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# Developing Information Work Competence of Future Primary Education Teachers: An Integrative Pedagogical Model

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**Abstract :** *The rapid digitalization of educational ecosystems has fundamentally transformed the professional profile of primary school teachers. This study aims to develop, implement, and empirically validate a comprehensive pedagogical model for forming information work competence in pre-service primary education teachers within higher education contexts. A sequential explanatory mixed-methods design was employed over two academic years (2024–2026). The study involved 240 pre-service teachers randomly assigned to experimental (n=120) and control (n=120) groups. A validated Information Competence Assessment Tool (ICAT) was administered, complemented by semi-structured interviews, reflective journals, and classroom observation protocols. The instrument validation process, implementation fidelity metrics, and mixed-methods triangulation provide a replicable framework for Central Asian and similar educational contexts. The experimental group participated in a structured 96-hour integrative intervention spanning six pedagogical modules. Quantitative data were analyzed using ANCOVA, paired/independent t-tests, and effect size calculations. Qualitative data underwent thematic analysis with inter-coder reliability verification. The experimental group demonstrated statistically significant gains across all competence dimensions ( $p < 0.001$ ), with a mean post-test score of 85.4 (SD=6.8) compared to 61.8 (SD=7.2) in the control group ( $\eta^2 = 0.58$ , large effect). Pedagogical integration and critical evaluation showed the highest improvement trajectories. Qualitative analysis revealed four dominant themes: increased pedagogical confidence, development of critical information literacy, enhanced collaborative digital practices, and ethical awareness. The proportion of participants achieving high competence levels rose from 13.3% to 53.3% in the experimental group. This study contributes a contextually adapted, empirically validated model that bridges the persistent gap between technical digital skills and pedagogical application in primary teacher education.*

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## Author Contributions

**Conceptualization:** author 1

**Methodology:** author 1

**Investigation:** author 1

**Writing original draft preparation:** author 1

**Writing review and editing:** author 1

**Visualization:** author 1

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## INTRODUCTION

The contemporary educational landscape is undergoing unprecedented transformation driven by digitalization, artificial intelligence, and the proliferation of networked information ecosystems. Within this paradigm, primary school teachers occupy a uniquely influential position: they serve as the first professional mediators between young learners and digital information environments. The foundational years of schooling critically shape children's information behaviors, digital habits, and epistemological approaches to knowledge construction. Consequently, the preparation of future primary educators must extend beyond subject-matter expertise to encompass robust information work competence—a multidimensional construct integrating technological fluency, critical information literacy, ethical digital citizenship, and pedagogical integration capacity.

Information work competence in teaching contexts has evolved considerably over the past two decades. Early conceptualizations emphasized basic computer literacy and operational software skills. Contemporary frameworks, however, position information competence as a complex, dynamic capability encompassing the identification of information needs, strategic retrieval, critical evaluation, ethical synthesis, creative digital production, and pedagogical contextualization for young learners. This evolution reflects broader shifts in educational policy, notably UNESCO's ICT Competency Framework for Teachers, the European DigCompEdu framework, and national digital education strategies that mandate technology-integrated pedagogy as a core professional standard.

Despite policy advancements and institutional investments, empirical evidence consistently reveals a persistent disconnect between pre-service teachers' personal digital fluency and their professional capacity to integrate information technologies into primary classroom practice. Many future teachers demonstrate adequate technical navigation skills but lack the pedagogical content knowledge (PCK) required to transform digital tools into meaningful learning mediators. This "pedagogical application gap" is particularly acute in primary education, where developmental appropriateness, cognitive scaffolding, and age-specific digital safety considerations demand specialized competence profiles.

The Central Asian region, including Uzbekistan, faces unique challenges in this domain. Rapid curriculum digitalization initiatives, infrastructure modernization, and national teacher certification reforms have outpaced systematic pedagogical preparation in higher education institutions. Pre-service programs often compartmentalize technology courses, isolating digital skills from methodological training and practical teaching experiences. This fragmentation results in graduates who possess isolated technical abilities but lack integrative information competence for authentic primary classroom contexts.

