LMS-supported Metacognitive Scaffolding and Digital Competence in Pre-service Teachers

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Abstract: Digital competence and metacognitive self-regulation are increasingly treated as core outcomes of teacher education, yet their co-development through routine learning management system (LMS) use remains underexamined. This study evaluated a 15-week Platonus-based intervention at L.N. Gumilyov Eurasian National University in Kazakhstan. The intervention integrated metacognitive prompts with professionally relevant digital tasks, connecting learning-to-learn support with digital pedagogy in teacher preparation. A quasi-experimental, non-equivalent groups design involved 249 final-year pre-service teachers: 125 students completed structured LMS activities combining multimedia modules, reflective journals, prediction–feedback quizzes, discussion forums, peer review and digital lesson production, while 124 students received the same course content through conventional instruction with minimal LMS use. Baseline equivalence was assessed, and outcome changes were analysed using 2 × 2 mixed-design analyses of variance; open-ended responses and LMS activity data were used to contextualise the quantitative findings. Metacognitive awareness was measured with the Metacognitive Awareness Inventory, and perceived professional digital competence with a DigCompEdu-informed self-report questionnaire. Mixed-design analyses of variance showed significant Time × Group interactions for metacognitive awareness, $F(1, 247) = 98.3$, $p < .001$, partial $\eta^2 = .285$, and perceived digital competence, $F(1, 247) = 123.5$, $p < .001$, partial $\eta^2 = .333$. The experimental group gained 11.8 points in metacognitive awareness and 17.8 points in perceived digital competence on 0–100 scales, whereas control-group changes were small. Supplementary open-ended feedback identified immediate formative feedback and peer exchange as the most salient affordances of the LMS activities. The design offers a practical model for teacher-education programmes: structured cycles of prediction, reflection, feedback, peer interaction and digital production can connect self-regulation with pedagogical technology use without requiring a new platform. Within this single institutional context, the findings indicate that an existing LMS can be redesigned as a pedagogical scaffold linking planning, monitoring and evaluation with authentic digital teaching practice; however, the unusually large effects require independent replication before broader conclusions are drawn.

Keywords: e-Learning, Digital competence, Metacognitive awareness, Self-regulated learning, Pre-service teachers, Kazakhstan

1. Introduction

Digital technologies can extend access to resources, feedback, collaboration and representation, but their educational value depends on how they are incorporated into pedagogy rather than on availability alone. Meta-analytic evidence has generally identified positive effects of educational technology, while studies of classroom practice continue to show substantial variation in the quality and consistency of teachers' technology integration (Tamim et al., 2011; Chauhan, 2017; Backfisch et al., 2021). This implementation gap makes initial teacher education a critical setting in which future teachers must learn not only to operate digital tools, but also to select, adapt and evaluate them in relation to pedagogical purposes.

Professional digital competence therefore extends beyond generic information and communication technology skills. It includes the capacity to combine technological, pedagogical and content knowledge; to create and adapt digital resources; to communicate and collaborate in digital environments; and to use technology for assessment and learner support (Mishra and Koehler, 2006; Redecker, 2017; Falloon, 2020). However, preparedness remains uneven. In a 2025 mixed-methods study of 322 advanced pre-service teachers at a Central European university, approximately half reported that their programme had not prepared them sufficiently to foster pupils' digital competence (Dolezal, Motschnig and Ambros, 2025). Such evidence suggests that frequent personal use of technology cannot be equated with professional competence for digitally mediated teaching.

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The issue is also relevant in Kazakhstan, where universities have invested in institutional platforms such as Platonus and where digitalisation has become a prominent educational priority. Recent local studies indicate that pre-service teachers' digital literacy is positively associated with their ability to use technology, and that online professional communities can support practical digital proficiency (Nurzhanova et al., 2024; Polatova et al., 2025). At the same time, this regional evidence has mainly examined digital readiness, literacy or participation. Less attention has been given to the cognitive regulation required to use digital environments strategically for learning and teaching.

That regulatory dimension is captured by metacognition and self-regulated learning. Metacognition concerns learners' knowledge of their own cognition and their regulation of learning through planning, monitoring and evaluation (Schraw and Dennison, 1994). Self-regulated learning is broader: it includes metacognitive processes together with motivational and behavioural control (Zimmerman, 2002). The concepts are therefore related but not interchangeable. For pre-service teachers, their importance is dual. Future teachers must regulate their own learning in increasingly autonomous digital environments, and they must also develop the competence to model and support these processes for pupils (Karlen et al., 2023; OECD, 2019).

Existing research usually treats professional digital competence and metacognitive regulation as separate development targets. Studies of technology integration often focus on TPACK, confidence or tool use, whereas studies of metacognitive scaffolding emphasise reflection, self-questioning and strategy regulation. The present study addresses this separation by testing a single, structured intervention in which routine LMS activities were deliberately designed to serve both purposes. A quasi-experimental pre-test/post-test design with an intact comparison group was used to examine whether a 15-week Platonus-based intervention could improve pre-service teachers' metacognitive awareness and digital competence beyond changes observed under conventional instruction.

