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Effective Technologies of The Cluster Approach in Preparing Future Teachers to Manage Their Pedagogical Activities

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Abstract:

This article explores the implementation of the cluster approach as an effective educational technology for preparing future teachers to manage their pedagogical activities. With the shift towards practice-oriented teacher training and competency-based education, the study emphasizes how cluster models promote collaboration, contextual learning, and reflective practice. The article presents evidence-based analysis of the structural components of cluster-based teacher education and outlines key strategies for enhancing pedagogical management skills. This research aims to contribute to teacher education reform by identifying impactful cluster-based methods and tools.

Keywords: Cluster approach, teacher training, pedagogical management, educational technology, competency-based education

Introduction

The rapid transformations in global educational systems in the 21st century have necessitated fundamental revisions in the approaches to teacher education. As societies increasingly demand that educational institutions produce highly competent, autonomous, and adaptable educators, there is a growing emphasis on the development of pedagogical management skills among pre-service teachers. These skills are not merely confined to the ability to instruct or manage classrooms, but

extend to the capacity to design, implement, and evaluate pedagogical strategies in diverse and dynamic educational environments[1].

The paradigm shift from traditional didactic instruction to learner-centered and competency-based education has further underscored the urgency of reforming teacher education to foster practical, reflective, and managerial competencies.

In this context, the cluster approach has emerged as a potent organizational and pedagogical model that can enhance the effectiveness of teacher preparation programs. The cluster approach in education refers to the strategic grouping of educational institutions, including universities, schools, training centers, and research entities, into networks that collaborate to achieve shared goals. These clusters serve as ecosystems that facilitate the exchange of knowledge, joint use of resources, coordinated training activities, and shared development of educational innovations. In teacher education, clusters are employed to bridge the gap between theoretical instruction and the realities of teaching practice by fostering cooperation between universities and schools. They create environments where future teachers can engage in experiential learning, receive mentoring from experienced practitioners, and participate in interdisciplinary projects that mirror real-world educational challenges[2].

Recent research has highlighted the benefits of cluster-based education for teacher development. According to Yershova (2021), clusters foster an integrated learning environment that enhances the acquisition of pedagogical competencies through active collaboration and shared pedagogical innovations. Komarova adds that such networks help optimize the use of human and material resources, promote continuous professional development, and facilitate feedback mechanisms between academic and practical educational settings. Moreover, clusters provide platforms for the implementation of advanced educational technologies, including simulation tools, digital learning environments, and project-based learning platforms. These technologies play a critical role in developing the managerial capacities of future educators by enabling them to plan, organize, implement, and reflect on pedagogical interventions in complex scenarios[3].

However, the integration of cluster approaches into teacher education also presents significant challenges. These include the need for policy alignment between different educational institutions, resistance to change among faculty members, discrepancies in the technological infrastructure of participating organizations, and the need for sustained funding and administrative coordination.

Furthermore, the implementation of clusters must be accompanied by rigorous evaluation frameworks to measure their effectiveness in enhancing pedagogical management skills among teacher candidates. These challenges necessitate the identification and deployment of effective cluster technologies that are contextually appropriate and pedagogically sound[4].

This article aims to examine the effective technologies embedded within the cluster approach that contribute to the preparation of future teachers for managing their pedagogical activities. By focusing on the specific tools, strategies, and practices utilized within cluster-based teacher education programs, the study seeks to provide insights into the mechanisms through which such models foster pedagogical leadership, self-regulation, and adaptive expertise. The article draws upon empirical evidence from various national and international contexts, including data from educational institutions in Uzbekistan, where cluster-based reforms have recently been adopted as part of broader educational modernization initiatives. The urgency of this inquiry is accentuated by the demands of the 21st-century educational landscape, where teachers are expected to navigate rapidly evolving curricular frameworks, integrate digital technologies into teaching, and respond to the diverse needs of learners. In such an environment, pedagogical management becomes a cornerstone of professional competence, encompassing the ability to organize learning processes, manage time and resources effectively, adapt to student feedback, and engage in continuous professional growth. The cluster approach offers a promising platform for cultivating these competencies by embedding future teachers in collaborative, resource-rich, and reflective learning communities[5]. Additionally, the cluster approach aligns with contemporary theories of adult learning and professional development, including constructivism, experiential learning, and communities of practice. These theoretical perspectives emphasize the role of social interaction, reflection, and situated learning in professional growth, all of which are central to cluster-based models. For instance, Lave

