Constructivist-based teacher education and pre-service teachers' instructional competence for fostering cognitive activity

Bakytkul Yessentayeva[1], Sazhila Nurzhanova[1], Askarbek Kussainov[1], Assel Tanatova[2], Bakyt Aidarkhan[2], Iroda Kholdorova[3]
[1]Department of Primary Education, Abai Kazakh National Pedagogical University, Almaty, Kazakhstan
[2]Department of Pedagogics, Abai Kazakh National Pedagogical University, Almaty, Kazakhstan
[3]Department of Primary Education Methodology, Fergana State University, Fergana, Uzbekistan

Article Info

Article history:

Received May 26, 2026
Revised Jul 10, 2026
Accepted Aug 6, 2026

Keywords:

Cognitive activity
Constructivist education
Instructional competence
Pre-service teachers
Teacher education

ABSTRACT

This study examines the effect of a constructivist-based teacher education (CBTE) program on pre-service primary teachers' (PST) instructional competence for fostering cognitive activity (IC-CA). A quasi-experimental pretest–posttest control group (CG) design was employed with 180 pre-service teachers assigned to experimental (n=90) and control (n=90) groups using stratified allocation within intact cohorts. The intervention consisted of a 12-week program incorporating problem-based learning, collaborative tasks, microteaching, and reflective activities. Results indicated a statistically significant difference in adjusted posttest instructional competence scores in favor of the experimental group (EG) after controlling for baseline performance. Although both groups showed improvement over time, gains were greater in the experimental condition. The findings suggest that structured constructivist teacher education is associated with enhanced development of multidimensional instructional competence for fostering cognitively engaging teaching practices, including instructional design, learner interaction, pedagogical questioning, reflection, and instructional decision-making. The study provides empirical evidence that practice-oriented constructivist learning environments can support the development of such competence in pre-service teachers.

Corresponding Author:

Sazhila Nurzhanova
Department of Primary Education, Abai Kazakh National Pedagogical University
Dostyk Ave., 13, 050010 Almaty, Kazakhstan
Email: yessentayeva.bakytkul@mail.ru

1. INTRODUCTION

Worldwide, primary education increasingly aims not only at knowledge acquisition but also at fostering students' cognitive activity (CA), critical thinking, and independent learning skills [1]. Contemporary learners are expected to actively construct knowledge, apply it in diverse contexts, and engage in higher-order thinking processes such as analysis, reasoning, and problem-solving. As a result, primary education plays a key role in developing these foundational competencies.

CA refers to learners' active engagement in processes of understanding, reasoning, and knowledge construction, including attention, reflection, and problem-solving [2]. Research shows that higher levels of CA are associated with deeper learning, improved academic achievement, and stronger motivation [3]. Achieving these outcomes requires instructional approaches that move beyond teacher-centered practices toward more active, learner-centered pedagogy.

Constructivist learning theory provides a widely accepted framework for promoting CA. It conceptualizes learning as an active process in which knowledge is constructed through interaction with content, prior experience, and social collaboration. Constructivist classrooms emphasize inquiry, problem-solving, collaboration, and reflection, enabling students to actively explore and construct understanding [4]. The success of constructivist approaches depends largely on teachers' ability to design and facilitate such learning environments. Therefore, pre-service primary teacher (PST) education plays a critical role in preparing future teachers to implement student-centered instruction that supports CA [5]. However, although PSTs are often familiar with constructivist principles, many struggle to translate them into practice, particularly in designing and facilitating cognitively engaging instruction.

Prior research suggests that teacher preparedness is closely linked to instructional quality and student learning processes [6]. Teachers with stronger preparation in constructivist pedagogy are more likely to employ strategies that support inquiry and higher-order thinking. In contrast, insufficient preparation often results in continued reliance on traditional instructional methods that limit students' cognitive engagement. Against this background, this study examines the impact of a constructivist-based teacher education (CBTE) program on pre-service teachers' instructional competence for fostering cognitive activity (IC-CA). IC-CA is conceptualized as a multidimensional construct reflecting perceived competence in instructional design, pedagogical questioning, facilitation of learning processes, reflection, and instructional decision-making. Unlike narrower competence measures, it captures multiple interrelated aspects of teaching for cognitive engagement [7].

This study addresses several gaps in the literature. First, it extends research on CBTE by empirically examining its effects using a quasi-experimental pretest–posttest control group (CG) design. Second, it contributes to instructional competence research by conceptualizing IC-CA as a multidimensional construct rather than a single-scale measure. Third, it provides evidence from an authentic teacher education context, where experimental studies remain limited. The novelty of this study lies in investigating whether participation in a structured CBTE program leads to significant differences in PSTs' IC-CA compared to a CG, while controlling for baseline competence. Therefore, the aim of this study is to examine whether participation in a CBTE program leads to differences in PSTs' IC-CA compared to a CG, while controlling for baseline competence. Accordingly, the study addresses the following research question: do PSTs in the experimental group (EG) achieve significantly higher posttest IC-CA scores than those in the CG, controlling for pretest IC-CA?

2. THE COMPREHENSIVE THEORETICAL BASIS

2.1. Constructivist teacher education: concept, structure, and relevance

CBTE refers to the preparation of teachers based on the principles of constructivist learning theory. It emphasizes active learning, reflection, collaboration, and the construction of knowledge through experience. Within this approach, PSTs are not passive recipients of information but active participants in their own learning process [8]. They engage in activities such as problem-solving, discussion, microteaching, and reflection, which support the development of a deeper understanding of teaching and learning.