The study was guided by three research questions:

RQ1. To what extent does the LMS-supported intervention improve pre-service teachers' metacognitive awareness compared with conventional instruction?

RQ2. To what extent does the intervention improve pre-service teachers' perceived professional digital competence, as assessed by the DigCompEdu-informed self-report questionnaire, compared with conventional instruction?

RQ3. How do participants describe the usefulness of the LMS-supported activities for their learning?

By answering these questions, the study contributes an integrated account of how metacognitive scaffolding and professional digital competence can be developed through an LMS already embedded in institutional practice. The remainder of the article reviews the relevant theoretical and empirical literature, describes the research design and intervention, presents the quantitative and supplementary qualitative findings, and discusses the study's theoretical, methodological and practical implications.

2. Theoretical Background

2.1 Professional Digital Competence in Teacher Education

Digital competence in teacher education is best understood as a situated professional capacity rather than a checklist of technical skills. The TPACK framework places effective technology integration at the intersection of technological, pedagogical and content knowledge (Mishra and Koehler, 2006), and DigCompEdu outlines six areas of educator competence: professional engagement, digital resources, teaching and learning, assessment, learner empowerment and facilitating learners' digital competence (Redecker, 2017). Falloon (2020) also states that teacher digital competence involves personal-ethical, professional and pedagogical aspects. In all of these frameworks, the main argument is that technology can only be educationally relevant when teachers are able to link the affordances of the technology to instructional decisions.

Studies however indicate that this ability is not a natural one. Teacher preparation reviews have consistently shown a lack of coherence in the curriculum as well as a lack of opportunities to use technology in authentic pedagogical tasks (Tondeur et al., 2012; Røkenes and Krumsvik, 2016; Instefjord and Munthe, 2017). Furthermore, Farjon, Smits and Voogt (2019) found that attitudes, self-efficacy, competence, access and previous experience influence the way pre-service teachers integrate technology. This multidimensionality can explain why programmes that introduce tools can generate confidence but not transferable pedagogical judgement.

More recent intervention research paints a different picture. Structured TPACK intervention resulted in positive gains in technological-pedagogical knowledge and technology-related self-efficacy (Lachner et al., 2021). However, a large multi-cohort quasi-experiment on digital collaboration reported a positive treatment effect for TPCK, but no consistent intervention effects for attitudes, intrinsic motivation or self-efficacy (Ohle-Peters, Ludewig and McElvany, 2024). These mixed results suggest that digital competence development is a function of learning opportunities in terms of their length and intensity and their pedagogical design. The repeated use, reflection and authentic production may be more significant than single exposure.

Kazakhstani studies reinforce the need for contextualised intervention. Nurzhanova et al. (2024) found that digital literacy significantly predicted technology-use skills among future teachers, but their cross-sectional design could not establish how those capacities develop. Polatova et al. (2025) reported benefits from an online teaching community, while also stressing that outcomes depend on programme design, guidance and access. The next step is therefore to test whether an existing institutional LMS can become a sustained environment for pedagogically purposeful digital practice rather than a repository for files and assignments.

2.2 Metacognition and Self-regulated Learning

Metacognition comprises knowledge of cognition and regulation of cognition. Knowledge of cognition includes awareness of one's strategies, task demands and personal learning characteristics; regulation includes planning, monitoring, information management, debugging and evaluation (Schraw and Dennison, 1994). Self-regulated learning incorporates these metacognitive processes but also encompasses motivation, effort, help-seeking and behavioural management (Zimmerman, 2002). Metacognition can thus be understood as a central cognitive-regulatory component of the broader self-regulated learning system.

This distinction is especially important in online and blended learning, where reduced external structure increases the need for goal setting, time management, monitoring and strategic adjustment. Broadbent and Poon's (2015) systematic review linked self-regulated learning strategies with achievement in online higher education. In teacher education, the issue extends beyond student success: teachers' own knowledge, beliefs and self-regulatory competence influence their capacity to promote metacognition among learners (Karlen et al., 2023). Teacher preparation should therefore position pre-service teachers simultaneously as self-regulating learners and as future designers of self-regulated learning environments.

Metacognitive processes can be strengthened through explicit and repeated scaffolding. Reflective practice activities, guided journals and structured discussion have been associated with gains in pre-service teachers' metacognitive knowledge and self-regulation (Elsayary and Mohebi, 2023). Prediction tasks, including judgements of learning, make learners compare expected and actual performance and can improve monitoring accuracy (Soderstrom et al., 2015). In technology-integration contexts, metacognitive prompts have also improved pre-service teachers' self-regulatory skills and lesson design (Kramarski and Michalsky, 2010). Michalsky (2024) provides recent experimental evidence that metacognitive scaffolding can enhance both self-regulated reflection and the design of higher-order teaching tasks. Together, these studies support a design in which scaffolds are embedded throughout a course rather than offered as a one-off study-skills intervention.