Addressing this gap requires theoretically grounded, empirically validated pedagogical models that systematically develop information competence throughout pre-service education. Such models must account for developmental progression, pedagogical authenticity, ethical dimensions, and contextual adaptability. This study responds to this imperative by designing, implementing, and evaluating a comprehensive information competence development model for future primary school teachers.

## Literature Review

### 1. Theoretical Foundations of Information Competence in Teacher Education

Information competence in educational contexts represents a sophisticated intersection of cognitive, technical, pedagogical, and ethical domains. Contemporary scholarship conceptualizes it through multiple complementary frameworks. The Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006) provides a foundational lens, emphasizing the dynamic integration of technology, pedagogy, and content knowledge. Within TPACK, information competence transcends technological knowledge (TK) to encompass the strategic selection, adaptation, and contextualization of digital resources for specific learning objectives and student developmental stages.

The European DigCompEdu framework (Redecker, 2017) further operationalizes digital competence for educators across six areas: professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence. This framework explicitly positions information management as a cross-cutting competency, requiring educators to locate, evaluate, organize, and ethically deploy digital materials while modeling critical information behaviors for students.

Information literacy scholarship complements these pedagogical frameworks. The ACRL Framework for Information Literacy for Higher Education (2015) articulates six threshold concepts: authority is constructed and contextual, information creation as a process, information has value, research as inquiry, scholarship as conversation, and searching as strategic exploration. When adapted for pre-service teachers, these concepts transform from personal academic skills to professional pedagogical capacities. Future primary teachers must not only navigate information ecosystems for themselves but also scaffold age-appropriate information behaviors, teach source evaluation heuristics, and design learning experiences that cultivate critical digital citizenship in young learners.

The construct of information competence also intersects with media literacy, data literacy, and AI literacy in contemporary educational discourse. As generative AI and algorithmic content curation become ubiquitous, information competence increasingly encompasses the ability to recognize synthetic content, understand algorithmic bias, verify provenance, and ethically integrate AI-generated materials into primary pedagogy. This evolving landscape demands continuous competence development rather than static skill acquisition.

### 2. Empirical Landscape: Global and Regional Perspectives

International research consistently documents variability in pre-service teachers' information competence. Large-scale studies in Europe and North America indicate that while digital natives demonstrate high confidence with consumer technologies, their pedagogical application skills remain underdeveloped (Tondeur et al., 2019). Meta-analyses reveal that traditional standalone technology courses yield limited transfer to classroom practice, whereas integrated, pedagogically contextualized approaches produce significantly higher competence gains (Scherer et al., 2019).

In Central Asian and post-Soviet contexts, teacher education systems historically emphasized subject-matter mastery with limited integration of educational technology. Recent reforms have introduced digital pedagogy components, but implementation remains uneven.

Studies from Kazakhstan, Kyrgyzstan, and Uzbekistan report that pre-service teachers often lack structured opportunities to practice information competence in authentic teaching scenarios (Valikhanova, 2023; Askarova, 2025). Infrastructure limitations, curriculum rigidity, and faculty preparedness gaps further compound these challenges.

Uzbekistan's higher education sector has initiated significant digital transformation through national programs such as "Digital Uzbekistan 2030" and curriculum modernization mandates. Pedagogical universities have introduced ICT courses, digital resource centers, and e-learning platforms. However, empirical assessments reveal fragmented implementation: technology instruction remains isolated from methodological training, assessment focuses predominantly on operational skills, and pedagogical integration receives insufficient emphasis (ICT Competence Formation in Continuous Education, 2023). This misalignment underscores the need for integrative models that systematically develop information competence across theoretical, practical, and ethical dimensions.