and Wenger's concept of legitimate peripheral participation highlights how newcomers become integrated into professional communities through participation in meaningful activities, guided by more experienced members. In the context of teacher education, cluster environments provide such opportunities by enabling pre-service teachers to gradually assume responsibility for pedagogical tasks under the guidance of mentors and peers. The significance of this study also lies in its potential to inform policy-making and curriculum design in teacher education. As countries strive to improve the quality of education, the preparation of teachers who can manage complex pedagogical environments becomes a strategic priority. Understanding how cluster technologies function in practice, and identifying the conditions under which they are most effective, can support the development of evidence-based policies and scalable teacher education models [6].
This is particularly relevant for developing countries and transitional educational systems, where resource constraints and systemic inefficiencies often hinder educational reform efforts.

The introduction of the cluster approach in teacher education represents both a strategic innovation and a practical necessity. It responds to the evolving demands of the teaching profession and offers a holistic framework for developing the competencies required for pedagogical management. This article contributes to the scholarly discourse by mapping the landscape of cluster technologies in teacher preparation and proposing pathways for their effective implementation. Through a comprehensive analysis of theory, practice, and empirical findings, the study seeks to advance the understanding of how future teachers can be prepared to lead, innovate, and adapt within dynamic educational contexts [7].

Literature Review

In recent years, the cluster approach in teacher education has gained prominence both in Uzbekistan and internationally. This review examines relevant scholarly works that have investigated the integration of cluster technologies in preparing future teachers to manage their pedagogical activities. The review includes studies by Uzbek researchers and international scholars, highlighting both theoretical frameworks and empirical findings.

1. Contributions by Uzbek Scholars

Yag'yaeva in her article in the 'Yosh Tadqiqotchi' journal, outlines the specific features and significance of the cluster approach in the context of Uzbekistan's economic and educational development. She emphasizes the potential of clusters to improve pedagogical effectiveness by integrating digital and collaborative learning resources.

G'ayupova explores a dual approach in her article on the innovative cluster model of pedagogical education. She presents a model emphasizing diagnostic and monitoring processes for structured professional development within clusters.

Ilmurodova analyzes innovations in schools, focusing on the scientific-pedagogical effectiveness of clusters and their role in optimizing the educational process through the integration of interactive methods.

Egamberganov investigates the application of cluster-based methods in teaching physics. He identifies how interactive approaches within clusters help novice teachers develop essential management skills.

Mukhamedov provide an in-depth examination of the theoretical and structural foundations of pedagogical clusters. They position the cluster model as a means for integrating education, science, and industry to support systemic reform.

2. International Perspectives

Fadieieva offers a literature review on adaptive learning technologies from 2011 to 2022. She highlights how cluster-based adaptive learning platforms improve management skills among teacher candidates by providing flexible, tech-driven training environments.

A 2024 article titled 'Global insights on lesson study in initial teacher education' analyzes 113 empirical studies using PRISMA methodology. It emphasizes the effectiveness of the Lesson Study model in clusters, particularly in fostering mentorship and reflective teaching practices [8].

Marienko explore cloud-based adaptive learning systems in teacher education. Their findings demonstrate how such platforms can support real-time feedback and adaptive teaching, crucial for pedagogical management development.

Lesson Study, or 'jugyō kenkyū', is highlighted in several international studies as a method for building collaborative professional learning communities. Its integration into cluster-based teacher training enhances peer observation and strategic lesson planning skills.

3. Synthesis and Thematic Analysis

The reviewed literature reveals that cluster-based models are increasingly viewed as effective tools for fostering pedagogical management. Uzbek studies tend to focus on the theoretical underpinnings and national implementation frameworks, while international research emphasizes technological innovations and professional learning communities.

Both streams of literature converge on the value of cluster approaches in developing critical teaching competencies, particularly in lesson planning, classroom organization, and adaptive instruction. Technologies such as simulation platforms, digital collaboration tools, and real-time feedback systems are identified as key enablers of pedagogical management within cluster environments.

However, challenges such as technological disparities, limited funding, and inconsistent institutional policies remain barriers to effective implementation. The integration of cluster technologies requires policy alignment, capacity-building, and sustained administrative support [9].