The structure of CBTE typically includes several key components. First, it integrates theoretical knowledge with practical experience by enabling PSTs to connect pedagogical theories with real or simulated classroom situations, thereby applying abstract concepts in practice. This integration fosters situational pedagogical knowledge and strengthens instructional decision-making. Second, CBTE emphasizes collaborative learning through joint problem-solving, analysis of pedagogical cases, and co-construction of knowledge. Peer interaction exposes PSTs to multiple perspectives, enhancing their ability to reflect on and refine their teaching approaches. This collaborative dimension is essential for developing professional reasoning in teaching contexts. Third, reflection plays a central role, as PSTs are guided to critically analyze their learning experiences, teaching practices, and underlying assumptions about teaching and learning. Such reflective processes contribute to professional identity formation and support metacognitive awareness in instructional planning and decision-making [9].

The relevance of CBTE lies in its potential to prepare teachers for contemporary educational demands. In constructivist learning environments, teachers are conceptualized as facilitators rather than transmitters of knowledge, guiding learning processes, supporting inquiry, and fostering meaningful cognitive engagement and the development of students' CA. Accordingly, teacher education programs must develop not only pedagogical knowledge but also the ability to design, facilitate, and evaluate such environments that support students' cognitive development. Research in teacher education indicates that CBTE can positively influence pedagogical thinking and perceived instructional competence, with PSTs often reporting a stronger orientation toward interactive teaching strategies, student participation, and support for higher-order thinking [10], [11]. However, its effectiveness depends on implementation quality, including active engagement, task authenticity, and the quality of feedback provided to PSTs.

2.2. Students' cognitive activity: definition, components, and educational significance

Students' CA refers to learners' active engagement in knowledge acquisition and construction processes [12], [13]. It encompasses core cognitive functions such as attention, perception, memory, reasoning, and problem-solving, reflecting both their presence and their qualitative depth during learning. A key component is higher-order thinking, including analysis, synthesis, and evaluation, which enables learners to progress from surface-level engagement to deep conceptual understanding. Metacognitive regulation represents another essential dimension, involving awareness and control of one's cognitive processes, allowing learners to monitor understanding and adjust learning strategies accordingly. CA also includes active knowledge construction, understood as the integration of prior and new information to generate meaningful understanding. This dimension is particularly relevant in CBTE-oriented contexts, where learners engage in interpretation, inference, and application of knowledge in novel situations. The educational significance of CA is reflected in its strong association with academic achievement, motivation, and lifelong learning skills, as learners with high CA typically demonstrate greater engagement, persistence in problem-solving, and transfer of knowledge across contexts. Accordingly, CA is considered a core objective of contemporary education systems [14]–[16]. Constructivist learning environments are considered effective for promoting CA. However, their effectiveness depends on teachers' instructional competence in designing cognitively demanding tasks and facilitating meaningful interaction. In this study, CA is conceptualized as a theoretical construct underlying IC-CA rather than as a directly measured student-level outcome.

2.3. Challenges in preparing pre-service primary teachers for constructivist teaching

Despite the importance of constructivist approaches, several persistent challenges remain in preparing PSTs for their effective implementation. A key issue is the persistence of traditional teaching beliefs, as many PSTs have been predominantly exposed to teacher-centered instruction, shaping their understanding of teaching as knowledge transmission rather than knowledge construction. Another challenge relates to limited opportunities for applying constructivist principles within teacher education programs. Although these concepts are introduced theoretically, PSTs often lack sufficient experience in authentic or simulated settings, resulting in a gap between theory and practice [17]. Time constraints further limit sustained engagement with constructivist pedagogy, reducing opportunities for practice-based reinforcement.

In addition, PSTs differ in prior knowledge, motivation, and learning experiences, which affects their readiness to adopt constructivist approaches [18], [19]. The transition to student-centered pedagogy therefore requires sustained practice, structured feedback, and systematic reflection; without these conditions, the development of constructivist teaching practices remains constrained [20]. A further difficulty concerns the misalignment between pedagogical theory and assessment practices, as PSTs are often evaluated primarily on declarative knowledge rather than demonstrated instructional competence in authentic or simulated contexts [21], [22]. This misalignment limits the extent to which assessment supports the development of practice-oriented skills. Collectively, these challenges underscore the need for teacher education programs that coherently integrate theory, practice, and reflection. However, existing research has rarely examined whether structured CBTE programs can systematically develop pre-service teachers' multidimensional IC-CA using an intervention-based design in primary education contexts.

Given the complexity of instructional work in constructivist classrooms, IC-CA is conceptualized as a multidimensional construct rather than a single-skill measure. Effective cognitively activating instruction requires the integration of instructional design, pedagogical questioning, learner interaction, reflection, and instructional decision-making. Therefore, a multidimensional framework is necessary to capture the full scope of pre-service teachers' perceived IC-CA.

2.4. Theoretical contribution

This study contributes to the literature on CBTE and instructional competence by advancing three interrelated theoretical dimensions. The study extends constructivist teacher education theory by operationalizing its core principles, namely active learning, collaboration, and reflection, within a multidimensional framework of pre-service teachers' instructional competence for fostering IC-CA. While CBTE has been widely discussed at the conceptual level, its translation into structured competence domains remains underdeveloped. This study addresses this gap by specifying how constructivist principles are reflected in distinct but interrelated dimensions of instructional competence. It further refines existing conceptualizations of instructional competence by explicitly integrating the goal of fostering students' CA as a central organizing construct. Unlike traditional competence models that emphasize general pedagogical skills, the proposed framework positions CA not merely as an outcome variable, but as a theoretical lens that shapes instructional decision-making, task design, and teacher reflection. In addition, the study integrates constructivist learning theory with competence-based teacher education research by linking pedagogical processes (e.g., reflection, collaboration, and active learning) with measurable competence structures.