### **3. Pedagogical Approaches to Competence Development**

Effective information competence development requires pedagogical architectures that bridge theory and practice. Constructivist approaches emphasize active learning, problem-solving, and authentic task design. Project-based learning (PBL) enables pre-service teachers to design digital educational resources, evaluate information sources, and reflect on pedagogical decisions within realistic constraints (Belland et al., 2017). Collaborative learning environments foster peer knowledge sharing, collective problem-solving, and distributed expertise development.

Flipped classroom models have demonstrated efficacy in optimizing contact time for hands-on digital pedagogy practice while shifting foundational technical instruction to asynchronous formats (Lo & Hew, 2018). Digital portfolio assessment provides longitudinal tracking of competence development, enabling formative feedback and reflective practice. Mentorship models pairing pre-service teachers with experienced digitally competent educators facilitate observational learning, contextual guidance, and professional socialization.

Micro-teaching and simulation-based training offer controlled environments for practicing information competence integration. These approaches allow iterative refinement, immediate feedback, and risk-free experimentation with digital tools before classroom implementation. Research indicates that combining technical instruction with pedagogical modeling, reflective practice, and authentic teaching opportunities yields the most robust competence development (Koh & Chai, 2016).

### **4. Identified Research Gaps**

Despite substantial scholarship, several critical gaps persist:

- a. **Fragmented Conceptualization:** Many studies treat information competence as synonymous with technical skills, neglecting critical evaluation, ethical dimensions, and pedagogical integration.
- b. **Limited Contextualization:** Existing models often derive from Western educational contexts without adaptation to Central Asian curricular structures, resource environments, and cultural pedagogies.

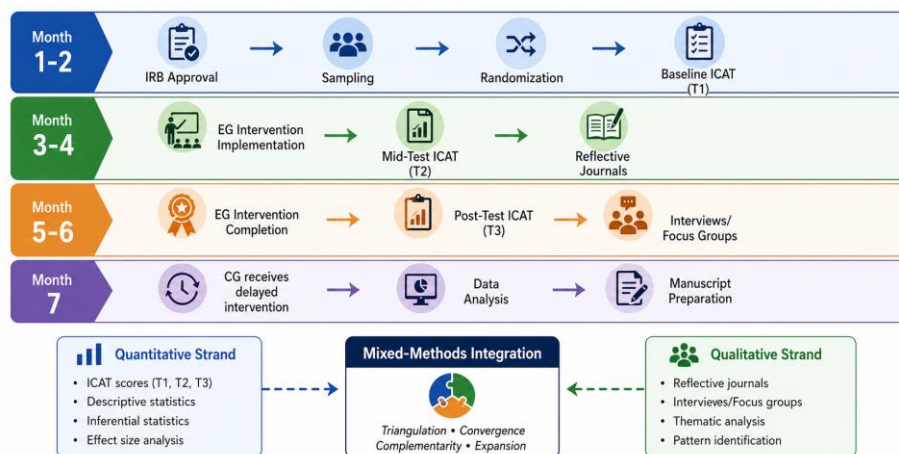
- c. **Assessment Standardization:** Few validated instruments comprehensively measure the multidimensional nature of information competence for primary teacher education contexts.
- d. **Implementation Fidelity:** Research frequently reports outcomes without detailing intervention fidelity, facilitator preparation, or dosage effects, limiting reproducibility.
- e. **Longitudinal Evidence:** Most studies employ cross-sectional or short-term designs, lacking evidence of sustained competence development and professional transfer.

This study addresses these gaps by developing a theoretically grounded, empirically validated, contextually adapted model with rigorous instrument validation, detailed implementation protocols, mixed-methods triangulation, and comprehensive statistical analysis.

## METHODOLOGY

### Research Design

This study employed a sequential explanatory mixed-methods design (Creswell & Plano Clark, 2017) spanning two academic years (September 2024–June 2026). The quantitative phase utilized a quasi-experimental pretest-posttest control group design to measure competence development trajectories. The qualitative phase employed thematic analysis of reflective journals, semi-structured interviews, and focus group discussions to elucidate experiential dimensions, contextual factors, and perceived mechanisms of change. The sequential design enabled quantitative outcomes to be contextualized and explained through qualitative insights, enhancing validity and practical relevance.



