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EFFECTIVENESS OF A SOFTWARE-BASED METHODOLOGY FOR DEVELOPING PROFESSIONAL DIGITAL COMPETENCIES OF PRE-SERVICE PRIMARY SCHOOL TEACHERS: A QUASI-EXPERIMENTAL STUDY IN THREE UZBEK UNIVERSITIES

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Abstract. The study evaluates the effectiveness of a methodology for developing professional digital competencies of pre-service primary school teachers through improved software and methodological support. The methodology combined a six-block methodological model, the integrating educational platform "DigiPed" with five curriculum-aligned modules, a unified cycle of innovative methods and a multi-stage assessment system. A quasi-experimental pre-test/post-test design with non-equivalent intact groups was carried out in 2023–2025 at three higher education institutions in Uzbekistan with 770 students (experimental group n = 386, control group n = 384). Competence was measured on motivational, cognitive, activity and reflective criteria combined into a weighted integral index $K = 0.20k_1 + 0.25k_2 + 0.35k_3 + 0.20k_4$; assessors were blind to group membership. At baseline the groups did not differ ($\chi^2 = 0.08–3.39$; $t = 0.13–1.03$). After three semesters the experimental group's mean integral score rose from 56.77 to 67.52 and the control group's from 56.26 to 59.24 ($t = 9.79$, $p < 0.05$). The share of experimental students at the low level fell from 62.7 % to 30.8 % (control group: 51.8 %), and differences were significant on all criteria ($\chi^2 = 49.75–68.31$). The efficiency coefficient was $\eta = 1.14$ overall and 1.13–1.17 across institutions, indicating that the effect is transferable beyond a single university.

Keywords: professional digital competence, pre-service teachers, primary education, quasi-experiment, software and methodological support, educational platform, integral index, chi-square test, Student's t-test, effectiveness

1. Introduction

Frameworks such as DigCompEdu, the UNESCO ICT Competency Framework for Teachers and TPACK describe what a digitally competent teacher should know and be able to do [1; 2; 3]. Much less is known about how teacher education programmes can reliably develop this competence and how its development can be measured. Studies of pre-service teachers repeatedly show that high everyday digital activity does not translate into professional digital skills [4; 5], and that digital training in universities is often fragmented across isolated tools and courses [6].

In Uzbekistan, the Development Strategy of New Uzbekistan for 2022–2026 and the Digital Uzbekistan — 2030 strategy prioritise the digital competences of future teachers [7; 8]. To address this priority, we developed a methodology for improving the software and methodological support of the Primary Education programme. Its components are: (a) a methodological model with target, conceptual-methodological, content-programme, procedural-activity, methodological and evaluation-result blocks; (b) the integrating platform "DigiPed" with eight sections and five modules embedded in the curriculum; (c) a unified practice cycle — flipped classroom, digital case, project producing an electronic didactic product, micro-teaching and peer assessment — with gamification, STEAM and critical AI use as cross-cutting methods; and (d) a transition criterion under which a student moves to the next module only when the product is ready for use in teaching practice.

The present article reports the quasi-experimental evaluation of this methodology. The research questions were: (1) Does the methodology lead to a significantly higher level of

professional digital competence than conventional training? (2) Is the effect balanced across the motivational, cognitive, activity and reflective components? (3) Is the effect reproducible in institutions with different conditions?

2. Methods

Design and setting. A quasi-experimental pre-test/post-test design with non-equivalent intact groups was used. Students were not re-distributed within cohorts so as not to disrupt the educational process; in each institution some academic groups of a year were assigned to the experimental group (EG) and others to the control group (CG). The study ran from September 2023 to December 2025 in three stages: baseline (September 2023 – January 2024), intervention (February 2024 – May 2025, three semesters) and post-test (September – December 2025).

Participants. The sample comprised 770 second- to fourth-year students of the Primary Education programme at three institutions (Table 1). None had a long-standing methodological school of digital teacher training, so the effect could hardly be explained by established departmental traditions. Two branches of the same university follow identical curricula, which allows the influence of regional conditions to be observed, while the third belongs to a different organisation and tests transferability.