This integration provides a more coherent explanatory model of how constructivist teacher education influences pre-service teachers' perceived ability to design and facilitate cognitively activating instruction. Overall, the study moves beyond descriptive accounts of CBTE and proposes a structured conceptual model that connects constructivist principles with multidimensional instructional competence aimed at fostering students' cognitive engagement and higher-order thinking.

3. METHOD

3.1. Research design

This study employed a quasi-experimental pretest–posttest CG design [23]. CBTE was implemented as an operationalized intervention model of constructivist teacher education. The design incorporated stratification to enhance baseline comparability across key observed covariates while preserving the naturalistic structure of the educational setting. Accordingly, it is characterized as a quasi-experimental stratified group-level allocation design within intact cohorts rather than a randomized controlled trial. Both groups were assessed at two time points: pretest (O_1) and posttest (O_2). The EG participated in the CBTE program (X), whereas the CG followed the standard teacher education curriculum (C), delivered under routine instructional conditions, as shown in Figure 1.

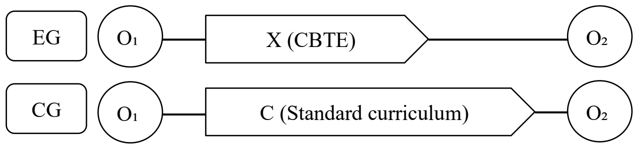

Figure 1. Pretest–posttest CG design

3.2. Participants

The study involved 180 PSTs enrolled in the "Primary Education with Information and Communication Technologies" program at Abai Kazakh National Pedagogical University. Participants were selected using purposive sampling based on predefined inclusion criteria: i) enrollment in a teacher education program; ii) completion of foundational pedagogy coursework; and iii) basic ICT literacy. These criteria were intended to ensure that participants possessed sufficient academic preparation to engage meaningfully with the intervention. Following recruitment, participants were assigned to the EG (n=90) and CG (n=90) using a stratified group-level allocation procedure within intact cohorts. Stratification was based on year of study, cumulative grade point average (GPA), and gender, with the aim to support baseline comparability across groups while preserving the natural structure of existing academic cohorts.

The adequacy of the sample size was evaluated based on statistical power considerations. A post hoc power analysis conducted using G*Power 3.1 [24] indicated that a minimum sample of approximately 128 participants would be required to detect a medium effect size (d=0.50) with a significance level of α=0.05 and a statistical power of 0.80. Since the final sample consisted of 180 participants, the study exceeded the recommended minimum sample size. Recent methodological studies have emphasized that adequate sample sizes are essential for ensuring sufficient statistical power and the reliability of findings in educational research [25]. Therefore, the sample size used in the present study was considered sufficient to detect meaningful differences between the EG and CG.

The mean age of participants was 20.85 years (SD=1.15), with a predominance of female students (82.8%), reflecting the typical gender distribution in primary teacher education programs in this context. All participants provided informed consent prior to participation. Ethical approval was obtained in accordance with institutional research ethics requirements of Abai Kazakh National Pedagogical University. Participation was voluntary, and confidentiality and anonymity were maintained throughout the study.

3.3. Procedure

Data collection was conducted over one academic semester (12 weeks), from September to December 2025, within a teacher education context at Abai Kazakh National Pedagogical University. The study followed a structured pretest–intervention–posttest design implemented under naturalistic classroom conditions without disrupting the institutional timetable. At the pretest stage, both the EG and CG completed an IC-CA assessment with established validity evidence. The assessment was administered simultaneously across groups under identical instructions, timing, and testing conditions to ensure procedural consistency.

Following the pretest, the intervention phase was conducted, during which the EG participated in the CBTE program, while the CG followed the standard teacher education curriculum. Both conditions were implemented within the same faculty, followed an identical semester schedule, and involved comparable instructional workload. Although delivery conditions were controlled, CBTE activities allowed for open-ended responses to support variability in pedagogical reasoning. Fidelity of implementation was monitored using a multi-method approach, including weekly adherence checks based on instructional plans, structured classroom observations at three time points (weeks 4, 8, and 11) using an observation checklist, and analysis of instructional artifacts (lesson plans, reflection reports, and microteaching outputs). Observations were conducted by trained independent research assistants who were not involved in instruction or assessment. Fidelity evaluation focused on adherence to instructional principles rather than uniformity of task outcomes. Posttest data were scored by external raters blinded to group allocation to further reduce potential assessment bias.

3.4. Intervention

The CBTE program consisted of three contact hours per week (36 instructional hours in total) and was fully embedded within the standard curriculum schedule. Each session followed a consistent instructional sequence: i) activation of prior pedagogical knowledge; ii) engagement in an authentic instructional problem; iii) collaborative analysis of alternative teaching approaches; iv) reflection on instructional decision-making; and v) synthesis of key pedagogical principles guided by the instructor. Instructional content was organized around progressively complex teaching scenarios drawn from primary education contexts. Early sessions focused on identifying and analyzing instructional challenges, whereas later sessions required PSTs to design, justify, and refine lesson structures under increasingly complex contextual constraints, such as heterogeneous learner groups, time limitations, and curriculum alignment requirements. This progression was intended to support the gradual development and differentiation of IC across instructional scenarios. To provide a macro-level overview, the intervention was also organized into three developmental phases, as shown in Table 1.

Core components of CBTE included problem-based learning tasks, collaborative instructional design, analysis of authentic classroom cases, microteaching activities, and structured reflection. These components were implemented as open-ended professional learning tasks that emphasized justification of pedagogical decisions rather than reproduction of fixed teaching strategies. The sequence of activities followed a gradual increase in task complexity and learner autonomy, allowing PSTs to progressively engage in more complex forms of instructional reasoning.