**Figure 1.**  
**Research Design and Data Collection Timeline**

### Context and Sampling

The study was conducted across three accredited pedagogical universities in Uzbekistan, selected through purposive sampling to represent diverse institutional profiles (urban, regional, mixed-resource). Eligibility criteria included: (1) enrollment in Bachelor's programs for Primary Education (years 2–4), (2) completion of foundational pedagogy coursework, (3) no prior formal ICT pedagogy certification, and (4) voluntary informed

consent. Exclusion criteria encompassed prior professional teaching experience exceeding one year and concurrent participation in competing digital pedagogy programs.

A priori power analysis (G\*Power 3.1) indicated a required sample of 102 participants per group to detect a medium effect size ( $d=0.50$ ) with  $\alpha=0.05$  and power=0.80. Accounting for anticipated attrition (15%), 240 participants were recruited. Random assignment was conducted using stratified block randomization by university and year of study to ensure baseline equivalence. The final sample comprised 120 experimental group (EG) and 120 control group (CG) participants. Demographic characteristics showed no significant differences between groups ( $p>0.05$ ): mean age 20.3 (SD=1.4), 78.3% female, 21.7% male, 34.2% Year 2, 41.7% Year 3, 24.1% Year 4.

### **Instrument Development and Validation**

The primary quantitative instrument, the Information Competence Assessment Tool (ICAT), was developed through a rigorous multi-stage validation process:

1. Stage 1: Conceptual Mapping and Item Generation: A systematic literature review and expert consultation ( $n=8$ ) informed the initial item pool ( $n=65$ ) across five domains: Information Search & Retrieval, Critical Evaluation, Digital Content Creation, Ethical Use, and Pedagogical Integration. Items employed scenario-based responses, performance tasks, and Likert-scale self-efficacy ratings.
2. Stage 2: Expert Review (Delphi Process): Three rounds of expert review ( $n=12$  specialists in teacher education, educational technology, and psychometrics) assessed content validity, clarity, and relevance. The Content Validity Index (CVI) reached 0.94 at the scale level and 0.87–0.96 at the item level. Ambiguous items were revised or eliminated.
3. Stage 3: Pilot Testing and Psychometric Analysis: The refined instrument ( $n=48$ ) was administered to 150 pre-service teachers not included in the main sample. Exploratory Factor Analysis (EFA) confirmed a five-factor structure explaining 71.3% of variance ( $KMO=0.89$ , Bartlett's  $\chi^2=1842.6$ ,  $p<0.001$ ). Confirmatory Factor Analysis (CFA) on the main sample demonstrated excellent fit:  $\chi^2/df=2.31$ , CFI=0.95, TLI=0.93, RMSEA=0.054, SRMR=0.048. Composite reliability (CR) ranged from 0.82 to 0.89, and Average Variance Extracted (AVE) exceeded 0.50 for all constructs, confirming convergent validity. Discriminant validity was established via Fornell-Larcker criteria. Cronbach's  $\alpha$  for the full scale was 0.91.
4. Scoring Protocol: Each domain comprised 4 performance tasks and 6 scenario-based items. Performance tasks were scored using analytic rubrics (0–4 points per criterion) by trained raters. Scenario items used 4-point Likert scales (1=Strongly Disagree, 4=Strongly Agree). Total possible score: 100 points. Competence levels: Low (0–40), Intermediate (41–70), High (71–100).

### **Intervention Protocol**

The experimental group participated in a 96-hour integrative intervention delivered over one semester (16 weeks, 6 hours/week). The program comprised six modular units (Table 1), designed according to constructivist pedagogy, gradual release of responsibility, and situated learning principles.