Table 1

Participants by institution and group

Institution	EG	CG	Total
Samarkand branch of International School of Finance Technology and Science (ISFT)	132	130	262
Tashkent branch of ISFT	128	128	256
Namangan branch of Kimyo International University in Tashkent (KIUT)	126	126	252
Total	386	384	770

Intervention and control conditions. The groups differed only in software and methodological support. In the EG, the courses “ICT in Education”, “Pedagogical Technologies”, methods of teaching mathematics and native language, and teaching practice were delivered on the DigiPed platform, with modules M1–M5 built into course syllabi, the practice cycle applied in each module and tasks differentiated into reproductive, productive and creative levels. In the CG, the same courses followed existing syllabi: lecturers used presentations, separate electronic resources and online tests, but without a single platform, without linking outcomes to an electronic didactic product and without a transition criterion. Contact hours, teaching staff and examination periods were identical. EG lecturers attended two training seminars on the platform; no additional activities were held for CG lecturers, since the aim was to compare the new organisation with the one that actually exists in universities.

Instruments. Four criteria corresponding to the structure of the competence were assessed on a 0–100 scale: motivational (24-item Likert questionnaire, interviews, observation of optional task choices); cognitive (30-item test with two parallel forms); activity (practical task — creating an electronic didactic product for a grade 2–3 lesson — evaluated with a rubric, plus micro-teaching); and reflective (portfolio rubric, peer-review protocols, reflective entries). Instruments were piloted

on students outside the sample; items that almost everyone or almost no one solved were removed, and rubric descriptors were made operational (e.g., "the student names at least two shortcomings of the product and proposes a way to fix them"). The weighted integral index $K = 0.20k_1 + 0.25k_2 + 0.35k_3 + 0.20k_4$ was agreed with nine experts (university lecturers and primary school teachers); the activity criterion received the highest weight because it reflects the ability to create and use a product. Three levels were defined: high (creative, 86–100), medium (productive, 60–85) and low (reproductive, 0–59).

Procedure and analysis. Baseline and post-test diagnostics were conducted in EG and CG simultaneously, during regular class time and by the same experts. At post-test, products and practical tasks were presented to experts anonymised, so that assessors did not know whether a work came from the EG or the CG. Differences in level distributions were tested with Pearson's χ^2 ($df = 2$, $\alpha = 0.05$, $\chi^2crit = 5.99$) and differences in means with Student's t-test for independent samples ($tcrit = 1.96$). Effectiveness was expressed by the coefficient η = mean(EG) / mean(CG) at post-test, and efficiency gain as $(\eta - 1)\cdot 100$ %.

3. Results

Baseline equivalence. At baseline the initial level was low and practically identical in both groups (Table 2). On the integral index, 62.7 % of EG and 61.7 % of CG students were at the low level and none at the high level. χ^2 values for all criteria and the index ranged from 0.08 to 3.39 and t values from 0.13 to 1.03, below the critical values; within institutions the t values for the index were 1.39, 0.00 and 0.20. The weakest criteria were the activity criterion — 68.7 % of EG and 72.1 % of CG students could not independently create a product suitable for a lesson — and the reflective criterion, where many students rated their products much higher than experts did.

Table 2

Mean scores (SD) of EG and CG at baseline and post-test and Student's t-test

Criterion	Baseline EG	Baseline CG	t	Post-test EG	Post-test CG	t	η
Motivational	61.33 (11.04)	60.54 (11.58)	0.98	72.73 (14.80)	63.84 (12.10)	9.13	1.14
Cognitive	58.06 (11.42)	57.19 (11.98)	1.03	68.91 (15.26)	60.21 (12.56)	8.63	1.14
Activity	54.02 (11.48)	53.72 (11.07)	0.37	64.43 (15.70)	56.72 (11.33)	7.82	1.14
Reflective	55.39 (11.87)	55.28 (11.29)	0.13	65.95 (16.01)	57.86 (11.75)	7.99	1.14
Integral index K	56.77 (9.33)	56.26 (9.54)	0.74	67.52 (13.54)	59.24 (9.55)	9.79	1.14