The CG participated in the standard teacher education curriculum over the same 12-week period with equivalent contact hours. The CG program followed institutional requirements and included lectures, seminar discussions, textbook-based assignments, and pedagogical practice tasks. Although some interactive elements were present, these activities were not organized around iterative instructional design cycles or structured reflection on teaching decisions. To ensure comparability of learning exposure across groups, both the EG and CG were taught by instructors with equivalent academic qualifications and teaching experience within the same department. However, the EG participated in a systematically designed constructivist-based program characterized by problem-based learning, collaborative instructional design, microteaching, and structured reflection, whereas the CG followed a conventional curriculum without a comparable structured instructional design framework. Table 2 presents the weekly structure of the CBTE program in the CBTE condition.

Table 1. Phase structure

Phase	Weeks	Focus
Phase 1	1–3	Orientation and analysis
Phase 2	4–8	Practice and development
Phase 3	9–12	Reflection and consolidation

Table 2. Weekly structure of the CBTE program (CBTE condition)

Week	Focus	Instructional focus
1	Orientation to constructivist pedagogy	Activation of prior knowledge
2	Learning processes	Analysis of instructional situations
3	Instructional design	Structuring teaching approaches
4	Instructional problem-solving	Addressing classroom challenges
5	Collaborative planning	Joint instructional design
6	Questioning strategies	Development of pedagogical questioning
7	Microteaching I	Teaching practice + peer feedback
8	Reflection	Analysis of instructional decisions
9	Learner reflection	Supporting student reflection
10	Case analysis	Interpretation of classroom cases
11	Microteaching II	Advanced teaching simulation
12	Consolidation	Integration of pedagogical learning

3.5. Instruments

To assess PSTs' IC-CA, a self-report instrument with established validity evidence from the present study was used, developed based on constructivist pedagogical frameworks and supported by evidence of content and construct validity. The development of the instrument was informed by prior research on constructivist teaching and learning environments [26], [27]. In particular, validated measures of constructivist teaching practices for pre-service teachers [28] provided a conceptual foundation, while the present instrument extends these approaches by incorporating instructional decision-making as an additional dimension. Methodologically, the validation procedure followed established practices in educational measurement [29], including the use of exploratory and confirmatory factor analysis (CFA). Furthermore, the conceptualization of IC-CA is consistent with broader perspectives on student-centered and self-directed learning (self-directed learning and student-centered learning: a conceptual comparison), emphasizing active knowledge construction and reflective processes.

The instrument consisted of 30 items comprising five dimensions: i) cognitively activating task design; ii) facilitation of learner interaction; iii) pedagogical questioning strategies; iv) reflection and metacognitive support; and v) instructional decision-making. All items were rated on a 5-point frequency scale (1=never to 5=consistently). As a self-report measure, responses may be subject to perceptual and social desirability bias. Prior to the main study, the instrument was pilot-tested with PSTs (n=30) not included in the final sample to evaluate clarity, wording, and reliability. Minor revisions were made based on feedback. Content validity was established through expert review by four specialists in teacher education and educational psychology, who evaluated item relevance, clarity, and representativeness of the construct.

Construct validity was examined using exploratory factor analysis (EFA) on pretest data and CFA on posttest data. EFA supported a five-factor structure consistent with the theoretical model (Kaiser–Meyer–Olkin (KMO)=0.87; Bartlett's test $p<0.001$), explaining 62% of variance. CFA indicated good model fit (comparative fit index (CFI)=0.94, Tucker–Lewis index (TLI)=0.93, root mean square error of approximation (RMSEA)=0.05). Internal consistency reliability was acceptable to high (Cronbach's α=0.89), with subscale values ranging from 0.78 to 0.86.

Potential confounding variables were controlled through several design and procedural measures. First, participants in the EG and CG were stratified according to year of study, cumulative GPA, and gender to enhance baseline comparability. Second, both groups followed the same curriculum content, course duration, and assessment requirements, differing only in the instructional intervention. Third, all measurements were administered under standardized conditions using identical instruments and procedures. These measures helped minimize the influence of extraneous variables and strengthen the internal validity of the study. Table 3 presents the IC-CA questionnaire structure.

Table 3. IC-CA questionnaire structure

Dimension	Description	No. of items
A. Cognitively activating task design	Designing tasks that promote reasoning, application, and multiple solution strategies	6
B. Facilitation of learner interaction	Supporting student dialogue, collaboration, and peer learning	6
C. Pedagogical questioning strategies	Using questions to stimulate reasoning and conceptual understanding	6
D. Reflection and metacognitive support	Promoting reflection, self-evaluation, and strategy awareness	6
E. Instructional decision-making in practice	Adapting instruction based on student responses and classroom situations	6
	Total	30

3.6. Data analysis

To ensure transparency and methodological clarity, all statistical procedures applied in this study are systematically summarized. These include the operationalization of the dependent variable, preliminary analyses, the main inferential model, assumption testing, and effect size estimation. Table 4 presents a structured overview of the statistical analysis strategy.