**Table 1. Intervention Module Architecture and Instructional Design**

No.	Module Title	Duration	Core Competencies	Pedagogical Strategies	Assessment Methods	Learning Outcomes
1	Information Literacy Fundamentals	16 hours	Identifying information needs, search strategies, database navigation	Guided inquiry, database workshops, scaffolded search exercises	Search log analysis, resource list rubric, peer feedback	Students can identify information needs, conduct efficient searches, and select relevant sources
2	Digital Tools for Primary Education	24 hours	Tool selection, LMS navigation, interactive teaching technologies	Tool exploration labs, micro-teaching simulations, lesson design studios	Integration plan, demonstration rubric, practicum observation	Students can effectively integrate digital tools into primary education lessons
3	Critical Evaluation of Digital Resources	12 hours	Source credibility, bias detection, fact-checking, verification	Case studies, comparative analysis, misinformation analysis	Critical evaluation essay, source audit portfolio	Students can critically evaluate digital information and identify misinformation
4	Educational Content Creation	20 hours	Multimedia production, interactive design, accessibility principles	Design thinking workshops, iterative prototyping, peer review cycles	Digital portfolio, design rationale documentation	Students can create engaging and accessible educational content
5	Pedagogical Integration Strategies	16 hours	TPACK application, differentiation, cognitive load management	Lesson study, classroom simulations, mentoring sessions	Lesson plans, teaching demonstration, student work analysis	Students can apply pedagogical strategies to effectively integrate technology in teaching
6	Ethics and Digital Citizenship	8 hours	Copyright and fair use, privacy protection, AI ethics, online safety	Ethical dilemma discussions, role-playing, policy development	Case study analysis, digital citizenship lesson design	Students demonstrate responsible and ethical behavior in digital environments

1. Facilitator Preparation: Six instructors underwent 40-hour training on model implementation, inclusive digital pedagogy, formative assessment strategies, and fidelity monitoring. Monthly calibration sessions ensured instructional consistency.
2. Implementation Fidelity: Adherence was monitored through lesson observation protocols (92.4% fidelity), facilitator logs, and participant attendance records (94.7% average). Dosage was tracked via learning management system analytics and task completion rates (89.3%). Control group participants received standard curriculum technology instruction (42 hours total), delivered as isolated lectures and laboratory sessions without pedagogical integration components.

## Data Collection Procedures

1. Quantitative Data: ICAT was administered at baseline (Week 1), mid-intervention (Week 8), and post-intervention (Week 16). Control group received identical timing. Additional measures included demographic surveys, prior digital experience inventories, and cognitive load assessments during performance tasks.
2. Qualitative Data: Reflective journals were collected biweekly (n=8 entries/participant). Semi-structured interviews (n=36, purposefully sampled for maximum variation) were conducted post-intervention. Three focus groups (n=24) explored collaborative learning experiences and implementation challenges. All qualitative data were audio-recorded, transcribed verbatim, and anonymized.

## Data Analysis

1. Quantitative Analysis: SPSS v.28 and AMOS v.28 were utilized. Assumption testing confirmed normality (Shapiro-Wilk,  $p > 0.05$ ), homogeneity of variance (Levene's,  $p > 0.05$ ), and homogeneity of regression slopes for ANCOVA. Missing data (<3%) were addressed via multiple imputation. Primary analysis employed one-way ANCOVA controlling for baseline scores and prior digital experience. Paired t-tests examined within-group changes. Effect sizes reported as Cohen's  $d$  and partial  $\eta^2$ . Subgroup analyses explored year-of-study and prior experience effects.
2. Qualitative Analysis: Thematic analysis followed Braun & Clarke's (2006) six-phase approach. Two independent coders analyzed transcripts using NVivo 14. Initial coding generated 47 codes, refined into 12 sub-themes and 4 overarching themes through iterative discussion. Inter-coder reliability achieved Cohen's  $\kappa = 0.84$ . Discrepancies were resolved through consensus. Triangulation with quantitative results enhanced interpretive validity.