2.3 LMS-supported Scaffolding as an Integrative Mechanism

An LMS can operationalise scaffolding at the point where learning decisions occur. Modules can structure goals and sequence; reflective journals can prompt planning, monitoring and evaluation; prediction–feedback quizzes can expose calibration gaps; forums can make reasoning visible through dialogue; and digital artefact production can require learners to justify technological and pedagogical choices. These are not simply platform functions. Their educational value depends on prompts, feedback, task authenticity and the relationship between online and face-to-face activity.

The same activities can develop professional digital competence because learners must communicate, create content, assess information and design teaching materials within a digital environment. Brevik et al. (2019), for example, showed how an online course embedded in teacher education could support transformative agency and professional digital competence. However, the mixed results found by Ohle-Peters, Ludewig and McElvany (2024) warrant a nuanced understanding of the role that digitally collaborative practices play in changing all competence dimensions. A theoretical alignment is therefore required: every LMS activity has to have an explicit metacognitive function and an explicit professional digital competence target.

This alignment is used in the present study for a 15-week intervention. It does not expect metacognition to have a linear connection to digital competence, but rather that both can support each other. Planning and monitoring can foster more mindful use of digital tools, and authentic digital production can provide opportunities for reflection, feedback and strategic change. The quasi-experimental design aims to determine if this integrated approach results in higher pre-test/post-test gains compared to traditional instruction, and the open-ended component seeks to understand which activities in the LMS participants found useful.

3. Methodology

3.1 Research Design

The study used a quasi-experimental, non-equivalent groups pre-test/post-test design. Intact classes were retained because individual random assignment was not feasible within the university timetable. One class received the LMS-supported intervention and a second class served as the comparison condition. Both classes studied the same course content, followed the same learning outcomes, completed the same summative assessments and were taught by the same instructor. The design was selected to estimate whether change across the semester differed between conditions while preserving normal course organisation. Baseline equivalence and the comparison condition improve the interpretability of differential change, but intact-group allocation does not remove unmeasured selection or contextual confounding and therefore limits causal inference.

3.2 Context, Participants and Sampling

The research was conducted during the autumn 2024 semester at L.N. Gumilyov Eurasian National University in Kazakhstan. Participants were 249 final-year undergraduate pre-service teachers enrolled in a compulsory pedagogy-oriented course. Whole intact classes were included, constituting a convenience sample of the available cohort. The sample comprised 178 women (71.5%) and 71 men (28.5%). The experimental group included 125 students and the control group 124 students. Both classes contained students from several secondary-education specialisations and were comparable in gender composition and prior academic performance. Baseline tests confirmed no statistically significant differences in the two outcome variables. Figure 1 summarises the quasi-experimental design, group allocation and measurement points.

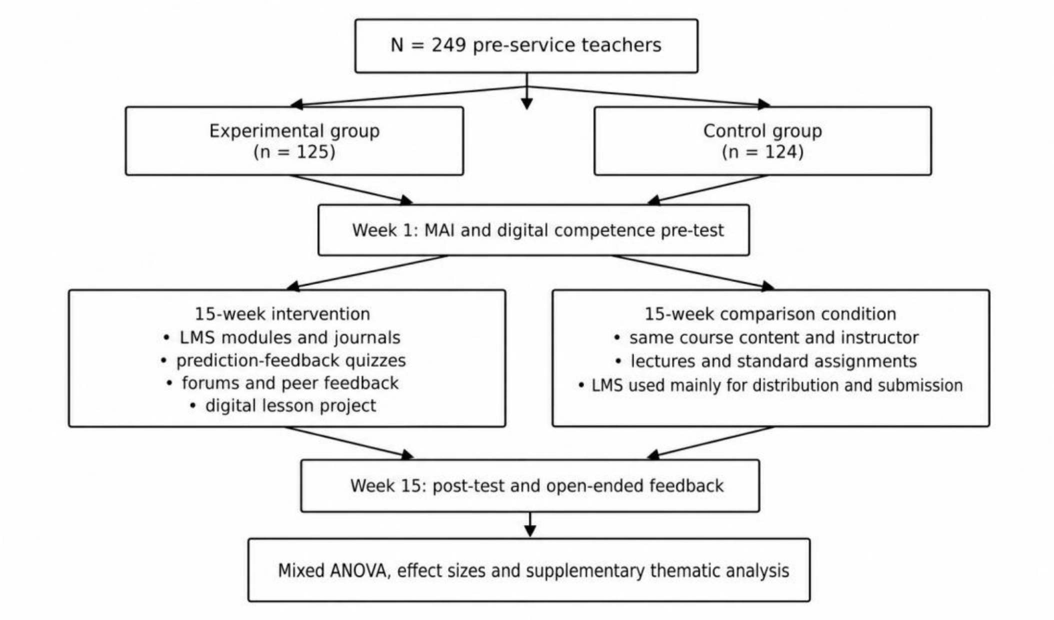

Figure 1: Quasi-experimental study design and measurement points

3.3 Intervention and Comparison Condition

The experimental condition redesigned the 15-week course around a sequence of Platonus-supported activities. Face-to-face sessions were retained, but they were used primarily for workshops, clarification and application of the online work. The intervention contained five connected components.

First, weekly multimedia modules consisting of short video explanations, readings, embedded questions and self-check quizzes. Students were able to go through the material at their own pace, and the tasks in the material were active rather than passive.