Table 4. Data analysis strategy

Analytical step	Procedure
Dependent variable	IC-CA composite score based on a validated 30-item instrument; dimension scores were standardized and equally weighted
Descriptive statistics	Means and standard deviations for pretest and posttest scores
Baseline equivalence	Independent samples t-tests and Chi-square tests
Main analysis	ANCOVA with posttest IC-CA as dependent variable, group as factor, pretest IC-CA as covariate
Assumption testing	Shapiro–Wilk, Q–Q plots, Levene's test, linearity checks, homogeneity of regression slopes
Effect sizes	Partial eta squared (η^2_p)

4. RESULTS

Table 5 presents baseline demographic and academic characteristics of participants. In addition to baseline equivalence in IC-CA composite scores, group comparability was examined across relevant background variables. No statistically significant differences were observed between groups ($p>0.05$ for all comparisons), indicating satisfactory equivalence at baseline. These results support the internal validity of subsequent analyses by confirming that the groups were comparable prior to the intervention.

Table 5. Baseline characteristics of participants

Variable	Category	EG	CG	Total
Gender	Female	74 (82.2%)	75 (83.3%)	149 (82.8%)
	Male	16 (17.8%)	15 (16.7%)	31 (17.2%)
Age (years)	Mean ± SD	20.8±1.1	20.9±1.2	20.85±1.15
GPA (scale 4.0)	Mean ± SD	3.54±0.24	3.51±0.25	3.53±0.24
Year of study	3rd year	45 (50.0%)	45 (50.0%)	90 (50.0%)
	4th year	45 (50.0%)	45 (50.0%)	90 (50.0%)
ICT competence	Low	13 (14.4%)	14 (15.6%)	27 (15.0%)
	Medium	57 (63.3%)	56 (62.2%)	113 (62.8%)
	High	20 (22.2%)	20 (22.2%)	40 (22.2%)
Teaching internship	Completed	65 (72.2%)	66 (73.3%)	131 (72.8%)
	Not completed	25 (27.8%)	24 (26.7%)	49 (27.2%)

Following the establishment of baseline equivalence, an analysis of covariance (ANCOVA) was conducted to examine group differences in posttest IC-CA scores while controlling for pretest IC-CA. Assumption checks confirmed that all ANCOVA requirements were satisfied. Adjusted means are presented in Table 6. The ANCOVA indicated a statistically significant effect of group on posttest IC-CA scores, $F(1, 177)=12.94$, $p<0.001$, $\eta^2_p=0.07$, as shown in Table 7, demonstrating a small-to-moderate effect size. After controlling for baseline performance, the EG demonstrated higher adjusted IC-CA scores than the CG. This represents a small-to-moderate effect size in the context of educational intervention research.

Table 6. Adjusted posttest IC-CA means (ANCOVA)

Group	Estimated marginal mean	Standard error
EG	3.60	0.04
CG	3.32	0.04

Table 7. ANCOVA results

Source	Sum of squares	df	Mean square	F	*p*	η^2_p
Pretest	3.92	1	3.92	25.62	<0.001	0.12
Group	1.98	1	1.98	12.94	<0.001	0.07
Residual	27.14	177	0.153			

5. DISCUSSION

The findings indicate higher posttest IC-CA scores in the CBTE group compared to the control condition after controlling for baseline performance. The results suggest that participation in CBTE is related to differences in PSTs' perceived instructional competence. This pattern is consistent with constructivist and sociocultural perspectives, which emphasize that professional knowledge and pedagogical self-perceptions develop through guided participation in structured learning environments, collaborative interaction, and reflection on instructional processes [30]–[32]. It should be noted that IC-CA reflects self-reported instructional competence rather than directly observed classroom teaching performance.

These findings are consistent with previous research demonstrating that CBTE can enhance preservice teachers' pedagogical reasoning and self-efficacy [33]–[35]. For example, studies have reported that structured inquiry-oriented environments contribute to stronger reflective practice and instructional awareness among PSTs [36], [37]. Similarly, collaborative and practice-based learning experiences are associated with higher levels of perceived teaching competence and more student-centered pedagogical orientations [38], [39]. The greater improvements observed in the EG suggest that structured constructivist learning experiences provide more sustained opportunities to engage with core pedagogical processes than conventional coursework [40]. In this context, IC-CA reflects changes in perceived competence across multiple interrelated dimensions, including task design, learner interaction, pedagogical questioning, reflective practice, and instructional decision-making.

For teacher education practice, these findings suggest that CBTE should be implemented as a systematic programmatic design rather than an isolated set of instructional strategies. In particular, the development of IC-CA requires sustained, repeated engagement with authentic pedagogical tasks across the teacher education curriculum. Teacher educators are encouraged to move beyond exposition-based instruction and deliberately design learning sequences in which PSTs progressively assume responsibility for planning, enacting, and evaluating cognitively activating instruction. This includes structured scaffolding that gradually shifts from guided demonstration to independent instructional design. In addition, the results highlight the importance of tight alignment between instructional methods and assessment practices. Assessment in teacher education should incorporate performance-based components such as lesson design tasks, microteaching evaluations, and reflective justification of pedagogical decisions, rather than relying primarily on theoretical examinations. From a program development perspective, iterative cycles of microteaching combined with structured peer feedback and guided reflection appear particularly relevant for strengthening instructional decision-making. Embedding these cycles across multiple courses may help PSTs internalize constructivist principles more effectively and apply them consistently in practice settings.

Despite these findings, several limitations should be acknowledged. First, the study was conducted within a single institutional context, which limits the generalizability of the results to other teacher education settings. Differences in curriculum design, institutional culture, and student characteristics may influence the effectiveness of CBTE programs. Building on this limitation, future research should examine the stability and transferability of IC-CA development across diverse institutional and cultural contexts. Longitudinal studies are also needed to investigate whether improvements in IC-CA persist over time and translate into actual classroom practice during teaching practicum or early career teaching. In addition, future studies should employ multi-method designs combining self-reports with classroom observations, portfolio assessments, or supervisor evaluations to provide more robust validation of instructional competence development. Finally, future research may explore the relationship between pre-service teachers' IC-CA and actual student outcomes, particularly students' CA and engagement, to provide stronger empirical evidence of the instructional impact of CBTE programs.