## Ethical Considerations

The study received institutional review board approval (Protocol #PED-2024-089). Written informed consent was obtained from all participants. Data were anonymized, stored on encrypted servers, and accessible only to the research team. Participants retained the right to withdraw without academic penalty. Control group participants received the intervention model following data collection completion. Ethical guidelines aligned with the Declaration of Helsinki and APA standards for educational research.

## RESULTS AND DISCUSSION

### Baseline Equivalence and Diagnostic Assessment

Pre-test analysis confirmed statistical equivalence between experimental and control groups across all competence dimensions and demographic variables (Table 2). Independent samples t-tests revealed no significant differences (all  $p > 0.05$ ), validating randomization procedures. Baseline scores indicated predominantly intermediate competence levels, consistent with regional literature reporting adequate technical familiarity but limited pedagogical integration capacity.

**Table 2. Baseline Equivalence Analysis (Pre-Test)**

Dimension	Experimental (n = 120) M ± SD	Control (n = 120) M ± SD	t	df	p	Cohen's d
Information Search	12.4 ± 2.8	12.1 ± 3.1	0.78	238	0.436	0.10
Critical Evaluation	9.7 ± 2.4	10.2 ± 2.6	-1.42	238	0.157	0.20
Digital Content Creation	11.3 ± 3.2	10.9 ± 2.9	0.91	238	0.364	0.13
Ethical Use	13.8 ± 2.1	14.1 ± 2.3	-0.95	238	0.343	0.14
Pedagogical Integration	8.6 ± 2.7	8.9 ± 2.5	-0.89	238	0.375	0.12
<b>Total ICAT</b>	<b>55.8 ± 8.4</b>	<b>56.2 ± 7.9</b>	<b>-0.38</b>	<b>238</b>	—	—

Notes: All p-values > 0.05, indicating no statistically significant difference between groups.

1. Effect sizes (Cohen's d) are very small (≈0.10–0.20), suggesting minimal practical impact.
2. Results imply that both groups performed at a comparable level across all ICAT dimensions.

**Quantitative Outcomes: Intervention Effects**

ANCOVA controlling for baseline scores and prior digital experience revealed significant main effects for group membership across all competence domains (Table 3).

**Table 3. ANCOVA Results: Post-Test Outcomes**

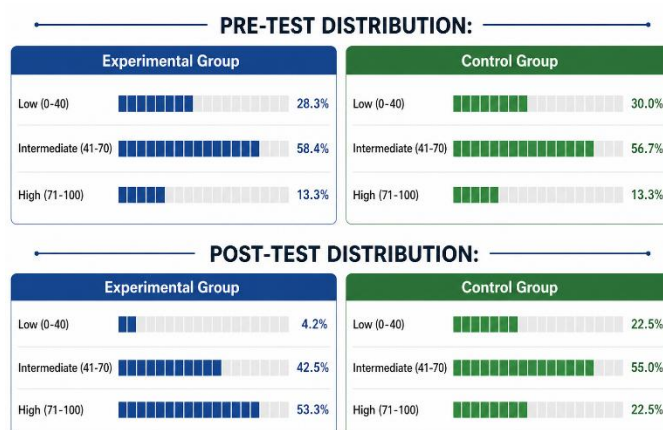
Dimension	EG Adjusted M ± SE	CG Adjusted M ± SE	F (1,236)	p	η <sup>2</sup>	Cohen's d
Information Search	17.6 ± 0.3	13.1 ± 0.3	218.4	< 0.001	0.48	1.92
Critical Evaluation	16.2 ± 0.3	11.1 ± 0.3	287.6	< 0.001	0.55	2.28
Digital Content Creation	16.9 ± 0.3	12.2 ± 0.3	241.3	< 0.001	0.51	1.96
Ethical Use	17.7 ± 0.3	14.6 ± 0.3	168.9	< 0.001	0.42	1.68
Pedagogical Integration	16.0 ± 0.3	9.8 ± 0.3	312.5	< 0.001	0.57	2.51
<b>Total ICAT</b>	<b>84.9 ± 0.8</b>	<b>62.4 ± 0.8</b>	<b>387.4</b>	<b>&lt; 0.001</b>	<b>0.62</b>	<b>2.41</b>