Second, weekly metacognitive journals included prompts that addressed planning, monitoring and evaluation. Before major tasks, students set goals and planned strategies; during the week, they noted areas of clarity and confusion; and after assessment, they reflected on the effectiveness of their approach. The journal entries were used to give short feedback and follow up questions by the instructor.

Third, students were asked to make ungraded prediction–feedback quizzes before taking each quiz, to compare their prediction with the actual outcome, and to describe what they would do differently or the same in the next learning cycle. The design aimed at improving the accuracy of monitoring and feedback use.

Fourth, discussion forums were provided for pedagogical cases, where each participant was asked to post a response and comment on at least two of the other participants' responses. This activity integrated articulation and evaluation of reasoning, digital communication and collaboration.

Fifth, small groups created a digital lesson resource, e.g., interactive quiz, video-based lesson, multimodal presentation and uploaded to Platonus. Two other groups gave each group peer comments and the product was revised. The task involved technological production, pedagogical justification, planning and evaluation.

The same readings, topic sequence and summative requirements were provided to the control group via lectures, seminars and regular assignments. Students had the opportunity to download materials and submit work using Platonus, but did not complete the structured journals, prediction–feedback sequence, online peer discussion or digitally mediated peer review. The difference was therefore pedagogical and not technological access, as both groups were able to access the LMS, but only the experimental group experienced a systematic scaffolded workflow. Table 1 maps the intervention components to their metacognitive functions, digital competence targets and observable process indicators.

Table 1: Mapping of intervention components to metacognitive functions and digital competence targets

LMS activity	Primary metacognitive function	Digital competence target	Observable process indicator
Interactive modules and self-check quizzes	Monitoring and evaluation	Digital resources and formative assessment	Module completion, quiz attempts and response accuracy
Weekly reflective journals	Planning, monitoring and evaluation	Professional engagement and reflective digital pedagogy	Journal submissions and response to instructor prompts
Prediction–feedback quizzes	Calibration and strategy adjustment	Digital assessment and feedback use	Predicted versus actual score and post-quiz reflection
Discussion forums	Monitoring and evaluation through dialogue	Digital communication and collaboration	Posts, replies and peer feedback
Digital lesson project and peer review	Planning and evaluation of design choices	Content creation and technology integration	Uploaded artefact, peer comments and revision cycle

Note. The mapping identifies the predominant function of each activity; several activities addressed more than one process or competence area.

Figure 2 illustrates how the LMS scaffolds were aligned with metacognitive processes, digital competence domains and outcome evidence.

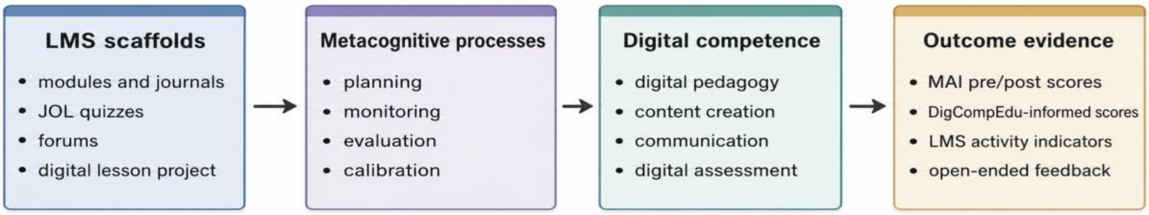

Figure 2: Operational alignment of LMS scaffolds, metacognitive processes, digital competence domains and outcome evidence

Implementation exposure was checked through LMS logs. On average, 92% of experimental-group students completed at least 80% of the online tasks. Completion of modules, quiz attempts, journal submissions and forum participation were used as a pragmatic fidelity indicator rather than as a substitute for outcome measurement.

3.4 Measures

3.4.1 Metacognitive awareness inventory

Metacognitive awareness was measured with the 52-item Metacognitive Awareness Inventory (MAI; Schraw and Dennison, 1994). Items assess knowledge of cognition and regulation of cognition on a five-point agreement scale. The instrument was administered in English, with Russian clarification of difficult terms where needed because English was the course medium. Raw totals were linearly transformed to a 0–100 scale for interpretability. Internal consistency in the present sample was high (Cronbach's $\alpha = .91$). The overall score was the primary outcome; the two broad subscales were examined descriptively and through paired comparisons.

3.4.2 Digital competence questionnaire

Digital competence was assessed with a 30-item questionnaire developed from DigCompEdu and adapted for pre-service teachers (Redecker, 2017). The questionnaire covered basic ICT and LMS operation, digital pedagogy, digital communication and collaboration, digital content creation, and digital assessment. Items used a five-point confidence scale and were converted to a 0–100 overall score. Three teacher-education specialists reviewed the items for content relevance and clarity. A pilot with 30 students outside the main sample led to minor wording revisions. Internal consistency in the study sample was good (Cronbach's $\alpha = .88$). Because the instrument elicits self-reported confidence rather than observed performance, it does not demonstrate whether participants can independently enact these competencies in authentic teaching. Accordingly, the outcome is interpreted as perceived professional digital competence rather than objectively demonstrated competence.