6. CONCLUSION

This study investigated the effect of participation in a CBTE program on PSTs' IC-CA using a quasi-experimental pretest–posttest CG design. In simple terms, the study shows that a structured CBTE program can improve PSTs' confidence in their ability to design and implement cognitively engaging lessons. The findings indicate that PSTs who participated in the CBTE program demonstrated higher IC-CA scores compared to those in the CG. The results further suggest that CBTE is related to differences in PSTs' perceived instructional competence for fostering cognitively engaging teaching practices, including instructional design, interaction, questioning, reflection, and instructional decision-making. The observed differences indicate differentiated developmental patterns between groups, with greater improvement in the experimental condition.

From a practical perspective, the findings highlight the potential value of integrating problem-based learning, collaborative tasks, microteaching, and structured reflection into teacher education curricula. Such components provide PSTs with opportunities to actively construct pedagogical knowledge and develop competencies aligned with cognitively activating instruction. Strengthening such integrative approaches can contribute to the preparation of future teachers for implementing cognitively activating instruction in primary education contexts and may support the development of instructional practices within training environments. However, it should be noted that the findings are based on self-reported instructional competence, and future studies should include direct observations of actual classroom teaching to better assess how these competencies translate into real instructional practice.

FUNDING INFORMATION

This study received no specific financial support.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Bakytkul Yessentayeva	✓		✓		✓			✓		✓		✓	✓	
Sazhila Nurzhanova		✓		✓		✓	✓		✓		✓		✓	
Askarbek Kussainov	✓		✓		✓		✓			✓		✓		✓
Assel Tanatova		✓		✓		✓		✓	✓		✓		✓	
Bakyt Aidarkhan	✓		✓		✓		✓			✓		✓		✓
Iroda Kholdorova		✓		✓		✓		✓		✓		✓	✓	

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

The corresponding author may provide study data upon reasonable request.

REFERENCES

[1] Seprie, W. Wuryandani, and Muthmainah, “Transforming primary education: balancing social skills and academic achievement through global inquiry-based learning models,” *Frontiers in Education*, vol. 10, p. 1512274, 2025, doi: 10.3389/feduc.2025.1512274.

[2] Y. Wang, M. Zuo, X. He, and Z. Wang, “Exploring students online learning behavioral engagement in university: factors, academic performance and their relationship,” *Behavioral Sciences*, vol. 15, no. 1, p. 78, Jan. 2025, doi: 10.3390/bs15010078.

[3] Y. Shi and S. Qu, “The effect of cognitive ability on academic achievement: the mediating role of self-discipline and the moderating role of planning,” *Frontiers in Psychology*, vol. 13, p. 1014655, Oct. 2022, doi: 10.3389/fpsyg.2022.1014655.

[4] M. Rob and F. Rob, “Dilemma between constructivism and constructionism,” *Journal of International Education in Business*, vol. 11, no. 2, pp. 273–290, Nov. 2018, doi: 10.1108/JIEB-01-2018-0002.

[5] S. Herbert and L. Hobbs, “Pre-service teachers’ views of school-based approaches to pre-service primary science teacher education,” *Research in Science Education*, vol. 48, no. 4, pp. 777–809, Aug. 2018, doi: 10.1007/s11165-016-9587-x.

[6] X. Yang and G. Kaiser, “The impact of mathematics teachers’ professional competence on instructional quality and students’ mathematics learning outcomes,” *Current Opinion in Behavioral Sciences*, vol. 48, p. 101225, Dec. 2022, doi: 10.1016/j.cobeha.2022.101225.

[7] B. C. Farkas, A. Krajcsi, K. Janacsek, and D. Nemeth, “The complexity of measuring reliability in learning tasks: an illustration using the alternating serial reaction time task,” *Behavior Research Methods*, vol. 56, no. 1, pp. 301–317, Jan. 2023, doi: 10.3758/s13428-022-02038-5.

[8] Q. Wang, “The PST framework,” in *Designing Technology-Mediated Learning Environments: Perspectives, Processes, and Applications*, Q. Wang, Ed., Singapore: Springer Nature Singapore, 2024, pp. 9–24, doi: 10.1007/978-981-96-0680-1_2.

[9] M. W. Tracey and A. Hutchinson, “Reflection and professional identity development in design education,” *International Journal of Technology and Design Education*, vol. 28, no. 1, pp. 263–285, Mar. 2018, doi: 10.1007/s10798-016-9380-1.

[10] P.-H. Chen, J.-C. Hong, J.-H. Ye, and Y.-J. Ho, “The role of teachers’ constructivist beliefs in classroom observations: a social cognitive theory perspective,” *Frontiers in Psychology*, vol. 13, p. 904181, Jun. 2022, doi: 10.3389/fpsyg.2022.904181.

[11] T. K. Haynes-Brown and P. Shannon-Baker, “Integrating video evidence in mixed methods research: innovations, benefits, and challenges for research exploring how beliefs shape actions,” *Methods in Psychology*, vol. 5, p. 100068, Dec. 2021, doi: 10.1016/j.metip.2021.100068.

[12] N. Martín-Alguacil and L. Avedillo, “Student-centered active learning improves performance in solving higher-level cognitive questions in health sciences education,” *International Medical Education*, vol. 3, no. 3, p. 346, 2024, doi: 10.3390/ime3030026.