Post-test differences. After the intervention, EG students outperformed CG students on every criterion (Table 2). The EG mean integral score rose by 18.9 % (from 56.77 to 67.52) and the CG mean by 5.3 % (from 56.26 to 59.24); growth in the CG is expected, since students continued to study and complete practice, but in the EG it was three and a half times larger. All t values (7.82–9.79) exceeded the critical value, so the null hypothesis of no difference was rejected.

Distribution by levels. On the integral index, the share of EG students at the high level grew from 0 to 10.1 %, at the medium level from 37.3 % to 59.1 %, while the low level shrank from 62.7 % to 30.8 % — more than twofold (Table 3). In the CG the corresponding shares were 0.8 %, 47.4 % and 51.8 %. χ^2 values ranged from 49.75 to 68.31 by criterion and reached 56.14 for the index. The largest shift was on the motivational criterion (high level from 1.6 % to 21.8 %); the largest absolute decline of the low level was on the activity criterion (from 68.7 % to 38.1 %).

Table 3
Distribution of students by levels at post-test, % (Pearson's χ^2)

Criterion	Group	High	Medium	Low	χ^2
Motivational	EG / CG	21.8 / 3.1	58.5 / 63.3	19.7 / 33.6	68.31
Cognitive	EG / CG	13.7 / 2.1	58.5 / 49.7	27.7 / 48.2	56.97
Activity	EG / CG	8.5 / 1.8	53.4 / 36.7	38.1 / 61.5	49.75
Reflective	EG / CG	11.1 / 0.5	55.4 / 45.3	33.4 / 54.2	59.99
Integral index K	EG / CG	10.1 / 0.8	59.1 / 47.4	30.8 / 51.8	56.14

Effectiveness and transferability. The efficiency coefficient was η = 1.14 on every criterion (motivational 1.139, cognitive 1.144, activity 1.136, reflective 1.140) and on the integral index, corresponding to an efficiency gain of 13.6–14.4 % (mean 14.0 %). Differences were significant in each institution separately (t = 5.00–6.41, tcrit = 1.97), with η between 1.13 and 1.17 (Table 4). The highest gain (16.5 %) was observed in Samarkand, where partner schools differed widely in equipment and students had to design each lesson in two versions; the lower gains in Tashkent (12.5 %) and Namangan (12.8 %) reflected, respectively, irregular self-study of working students and mainly smartphone-based work. The correlation between portfolio assessment and independent expert assessment of the final task in the EG was r = 0.86.

Table 4
Mean integral index and efficiency coefficient by institution

Institution	EG pre	EG post	CG pre	CG post	t (post)	η	Gain, %
Samarkand branch of ISFT	57.37	68.33	55.67	58.65	6.41	1.17	16.5
Tashkent branch of ISFT	57.62	68.22	57.63	60.63	5.55	1.13	12.5
Namangan branch of KIUT	55.26	65.94	55.49	58.45	5.00	1.13	12.8

4. Discussion

The results answer the three research questions positively. First, the methodology produced a significantly higher level of professional digital competence than conventional training. Second, gains were almost identical across the four criteria (13.6–14.4 %): the methodology did not "tilt" towards the cognitive component, as often happens when digital training is reduced to learning services. We explain this by the fact that each element of the cycle works on several criteria at once — the product-oriented project develops the activity component, micro-teaching and peer assessment the reflective component, and trying the product out in a real class strengthens motivation. Third, the effect was reproduced in three institutions with different technical and organisational conditions.