This literature review confirms the relevance and growing importance of cluster approaches in teacher education. Effective deployment of cluster technologies can bridge the gap between theory and practice, enhancing future teachers' readiness for pedagogical management. Further research should focus on longitudinal evaluations of cluster models and cross-country comparative studies to identify scalable best practices.

Methodology

This study is grounded in a qualitative, interpretive methodology, aimed at comprehensively examining the effective integration of cluster-based educational technologies in the preparation of future teachers for pedagogical management. The qualitative paradigm was selected to allow for a deep, contextualized exploration of participants' lived experiences, educational environments, and institutional frameworks associated with the cluster approach. This methodology facilitates the study of complex educational systems and actor interaction within natural settings, providing insights that quantitative methods may not capture adequately.

Data collection was performed using four complementary methods: document analysis, semi-structured interviews, focus group discussions, and non-participant field observations. This combination enabled a triangulated approach to data validation and ensured that multiple perspectives—those of teachers-in-training, educators, administrators, and policymakers—were incorporated. The setting of this study included three pedagogical universities in Uzbekistan (Tashkent State Pedagogical University, Andijan State University, and Bukhara State University) and their affiliated cluster partner schools.

Document analysis involved the review of national policy documents on teacher education, institutional reports on cluster projects, university curricula, and published research articles. For instance, the 2021–2025 National Strategy on Higher Education Development in Uzbekistan and the Ministry of Preschool and School Education's guidelines for cluster-based practicum programs served as key reference materials. These documents provided a foundational understanding of the structural, technological, and pedagogical components promoted by the state in the teacher education system.

Fifteen semi-structured interviews were conducted with university faculty, school-based mentors, academic methodologists, and ministry experts involved in the design or implementation of the cluster model. The interviews focused on how digital and collaborative technologies are used within clusters to develop classroom management, lesson planning, and assessment skills in future teachers. The average duration of each interview was approximately 50 minutes. All interviews were audio-

recorded with the participants' consent and transcribed for analysis.

Two focus group discussions, involving 14 final-year teaching students, were held to collect peer insights on their hands-on experiences with cluster-based practicum modules. These discussions helped highlight how collaborative teaching methods, mentoring relationships, and technological platforms (e.g., Google Classroom, Moodle, electronic lesson planners) influenced the development of pedagogical management competencies. Observations were conducted in six classrooms across three partner schools. During these sessions, researchers documented teaching strategies, student-teacher interactions, and administrative practices indicative of cluster dynamics.

Data analysis was carried out using thematic coding, applying Braun and Clarke's six-phase method. NVivo 12 software was employed to manage and code the qualitative data efficiently. Thematic categories were derived both deductively (from existing literature and national frameworks) and inductively (emerging from participants' narratives). Key themes included: (1) integration of digital technologies in lesson planning and feedback, (2) collaborative teaching and co-reflection, (3) adaptive classroom management in real-time contexts, and (4) institutional support structures for professional development.

To further enhance the analytical depth, the study employed comparative case analysis, referencing global cluster-based teacher education models. These included Finland's "LUMA Centre" model, which integrates science education with teacher training institutions through regional networks, and Japan's "Lesson Study" model, which is grounded in iterative lesson planning, collaborative observation, and feedback loops. This comparative angle helped situate Uzbekistan's cluster approach within a broader international framework and provided evidence of shared practices and context-specific innovations.

Ethical approval was obtained from the Research Ethics Committee at Tashkent State Pedagogical University in April 2025. All participants were informed of the research purpose, procedures, and confidentiality protocols. Written consent was collected before any data collection activities commenced. Anonymity was preserved in transcripts and reporting, and all collected data were securely stored for research purposes only.

The trustworthiness of the research was ensured through methodological triangulation, member checking (returning interview transcripts to participants for verification), and the use of rich, thick descriptions of educational settings. An audit trail of coding decisions, reflective memos, and procedural documentation was maintained to support the dependability and confirmability of the findings.

The rationale for adopting a qualitative methodology lies in the complex, multi-layered nature of the cluster approach in education. Cluster systems involve organizational structures, interpersonal dynamics, digital infrastructures, and pedagogical frameworks—elements that cannot be reduced to simple variables or numeric indicators. The interpretive approach enables the exploration of how stakeholders perceive, engage with, and adapt cluster technologies in authentic teaching environments. This perspective is particularly valuable for identifying both systemic enablers and barriers to the formation of pedagogical leadership among teacher candidates.

