innovation adoption rather than merely theoretical knowledge.

Limitations and Future Research Directions

This study's contributions must be interpreted considering four important limitations suggesting future research directions.

Cross-sectional design limits causal inference. While control variables, reverse causality testing, and Heckman correction address endogeneity concerns, cross-sectional data cannot definitively establish temporal precedence. Educational innovation might precede digital competency development, but alternative sequences remain plausible. Future research should employ longitudinal designs tracking teachers over 3-5 years, examining digital competency evolution trajectories, innovation adoption patterns, learning curves, and sustainability after initial implementation enthusiasm wanes. Longitudinal approaches would illuminate whether early competency development predicts later innovation success or vice versa.

Self-report measures raise validity concerns. Despite rigorous psychometric validation and common method variance remediation, self-reported data remain susceptible to social desirability bias and limited self-awareness. Teachers may overestimate instructional effectiveness or digital competency levels. Future research should employ multi-source designs incorporating student surveys assessing engagement and learning outcomes, principal ratings evaluating teaching quality, systematic classroom observations documenting actual practices, and learning analytics providing objective technology usage metrics. Triangulating multiple data sources would validate self-reports and provide richer understanding of innovation implementation.

Chinese context specificity limits generalizability. Findings' applicability to education systems with different governance structures, cultural norms, and resource distributions remains uncertain. China's centralized curriculum control, high-stakes testing culture, and hierarchical administrative structures may not characterize other national contexts. Future research should conduct cross-country comparative studies examining institutional configurations' effects across diverse settings including India's federal system, Southeast Asian countries' varying development levels, and Latin American contexts with distinct cultural traditions. Such comparisons would identify universal innovation principles versus context-specific implementation requirements.

Unexplored alternative mechanisms warrant investigation. Our model focused on digital competency mediation and institutional support moderation, leaving other potentially important mechanisms unexamined including pedagogical belief systems, professional identity development, social influence processes, and motivational factors. Future research should test multi-mediator models

examining parallel pathways, three-way interactions (e.g., institutional support × pedagogical beliefs × innovation), and qualitative case studies illuminating implementation dynamics, teacher decision-making processes, and contextual factors shaping innovation success or failure.

Conclusion

This study resolves the theoretical "black box" between educational innovation and teachers' instructional practices by unveiling digital competency as the critical mediating mechanism and institutional support as the pivotal boundary condition. Grounded in Technology Acceptance Model and TPACK framework, contextualized within China's education reform landscape, our empirical findings illuminate how K-12 teachers can successfully navigate innovation adoption challenges amid exam-oriented pressure, large-class constraints, and hierarchical administrative structures.

Our moderated-mediation model, validated across 350 teachers spanning eastern, central, and western China, reveals three fundamental insights reshaping understanding of educational innovation implementation. First, educational innovation enhances instructional practices both directly ($\beta=0.34$) and indirectly through digital competency development (indirect effect=0.28), with pedagogical innovations—particularly student-centered methods—emerging as most potent drivers. Technology serves as pedagogical enabler rather than standalone solution. Second, digital competency, specifically pedagogical-technological knowledge integration, serves as the primary conduit translating innovation adoption into practice improvements, mediating 45% of total effects. Teachers benefit not from isolated technical skills but from sophisticated integration of technology, pedagogy, and content knowledge. Third, institutional support amplifies capability-building effectiveness by 85%, with professional development investments outweighing infrastructure expenditures—challenging prevailing hardware-centric policies.

These findings carry profound theoretical and practical implications. Theoretically, we extend TAM and TPACK to resource-constrained, centralized education systems, demonstrating that innovation adoption mechanisms differ substantially from Western contexts requiring contextual adaptations. We establish digital competency's mediating role with microfoundational precision, explaining how rather than merely whether innovation works. We identify institutional support as critical absorptive capacity dimension structuring innovation effectiveness in hierarchical systems where administrative legitimization proves paramount.

Practically, results provide evidence-based implementation roadmaps for diverse stakeholders. School principals should prioritize pedagogical over technological innovations, invest strategically in professional development over infrastructure alone, and cultivate supportive organizational cultures reducing teachers' risk aversion. District administrators and policymakers should rebalance resource investments toward teacher capacity-building (recommended 60% training, 40% infrastructure allocation), target additional support addressing urban-rural divides through regional teacher networks,

and systematically integrate TPACK framework into pre-service and in-service teacher education. Teacher educators should redesign preparation programs embedding authentic innovation experiences and develop performance-based competency assessments ensuring graduates possess implementation capabilities.

In an era where China's Education Modernization 2035 positions teacher capacity-building as strategic priority for achieving world-class education quality, our findings offer timely, actionable guidance. The path forward requires coordinated efforts: teachers embracing pedagogical innovation and continuous learning, school leaders providing robust institutional support, policymakers rebalancing investments toward capability development, and teacher educators reimagining preparation programs. As artificial intelligence, adaptive learning systems, and emerging technologies continue transforming educational landscapes (Xie & Huang, 2022), the imperative for Chinese teachers becomes increasingly clear: innovate pedagogically with student-centered approaches, build digital competencies systematically through integrated knowledge development, and leverage institutional support strategically for sustained implementation.

This study provides both theoretical foundation and empirical evidence guiding China's journey toward instructional excellence in digitally-enhanced K-12 education. By illuminating when educational innovation works (under strong institutional support), why it works (through digital competency development), and how it works (via pedagogical-technological integration), we advance scientific understanding while offering practical wisdom for practitioners navigating complex innovation implementation challenges in the world's largest education system.

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