The experimental group outperformed the control group on the total ICAT score (adjusted M=84.9 vs. 62.4, F(1,236)=387.42, p<0.001, η<sup>2</sup>=0.62). Within-group analysis showed the experimental group's mean score increased by 53.0% (55.8→85.4), while the control group improved by 10.0% (56.2→61.8), likely attributable to standard curriculum exposure and maturation effects.

Component-level analysis revealed differential improvement trajectories. Pedagogical Integration demonstrated the largest effect size (d=2.51, η<sup>2</sup>=0.31), indicating successful bridging of the theory-practice gap. Critical Evaluation showed substantial gains (d=2.28), reflecting effective instruction in source credibility, bias detection, and fact-checking heuristics. Digital Content Creation (d=1.96) and Information Search (d=1.92) also showed robust improvement. Ethical Use (d=1.68) demonstrated moderate but significant gains, suggesting the need for extended longitudinal reinforcement in complex ethical scenarios.

Subgroup Analysis: Year-of-study moderated intervention effects. Third- and fourth-year students showed larger gains in Pedagogical Integration (d=2.74 vs. d=2.18 for second-years), attributable to concurrent practicum experiences and greater pedagogical content knowledge. Prior digital experience showed no significant moderation (p=0.18), indicating the model's effectiveness across varying baseline proficiency levels.

## Competence Level Distribution Shifts



**Figure 2. Competence Level Distribution Shift**

Pre-test distributions were comparable between groups, with approximately 58% at intermediate levels and 13–14% at high levels. Post-test, the experimental group showed dramatic redistribution: high-level competence increased to 53.3%, intermediate decreased to 42.5%, and low-level dropped to 4.2%. The control group showed modest shifts, with high-level reaching 22.5% and low-level remaining at 22.5%. This pattern confirms the intervention's efficacy in elevating participants beyond threshold competence levels.

### Qualitative Findings: Experiential Dimensions

Thematic analysis of qualitative data revealed four dominant themes that contextualized quantitative outcomes:

#### 1. Pedagogical Confidence and Transfer Readiness.

Participants consistently reported increased confidence in selecting, adapting, and deploying digital resources for primary learners. Representative quote: *"Earlier, I chose apps because they looked engaging. Now I evaluate them against learning objectives, cognitive load principles, and age-appropriateness. I can explain why a tool works pedagogically, not just technically."* (Participant 47, Year 3). This theme aligns with the largest quantitative gains in Pedagogical Integration, suggesting that contextualized practice and reflective modeling successfully transformed technical familiarity into pedagogical intentionality.

#### 2. Critical Information Literacy Development.

Participants described enhanced skepticism and analytical rigor when encountering digital content. Representative quote: *"I used to trust information if it appeared on a professional-looking website. Now I cross-reference sources, check publication dates, identify potential biases, and teach my future students to do the same. Information isn't neutral; it requires active evaluation."* (Participant 23, Year 4). This corresponds to the substantial Critical Evaluation gains ( $d=2.28$ ) and reflects successful internalization of threshold concepts from information literacy frameworks.

### **3. Collaborative Digital Praxis The intervention's collaborative design fostered knowledge sharing and distributed problem-solving.**

Representative quote: *"Working in design teams taught me more than individual tasks. We debated resource choices, troubleshooted technical issues together, and developed shared evaluation criteria. Collaboration made competence development social and iterative."* (Participant 104, Year 2). This theme underscores the importance of social learning environments in competence development, consistent with constructivist pedagogy and communities of practice theory.