3.4.3 Open-ended feedback and LMS activity data

At post-test, experimental-group students answered two open-ended questions: which online activities had helped their learning most, and what challenges they had encountered. The responses were used as supplementary qualitative evidence to contextualise the quantitative outcomes. LMS logs also provided counts of forum posts and journal entries for exploratory associations with gain scores.

3.5 Data Collection and Ethical Procedures

Pre-tests were administered in week 1 before the redesigned activities began. The intervention ran across the semester, and post-tests and open-ended feedback were collected in week 15. The MAI was completed during class using matched anonymous codes; the digital competence questionnaire was completed online under supervised class conditions. Participants received information about the research purpose, confidentiality and the separation of research measures from course grades. The university ethics committee approved the protocol, and informed consent was obtained before research data were used.

3.6 Data Analysis

Quantitative analyses were conducted in IBM SPSS Statistics 26. Scores were screened for data integrity and distributional assumptions. Both outcomes were approximately normally distributed within groups (absolute skewness values below .50), and Levene tests supported homogeneity of variance at baseline. Because the within-subject factor had two levels, the sphericity assumption did not apply.

For each outcome, a 2 × 2 mixed-design analysis of variance tested Time (pre-test, post-test) as the within-subject factor and Group (experimental, control) as the between-subject factor. The Time × Group interaction was the principal test of intervention effectiveness. Paired-samples t-tests described within-group change; independent-samples tests assessed baseline equivalence. Cohen's d quantified within-group change and partial eta squared (partial η^2) quantified ANOVA effects. Statistical significance was evaluated at $\alpha = .05$.

Pearson correlations examined the association between change in MAI and change in digital competence. Within the experimental group, supplementary correlations linked activity indicators to gain scores. These analyses were exploratory and were not interpreted causally. Open-ended responses were coded inductively into recurring activity-specific themes. Because this component was supplementary rather than a standalone qualitative design, it was used to explain perceived affordances and was not treated as a basis for population prevalence estimates.

4. Data Analysis and Findings

4.1 Baseline Equivalence and Descriptive Statistics

The groups began the semester at comparable levels. For MAI, the experimental-group mean was 66.3 (SD = 10.5) and the control-group mean was 65.5 (SD = 11.0), $t(247) = 0.56$, $p = .58$. For digital competence, the corresponding means were 54.2 (SD = 12.3) and 55.1 (SD = 13.0), $t(247) = -0.53$, $p = .60$. The non-significant baseline differences support comparison of change over time, although they do not eliminate all selection threats inherent in an intact-class design. The corresponding baseline and post-intervention results are reported in Table 2.

Table 2: Pre-test and post-test scores for metacognitive awareness and digital competence

Measure	Group (n)	Pre-test M (SD)	Post-test M (SD)	Mean change	Cohen's d	Paired-test p
MAI (0–100)	Experimental (125)	66.3 (10.5)	78.1 (9.8)	+11.8	1.38	< .001
	Control (124)	65.5 (11.0)	67.0 (10.7)	+1.5	0.17	.061
Perceived digital competence (0–100)	Experimental (125)	54.2 (12.3)	72.0 (11.0)	+17.8	1.60	< .001
	Control (124)	55.1 (13.0)	57.9 (12.5)	+2.8	0.22	.014

Note. Cohen's d values of approximately 0.20, 0.50 and 0.80 are conventionally interpreted as small, medium and large.

4.2 RQ1: Effect on Metacognitive Awareness

The experimental group's mean MAI score increased from 66.3 to 78.1, whereas the control group changed from 65.5 to 67.0. The experimental-group increase was statistically significant and large, $t(124) = 15.42$, $p < .001$, $d = 1.38$. The control-group change was small and did not reach the .05 threshold, $t(123) = 1.89$, $p = .061$, $d = 0.17$.

The mixed ANOVA showed a significant main effect of Time, $F(1, 247) = 114.7$, $p < .001$, partial $\eta^2 = .317$. More importantly, the Time × Group interaction was significant and large, $F(1, 247) = 98.3$, $p < .001$, partial $\eta^2 = .285$. The direction of the interaction demonstrates that the improvement in metacognitive awareness was concentrated in the experimental condition. Figure 3 presents the outcome pattern for both measures.