[13] H. Zhang, X. Wang, X. Li, J. Zhai, X. Li, and Y. Guo, “The impact of large-class flipped classrooms incorporating design thinking on self-awareness, team collaboration, learning efficiency, and comprehensive literacy of clinical medicine undergraduates,” *BMC Medical Education*, vol. 25, no. 1, p. 562, Apr. 2025, doi: 10.1186/s12909-025-07116-8.

[14] H. Gao, Y. Zeng, B. Ma, and Y. Pan, “Improving knowledge learning through modelling students’ practice-based cognitive processes,” *Cognitive Computation*, vol. 16, no. 1, pp. 348–365, Jan. 2024, doi: 10.1007/s12559-023-10201-z.

[15] Z. Zhumabayeva, K. Zhaxylikova, A. Omirzakova, E. Aitenova, M. Zhailauova, and S. Nurgaliyeva, “Enhancing teaching skills through digital feedback in microteaching: a study with prospective primary teachers,” *International Journal of Information and Education Technology*, vol. 15, no. 9, pp. 1820–1828, 2025, doi: 10.18178/ijiet.2025.15.9.2383.

[16] T. Kulgildinova, A. Sarsembayeva, D. Surova, I. Kalelova, M. Zhaizhatyrova, and S. Nurgaliyeva, “The influence of an adaptive non-formal education model on student learning activity and engagement,” *International Journal of Modern Education and Computer Science*, vol. 17, no. 5, pp. 96–108, Oct. 2025, doi: 10.5815/ijmecs.2025.05.06.

[17] K. Nesje, E. Lejonberg, E. Elstad, and K.-A. A. Christophersen, “Understanding the impact of motivational orientations on preservice teachers’ perceptions of classroom simulation: a mixed-methods study,” *European Journal of Teacher Education*, pp. 1–19, Sep. 2025, doi: 10.1080/02619768.2025.2559698.

[18] S. Lee and S. Kim, “Preservice teachers’ learning by design through space construction in the metaverse,” *British Journal of Educational Technology*, vol. 56, no. 1, pp. 208–230, Jan. 2025, doi: 10.1111/bjet.13493.

[19] J. Huang, G. Sang, and W. He, "Motivation to teach and preparedness for teaching among preservice teachers in China: the effect of conscientiousness and constructivist teaching beliefs," *Frontiers in Psychology*, vol. 14, p. 1116321, Apr. 2023, doi: 10.3389/fpsyg.2023.1116321.
[20] D. Kritt and N. Budwig, "The future of constructivist education," *Human Development*, vol. 66, no. 4–5, pp. 295–309, 2022, doi: 10.1159/000526275.
[21] N. Mektepbergenov, S. Nazanova, Y. Makhambetov, L. Orynbayeva, R. Bayaliyev, and S. Nurgaliyeva, "Pre-service teachers' readiness to use artificial intelligence: evidence from Kazakhstan," *International Journal of Information and Education Technology*, vol. 15, no. 12, pp. 2700–2706, 2025, doi: 10.18178/ijiet.2025.15.12.2465.
[22] S. Nurgaliyeva, A. Zhumabayeva, M. Zhorokpayeva, K. Yessenova, S. Zeinolla, and A. Bolatov, "Determinants of job satisfaction and online learning continuation: a study of Kazakhstani educators during COVID-19," *Online Learning*, vol. 30, no. 1, pp. 138–174, Mar. 2026, doi: 10.24059/olj.v30i1.4806.
[23] P. Bamrungsin and B. Khampirat, "Improving professional skills of pre-service teachers using online training: applying work-integrated learning approaches through a quasi-experimental study," *Sustainability*, vol. 14, no. 7, p. 4362, Apr. 2022, doi: 10.3390/su14074362.
[24] F. Faul, E. Erdfelder, A. Buchner, and A.-G. Lang, "Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses," *Behavior Research Methods*, vol. 41, no. 4, pp. 1149–1160, Nov. 2009, doi: 10.3758/BRM.41.4.1149.
[25] D. Lakens, "Sample size justification," *Collabra: Psychology*, vol. 8, no. 1, pp. 1–28, Mar. 2022, doi: 10.1525/collabra.33267.
[26] T. M. Alqahtani, F. D. Yusop, and S. H. Halili, "Content validity of the constructivist learning in higher education settings (CLHES) scale in the context of the flipped classroom in higher education," *Humanities and Social Sciences Communications*, vol. 10, no. 1, p. 268, May 2023, doi: 10.1057/s41599-023-01754-3.
[27] T. H. Morris, N. Bremner, and N. Sakata, "Self-directed learning and student-centred learning: a conceptual comparison," *Pedagogy, Culture & Society*, vol. 33, no. 3, pp. 847–866, May 2025, doi: 10.1080/14681366.2023.2282439.
[28] A. F. Backes *et al.*, "Adaptation and validation of the constructivist teaching practices inventory in elementary physical education (CTPI-EPE) for Brazilian physical education pre-service teachers," *International Journal of Environmental Research and Public Health*, vol. 19, no. 19, p. 12091, Sep. 2022, doi: 10.3390/ijerph191912091.
[29] N. Teistler, "Validity evidence for the attitudes on person-centered behavior toward students questionnaire (APBS): internal structure and associations with external variables," *Social Psychology of Education*, vol. 27, no. 5, pp. 2637–2676, Oct. 2024, doi: 10.1007/s11218-024-09895-2.
[30] E. T. Yenen and O. Kızkapan, "The influence of learning scenarios on pre-service science teachers' conceptions of constructivist pedagogy and attitudes toward instructional technologies," *Discover Education*, vol. 4, no. 1, p. 242, Jul. 2025, doi: 10.1007/s44217-025-00701-5.
[31] S. J. O. G. Alzate, W. V. Sánchez, and E. A. Arias, "A socio-constructivist framework for tactical development in team sports: fostering critical thinking through collaborative learning," *Frontiers in Psychology*, vol. 16, p. 1610750, Jun. 2025, doi: 10.3389/fpsyg.2025.1610750.
[32] S. Tsehay, M. Belay, and A. Seifu, "Challenges in constructivist teaching: insights from social studies teachers in middle-level schools, West Gojjam Zone, Ethiopia," *Cogent Education*, vol. 11, no. 1, pp. 1–17, 2024, doi: 10.1080/2331186X.2024.2372198.
[33] T. Temiz and M. S. Topcu, "Preservice teachers' teacher efficacy beliefs and constructivist-based teaching practice," *European Journal of Psychology of Education*, vol. 28, no. 4, pp. 1435–1452, Dec. 2013, doi: 10.1007/s10212-013-0174-5.
[34] K. E. Weber and F. Greiner, "Development of pre-service teachers' self-efficacy beliefs and attitudes towards inclusive education through first teaching experiences," *Journal of Research in Special Educational Needs*, vol. 19, no. S1, pp. 73–84, Dec. 2019, doi: 10.1111/1471-3802.12479.
[35] Y. Boz and A. Cetin-Dindar, "Teaching concerns, self-efficacy beliefs and constructivist learning environment of pre-service science teachers: a modelling study," *European Journal of Teacher Education*, vol. 46, no. 2, pp. 274–292, Mar. 2023, doi: 10.1080/02619768.2021.1919079.
[36] O. Tiainen, S. Lutovac, and R.-L. Korkeamäki, "Rethinking approaches to reflection in initial teacher education," *Educational Research*, vol. 66, no. 3, pp. 245–262, Jul. 2024, doi: 10.1080/00131881.2024.2346088.
[37] S. Avgitidou, K. Karadimitriou, M. Ampartzaki, C. Sidiropoulou, and M. Kampeza, "University teaching as a site for professional learning of teacher educators: the role of collaborative inquiry and reflection within a professional learning community," *Education Sciences*, vol. 14, no. 2, p. 207, Feb. 2024, doi: 10.3390/educsci14020207.
[38] H. Li, "Impact of collaborative learning on student engagement in college English programs: mediating effect of peer support and moderating role of group size," *Frontiers in Psychology*, vol. 16, p. 1525192, Apr. 2025, doi: 10.3389/fpsyg.2025.1525192.
[39] Y. Zhao and J. Ko, "Vocational teachers' perceptions on workplace learning in facilitating students' professional engagement in the context of industry-university collaboration in China," *Journal of Workplace Learning*, vol. 36, no. 4, pp. 282–297, May 2024, doi: 10.1108/JWL-12-2023-0197.
[40] K. S. Taber, "Educational constructivism," *Encyclopedia*, vol. 4, no. 4, pp. 1534–1552, 2024, doi: 10.3390/encyclopedia4040100.