The findings are consistent with research linking student engagement to the creation of products of real value with educational technology [9] and with studies showing that pre-service primary teachers need targeted support to move from user-level to professional digital skills [4; 5]. Qualitative data support the figures: by the end of the intervention, products created in M4–M5 were in most cases ready for school use without revision, and several were kept in use by partner-

school teachers after practice ended. EG students also justified their choice of a digital tool by the lesson objective and children's age far more often than CG students did.

Even at post-test, the activity criterion remained the most difficult. Designing a digital lesson requires technical, methodological and content knowledge simultaneously, and for some students three semesters were not enough to reach the productive level. This confirms that aligning pedagogical, content and technological knowledge with digital didactic tasks is the most demanding and longest-lasting part of professional digital training [3].

Limitations. The use of intact groups instead of random assignment limits causal inference, although baseline equivalence was tested statistically. The effectiveness of the methodology depended heavily on lecturers' readiness: where expert review of products was treated formally, the transition criterion lost its force. The methodology also requires more lecturer time for review and feedback, and students' use of AI services demands ongoing pedagogical review of their outputs [10]. Long-term retention after graduation was not examined.

5. Conclusion

Improving the software and methodological support of pre-service primary teacher education on the basis of a methodological model, an integrating platform, a unified cycle of innovative methods and a multi-stage assessment system produced a significantly higher level of professional digital competence than conventional training, with an overall efficiency gain of 14.0 % and consistent effects across three institutions. The DigiPed platform, its modules, the task system and the assessment criteria can be used by universities in ICT and pedagogical technology courses, in teaching practice and in in-service training of primary school teachers [11].

References

1. Redecker C. European Framework for the Digital Competence of Educators: DigCompEdu. – Luxembourg: Publications Office of the European Union, 2017. – 95 p.
2. UNESCO ICT Competency Framework for Teachers. Version 3. – Paris: UNESCO, 2018.
3. Mishra P., Koehler M.J. Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge // Teachers College Record. – 2006. – Vol. 108, No. 6. – P. 1017–1054.
4. Rizal R, Setiawan W and Rusdiana D 2019 Digital literacy of preservice science teacher in Journal of Physics: Conference Series 1157 2 p. 1–6.
5. Kushnir N., Manzhula A. Formation of Digital Competence of Future Teachers of Elementary School // In: Ermolayev V., Mayr H.C., Nikitchenko M., Spivakovsky A., Zholtkevych G. (eds.). ICT in Education, Research and Industrial Applications. ICTERI 2012. Communications in Computer and Information Science. – Berlin, Heidelberg: Springer, 2013. – Vol. 347. – P. 230–243.
6. Sergis S., Sampson D.G. A Holistic Approach for Managing School ICT Competence Profiles // International Journal of Digital Literacy and Digital Competence. – 2014. – Vol. 5, No. 4. – P. 33–46.
7. Decree of the President of the Republic of Uzbekistan No. PF-60 of 28 January 2022 "On the Development Strategy of New Uzbekistan for 2022–2026" // National Database of Legislation, 29.01.2022.
8. Decree of the President of the Republic of Uzbekistan No. PF-6079 of 5 October 2020 "On approval of the Digital Uzbekistan — 2030 strategy and measures for its effective implementation" // National Database of Legislation, 06.10.2020.
9. Bond M., Bedenlier S., Buntins K., Kerres M., Zawacki-Richter O. Facilitating Student Engagement in Higher Education Through Educational Technology: A Narrative Systematic Review in the Field of Education // Contemporary Issues in Technology and Teacher Education. – 2020. – Vol. 20, No. 2. – P. 315–368.

10. Zawacki-Richter O., Marín V.I., Bond M., Gouverneur F. Systematic Review of Research on Artificial Intelligence Applications in Higher Education: Where Are the Educators? // International Journal of Educational Technology in Higher Education. – 2019. – Vol. 16. – Article 39.
11. Otamuratov O.T., Shomirzaev D., Chorshanbiyev Ch. Improving distance learning using BIM technologies: Problems and solutions // AIP Conference Proceedings. – 2025. – Vol. 3356. – Art. 030003. – https://doi.org/10.1063/5.0296308