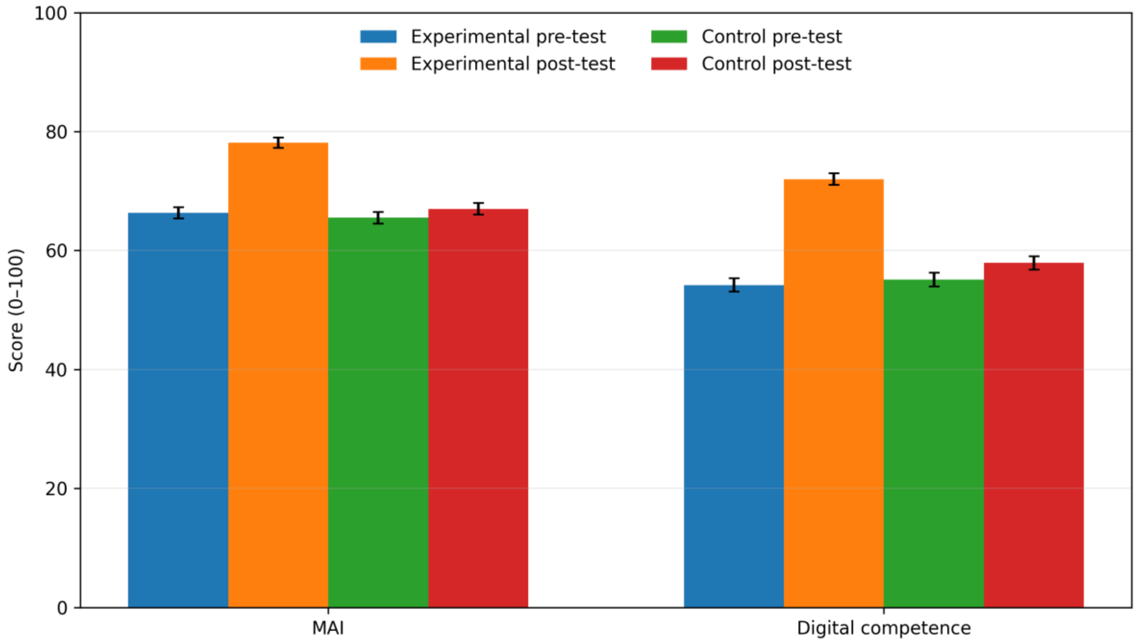

Figure 3: Pre-test and post-test means for metacognitive awareness and perceived professional digital competence; error bars show ±1 standard error

Both broad MAI components improved in the experimental group. Knowledge of cognition increased by 6.1 points on the normalised subscale, and regulation of cognition increased by 5.7 points. Neither component changed significantly in the control group. The regulation result is substantively consistent with the intervention's repeated emphasis on planning, monitoring, calibration and evaluation. The subscale results by group and measurement point are presented in Table 3.

Table 3: MAI subscale scores by group and measurement point

Subscale	Group	Pre-test M (SD)	Post-test M (SD)	Paired t	p
Knowledge of cognition	Experimental	31.9 (5.3)	38.0 (5.0)	12.27	< .001
	Control	31.5 (5.6)	32.4 (5.4)	1.69	n.s.
Regulation of cognition	Experimental	34.4 (5.8)	40.1 (5.2)	13.04	< .001
	Control	34.0 (6.1)	34.6 (5.8)	1.21	n.s.

Note. Subscale scores were normalised so that the two components sum to the overall 0–100 MAI score. n.s. = not significant.

4.3 RQ2: Effect on Perceived Professional Digital Competence

Perceived professional digital competence showed the same overall pattern, with a larger absolute change. The experimental-group mean rose from 54.2 to 72.0, a gain of 17.8 points, while the control-group mean rose from 55.1 to 57.9. The experimental-group change was large, $t(124) = 17.85$, $p < .001$, $d = 1.60$. The control-group change reached statistical significance but was small in magnitude, $t(123) = 2.48$, $p = .014$, $d = 0.22$. These values represent changes in questionnaire-based perceptions and should not be read as direct evidence of equivalent growth in observed teaching performance.

The mixed ANOVA for perceived professional digital competence produced a significant main effect of Time, $F(1, 247) = 152.9$, $p < .001$, partial $\eta^2 = .382$, and a significant Time × Group interaction, $F(1, 247) = 123.5$, $p < .001$, partial $\eta^2 = .333$. The interaction indicates that questionnaire scores increased substantially more in the experimental condition than under conventional instruction. Table 4 summarises both ANOVA models.

Table 4: Mixed-design ANOVA summary

Dependent variable	Effect	F(1, 247)	p	Partial η^2
MAI	Time	114.7	< .001	.317
	Group	101.4	< .001	.291
	Time × Group	98.3	< .001	.285
Digital competence	Time	152.9	< .001	.382
	Group	125.2	< .001	.337
	Time × Group	123.5	< .001	.333

Note. Interaction effects above .14 are conventionally considered large; the interaction is the principal estimate of differential change across conditions.

Item-level descriptive results suggest that growth was strongest in pedagogically situated uses of technology. Confidence in integrating technology into lesson plans increased by 50 percentage points, while confidence in online collaboration, digital assessment, LMS use for teaching and content creation also increased. Basic ICT operations showed less room for improvement because baseline ratings were already comparatively high. These item-level changes are detailed in Table 5.

Table 5: Selected item-level changes in the experimental group

Competence area	Pre-test confident (%)	Post-test confident (%)	Change (percentage points)
Using LMS tools for teaching	31	56	+25
Creating digital content	28	50	+22
Online collaboration and communication	42	68	+26
Integrating technology into lesson plans	25	75	+50
Assessing learners through digital tools	39	66	+27

Note. "Confident" combines respondents selecting confident or very confident on the five-point scale. These item-level percentages are descriptive and do not replace the validated overall score.