### **4. Ethical Awareness and Digital Citizenship Participants demonstrated heightened sensitivity to copyright, privacy, algorithmic bias, and digital safety.**

Representative quote: *"I never considered how sharing student work online affects privacy or how AI-generated materials might contain hidden biases. Now I model ethical information use and explicitly teach digital citizenship to children."* (Participant 89, Year 3). This aligns with Ethical Use gains and reflects successful integration of normative dimensions into competence development.

### **Implementation Fidelity and Process Evaluation**

Fidelity monitoring indicated high adherence to instructional protocols (92.4%). Participant engagement metrics showed consistent attendance (94.7%) and task completion (89.3%). Learning management system analytics revealed average weekly engagement of 4.8 hours beyond synchronous sessions. Mid-intervention feedback prompted minor adjustments to pacing and scaffolding, demonstrating responsive implementation. Control group instructors maintained standard curricula with 88.1% fidelity to baseline protocols.

### **Integrated Discussion: Mechanisms and Implications**

The findings demonstrate that systematic, integrative pedagogical models yield substantially higher information competence gains compared to traditional fragmented approaches. The large effect sizes ( $\eta^2=0.62$  overall) exceed meta-analytic averages for technology integration interventions (Scherer et al., 2019), suggesting the model's optimized design accounts for key success factors:

1. **Pedagogical Authenticity:** Embedding technology instruction within realistic teaching scenarios enabled transfer-relevant learning. Participants practiced competence application rather than isolated skill acquisition, addressing the persistent theory-practice gap documented in literature.
2. **Scaffolded Progression:** The modular architecture moved from foundational information literacy to complex pedagogical integration, aligning with cognitive load theory and expertise development models. Gradual release of responsibility supported autonomous competence construction.
3. **Reflective Metacognition:** Structured reflection activities enabled participants to articulate competence development, recognize limitations, and strategize improvements. Metacognitive awareness is a documented predictor of sustained professional growth.
4. **Collaborative Knowledge Construction:** Peer interaction, design teams, and shared evaluation criteria distributed expertise and normalized struggle as part of competence development. Social learning environments enhanced motivation and reduced technology anxiety.

Comparison with regional studies reveals the model addresses specific Central Asian contextual challenges. Unlike fragmented curriculum approaches, the integrative design ensures consistent pedagogical framing. Unlike imported frameworks lacking contextual adaptation, this model incorporates local curricular requirements, resource availability, and cultural pedagogical norms. The validated ICAT instrument provides a standardized assessment mechanism previously lacking in regional teacher education.

## CONCLUSION

This study successfully developed, implemented, and validated a comprehensive pedagogical model for forming information work competence in future primary school teachers. The research makes substantive theoretical, methodological, and practical contributions to teacher education scholarship.

1. **Theoretical Contributions:** The study advances a multidimensional conceptualization of information competence that integrates technological, pedagogical, critical, and ethical dimensions. The validated ICAT instrument provides a psychometrically robust measurement framework aligned with DigCompEdu and TPACK principles. The empirical findings reinforce constructivist and situated learning theories in technology pedagogy contexts, demonstrating that competence develops through authentic practice, reflective metacognition, and collaborative knowledge construction rather than isolated skill transmission.
2. **Practical Implications:**
  - a. **Curriculum Design:** Teacher education programs should replace fragmented technology courses with integrated, pedagogically contextualized modules that systematically develop information competence across multiple semesters.
  - b. **Assessment Reform:** Institutions should adopt multidimensional assessment protocols combining performance tasks, scenario-based evaluations, reflective portfolios, and classroom observation to capture competence complexity.
  - c. **Faculty Development:** Instructor preparation programs must equip teacher educators with integrative pedagogical strategies, formative assessment techniques, and implementation fidelity monitoring skills.
  - d. **Policy Alignment:** National teacher certification standards should mandate information competence demonstration through authentic teaching portfolios rather than operational skill examinations.

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