BIOGRAPHIES OF AUTHORS

Bakytkul Yessentayeva is a Master of Pedagogical Sciences and a senior lecturer at the Department of Primary Education at Abai Kazakh National Pedagogical University. Since 2014, she has been working as a lecturer at Taraz State Pedagogical University, and since 2023, she has been serving as a senior lecturer at Abai Kazakh National Pedagogical University. She actively conducts research in the training of future primary education teachers, the enhancement of students' learning and cognitive activity, and the development of constructivist approaches in education. She can be contacted at email: yessentayeva.bakytkul@mail.ru.

Sazhila Nurzhanova is a candidate of Pedagogical Sciences, associate professor of the Department of Primary Education at Abai Kazakh National Pedagogical University. The topic of her Candidate dissertation is "Pedagogical and Psychological Foundations of Developing Creative Thinking of Future Specialists in the System of Higher Professional Education" (2010). Her research interests include modern problems of science and primary education, multilingualism, and the development of soft skills. She can be contacted at email: sajila@mail.ru or yessentayeva.bakytkul@mail.ru.

Askarbek Kussainov is a Doctor of Pedagogical Sciences, Academician, Professor at Abai Kazakh National Pedagogical University. He is actively engaged in extensive scientific research in the fields of comparative pedagogy, the methodology and methods of comparative pedagogy, and the improvement of education quality. He can be contacted at email: apnkaz@mail.ru.

Assel Tanatova is a candidate of Pedagogical Sciences. She works as an associate professor at Abai Kazakh National Pedagogical University. In 2023-2025, she actively participated in a project funded by the Ministry of Science and Higher Education of the Republic of Kazakhstan. She focuses on addressing issues related to education, upbringing, and teaching in modern conditions, as well as improving the qualifications of teachers and heads of educational organizations in the Republic of Kazakhstan. She can be contacted at email: a.tanatova@abaiuniversity.edu.kz.

Bakyt Aidarkhan is an associate professor of the Department of Pedagogy at the Kazakh National Pedagogical University named after Abai, and a candidate of pedagogical sciences. Her research interests include the application of high technologies in higher education. She can be contacted at email: bakhyt2006@gmail.com.

Iroda Kholdorova is an associate professor at the Department of Primary Education Methodology, Faculty of Pedagogy, Psychology, and Art Studies, Fergana State University. In 2020, she successfully defended her dissertation on the topic "Linguopragmatic study of Generonyms in the Uzbek Language". She is the author of a textbook on "Methodology of Teaching Calligraphy in Primary Classes" and a teaching manual titled "Methodology of Teaching the Mother Tongue in Primary Classes". She can be contacted at email: irodaxoldarova70@gmail.com.