4.4 RQ3: Perceived Usefulness of the LMS Activities

The open-ended feedback identified two recurring activity-specific affordances. Comments about prediction–feedback quizzes centred on immediate information about understanding and the opportunity to correct an approach before the next task. Comments about forums centred on exposure to peers' reasoning, comparison of possible solutions and the transfer of digital discussion formats to future classroom practice. Participants' responses were generally brief and evaluative, so the qualitative component is presented as explanatory evidence rather than as a comprehensive account of experience. Table 6 summarises the two themes, associated activities and perceived learning affordances.

Table 6: Supplementary themes in participants' open-ended feedback

Theme	Activities most closely associated	Perceived learning affordance	Interpretive link to the intervention
Formative visibility and adjustment	Prediction–feedback quizzes and self-check tasks	Immediate feedback made current understanding more visible and supported revision of strategy	Reinforces monitoring, calibration and evaluation
Peer comparison and pedagogical transfer	Discussion forums and peer response	Other participants' approaches broadened the available solution set and suggested formats for future teaching	Connects reflective dialogue with digital communication and collaboration

Note. Themes are reported without frequency claims because the open-ended component was supplementary and responses were not designed for a full qualitative prevalence analysis.

4.5 Exploratory Relationship Between Metacognitive and Digital Gains

Across the full sample, change in MAI was positively associated with change in digital competence, $r = .30$, $p < .001$. The association was moderate and does not establish direction or causality, but it is consistent with the proposition that more strategic learning and more confident digital engagement developed together. Within the experimental group, forum participation and journal activity also showed small-to-moderate positive correlations with gain scores. These activity relationships should be interpreted cautiously because participation was not randomly assigned and may reflect prior motivation or engagement. The full correlation matrix is presented in Table 7.

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Table 7: Pearson correlations of gain scores with LMS activity indicators

Variables	Δ MAI	Δ digital competence	Forum posts	Journal entries
Δ MAI	—	.30***	.22**	.25**
Δ digital competence	.30***	—	.34***	.28***

Note. ***p < .001; **p < .01. The Δ MAI–Δ digital competence correlation uses the full sample (N = 249). Correlations involving forum posts and journal entries use the experimental group (n = 125).

5. Discussion

5.1 Metacognitive Outcomes

RQ1 sought to determine if the LMS-based intervention would increase metacognitive awareness. The large Time × Group interaction and the 11.8-point experimental-group gain offer positive evidence, although within the confines of a quasi-experimental design. The pattern is theoretically coherent because the intervention implemented the core regulatory cycle repeatedly as evidenced by the MAI: students planned an approach, monitored comprehension, compared predictions with performance and evaluated changes in strategy. The benefits thus seem less likely to be due to the general exposure to the platform, than to the specific design of the prompts and feedback.

The result extends earlier work on reflective practice and metacognitive prompting in teacher education (Kramarski and Michalsky, 2010; Elsayary and Mohebi, 2023). It is also consistent with Michalsky's (2024) finding that metacognitive scaffolding can improve pre-service teachers' self-regulated reflection and task design. The present study adds evidence from a full-semester institutional LMS context and from a broad pedagogical cohort rather than a narrowly defined short training activity. At the same time, the MAI is a self-report inventory; improved scores indicate greater reported awareness and regulation, not necessarily flawless metacognitive accuracy in every task.

5.2 Perceived Professional Digital Competence Outcomes

RQ2 concerned perceived professional digital competence. The experimental-group gain was substantial and was concentrated in pedagogically meaningful areas, especially lesson integration, digital assessment, collaboration and content creation. This pattern is consistent with the argument that professional digital competence develops through situated design and use rather than through decontextualised tool training (Brevik et al., 2019; Falloon, 2020). However, because the outcome was self-reported, the result demonstrates increased confidence in these practices rather than objectively verified teaching performance. The students were not only introduced to LMS functions, but also used them to solve pedagogical problems, give feedback, develop resources and revise teaching designs, which offers a plausible explanation for the reported change.

The finding also contributes to the understanding of the mixed results literature on intervention. Lachner et al. (2021) reported positive results with a structured TPACK intervention, but Ohle-Peters, Ludewig and McElvany (2024) reported selective effects: not all knowledge, attitude and motivation outcomes were affected. The present intervention was distinctive in its semester-long repetition and the relationship of each digital activity to a reflective or productive task. Nevertheless, the magnitude of the observed effects requires critical interpretation. The Time × Group effects for metacognitive awareness and perceived digital competence (partial η^2 = .285 and .333) and the corresponding within-group changes (d = 1.38 and 1.60) are unusually large for a 15-week educational intervention. Their size may reflect a combination of sustained exposure, high task completion, close alignment between the intervention activities and the questionnaire constructs, repeated use of the same regulatory language, and contextual features of a single course taught by one instructor. Because the intervention bundled journals, quizzes, forums, peer review and digital production, the design also cannot identify which component was responsible for the gains. These estimates should therefore not be treated as stable population effects or as gains that can be expected in other institutions until they have been independently replicated.

The finding builds on earlier research regarding digital literacy and online professional communities in Kazakhstan (Nurzhanova et al., 2024; Polatova et al., 2025). It shows that a platform locally created can do more than administrative, distribution and submission. The same infrastructure can serve as a place for professional digital practice and development of learning-to-learn when course designs change.

5.3 Perceived Usefulness and the Integrated Mechanism

RQ3 was used to determine participants' perceptions of activities. The two themes, formative visibility and peer comparison, reflect the mechanisms that the intervention aims to achieve. Prediction–feedback quizzes established a brief monitoring cycle: expectation, evidence and adjustment. Forums externalised reasoning, and enabled students to compare pedagogical choices. These perceptions are not on their own a measure of learning effects, but they do explain why routine LMS functions could have supported both outcome domains.

The positive association between gain scores is consistent with a mutually reinforcing explanation. More metacognitive regulation can help in the intentional exploration and assessment of digital tools, and more digital competence can help in the planning, collaboration and feedback strategies. The association is correlational and mediation and direction cannot be determined. Future research is needed to validate these mechanisms through multiple process measures, calibration indices and performance-based digital tasks.

5.4 Contributions and Practical Implications

The study has three contributions. It is a theoretical approach that links together two strands that are often studied independently: metacognitive scaffolding and professional digital competence, and sees them as co-designed outcomes of the same learning activities. Methodologically, it offers controlled pre-test/post-test evidence from a large intact cohort in a Central Asian teacher-education context, with process indicators and participant feedback. In practice, it is a process of turning the conceptual relationship into a replicable activity architecture with an LMS that is already available to the institution.

The practical implication is not that institutions need a new platform. Programmes can start by restructuring current workflows, based on the following four principles: including short planning and evaluation prompts in weekly tasks; pairing formative quizzes with prediction and post-feedback reflection; employing dialogic peer response instead of one-way posting; and connecting digital artefact production to explicit pedagogical justification and revision. The activity architecture is not technically specific to Platonus and may be adaptable to Moodle, Canvas or similar platforms. External validity cannot, however, be assumed: transfer should be tested in institutions with different student populations, course structures, instructors, digital infrastructures and levels of LMS maturity.

5.5 Limitations and Future Research

The conclusions are subject to several limitations. First, allocation involved two intact convenience classes rather than randomly assigned or matched participants. Baseline equivalence, a comparison group and a common instructor improve comparability, but they cannot rule out unmeasured selection effects, class-level influences or other confounding. The findings therefore support differential change associated with the intervention condition but do not establish definitive causality. Second, professional digital competence was assessed through a self-report confidence questionnaire rather than a performance-based assessment. The observed change should therefore be interpreted as growth in perceived professional digital competence, not as objectively demonstrated ability to design or enact digitally supported teaching. Self-report responses may also be influenced by increased familiarity with intervention terminology, social desirability or response-shift effects. Third, the study was conducted in one course at a single university in Kazakhstan, using an intact convenience sample over one semester. Its external validity is consequently limited, and the findings should not be generalised without qualification to other universities, programmes, countries, LMS platforms or stages of teacher education. Fourth, the qualitative component was based on short responses and was supplementary to the quantitative analysis, so it cannot represent the full breadth of participant experience. Finally, correlations between activity and improvement may reflect prior motivation or engagement and should not be interpreted as causal dosage effects.

Future research should prioritise independent, multi-institutional replication across different teacher-education programmes, regions and LMS environments. Where feasible, randomised allocation should be used; where randomisation is not practical, matched comparison groups, propensity-score procedures or stronger longitudinal controls could reduce selection bias. Perceived digital competence should be complemented by validated performance-based tasks, scored digital lesson artefacts, classroom simulations or practicum observations. Follow-up into practicum and early-career teaching is also needed to determine whether reported gains are sustained and transferred into practice. Repeated process measures could test whether monitoring accuracy, feedback use or engagement mediates change, while interviews or focus groups could provide a fuller account of how participants experience individual scaffolds.

6. Conclusion

Within the single institutional context examined, a 15-week Platonus-supported intervention was associated with substantially greater gains in pre-service teachers' metacognitive awareness and perceived professional digital competence than conventional instruction with minimal LMS use. The result suggests that learning-to-learn and digital pedagogy may be addressed through connected rather than entirely separate curriculum strands. When journals, prediction–feedback quizzes, discussion forums, peer review and digital production are aligned with planning, monitoring and evaluation, an institutional LMS may function as an integrated pedagogical scaffold.

For teacher-education practice, the central recommendation is to move from administrative LMS use to intentionally designed cycles of reflection, feedback and authentic digital creation. The model is promising within this context, but neither the magnitude of the effects nor their transferability should be assumed. Independent multi-site replication, randomised or matched designs, longitudinal follow-up and performance-based measures are required before broad claims are made about objectively demonstrated competence, cross-institutional transfer or sustained classroom impact.

Ethics Statement: Ethical approval was granted by the Ethics Committee of L.N. Gumilyov Eurasian National University prior to data collection. All participants provided informed consent. Research data were anonymised, stored confidentially and used only for the stated research purposes. Participation in the research measures did not affect course grades.

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