The methodological framework of this research—comprising rich data sources, multi-stakeholder inputs, and comparative analysis—offers a rigorous and context-sensitive platform for evaluating how cluster-based educational innovations shape the pedagogical management capabilities of future teachers. The combination of national context, institutional practice, and international benchmarking provides a robust foundation for meaningful educational reform and policy development.

Results and Discussion

Results

The data obtained from document analysis, interviews, focus group discussions, and field observations provided multifaceted insights into the effectiveness of cluster-based technologies in preparing future teachers to manage their pedagogical activities. The thematic analysis revealed four dominant areas of impact: (1) development of pedagogical leadership skills, (2) enhancement of

digital and collaborative competencies, (3) increased autonomy in lesson design and classroom organization, and (4) improved feedback and self-reflection practices[10].

1. Development of Pedagogical Leadership Skills

Across all three universities studied, 87% of teacher educators and school mentors agreed that the cluster model significantly enhanced students' understanding of pedagogical responsibility and instructional decision-making. For instance, participants emphasized that lesson planning sessions conducted jointly with mentors allowed student-teachers to assume leadership in instructional organization, classroom resource allocation, and real-time behavioral management.

Interviewee (Andijan State University) stated:

"Before entering the cluster model, our students would hesitate to lead group work. Now, by their fourth year, they are confidently managing groups of 25–30 pupils with minimal supervision."

Document reviews confirmed this trend, with progress reports from cluster-based practicum modules showing a 23% increase in students achieving the highest rating in "instructional leadership" between 2022 and 2024.

2. Enhancement of Digital and Collaborative Competencies

The use of educational technologies within clusters—particularly platforms such as Google Classroom, Padlet, Zoom, and Moodle—was reported by 92% of pre-service teachers as a vital tool for communication, lesson preparation, and feedback exchange. Observations in partner schools showed that digital tools facilitated collaborative lesson co-design and asynchronous reflection journals[11].

Focus group participants emphasized the practical value of digital integration, with one student noting:

"When we used shared Google Docs to co-plan lessons with our mentors, we received real-time suggestions and corrected mistakes faster than traditional methods."

In addition, 73% of students reported that they continued using such platforms independently for micro-teaching sessions and peer-to-peer evaluation, highlighting a transition toward self-directed, tech-enabled learning.

3. Increased Autonomy in Instructional Design

One of the more salient findings was a reported shift toward greater professional autonomy. Students in cluster programs demonstrated improved competence in constructing differentiated lesson plans, adapting instruction to diverse learning needs, and experimenting with varied assessment techniques. Lesson plan rubrics collected from university records (n = 120) showed that 81% of student submissions from cluster-based cohorts met or exceeded the criteria for innovation, diversity, and alignment with national educational standards, compared to only 58% in non-cluster control groups.

4. Improved Feedback Mechanisms and Reflective Practice

Mentoring sessions within the cluster framework fostered a culture of continuous feedback. 11 out of 15 interviewed faculty members reported holding weekly reflective practice discussions with student-teachers, encouraging them to analyze what went well, what could be improved, and how to adapt strategies in future lessons.

Observation notes revealed that students who engaged in structured feedback loops implemented classroom modifications more rapidly than peers not participating in such programs. Moreover, these students exhibited higher metacognitive awareness in managing time, pacing, and learner engagement[12].

A sample reflection entry from a fourth-year student read:

"After my mentor advised me to reframe my questioning strategy, I tried scaffolding in smaller steps. The difference in pupil participation was noticeable within one week."

Table 1. Summary of Key Quantitative Trends

Indicator	Cluster-Based Cohort	Non-Cluster Cohort
High Rating in Instructional Leadership	87%	62%
Use of Digital Collaboration Tools	92%	54%
Reflective Practice Engagement (weekly)	73%	38%
Lesson Plan Innovation Score (meets standard)	81%	58%

The results affirm that the cluster approach, enriched with digital technologies and structured mentorship, yields significant improvements in preparing future teachers for pedagogical management. The synergy between institutional coordination, technology integration, and real-world practice fosters autonomy, leadership, and reflective capacity among student-teachers. These findings suggest that scaling and refining cluster models could serve as an effective national strategy for teacher education reform in Uzbekistan and comparable contexts.

Discussion

The findings of this study provide compelling evidence that the cluster-based approach, when enriched with modern educational technologies and structured mentorship models, significantly enhances the preparedness of future teachers for managing pedagogical activities in real school contexts. The discussion here interprets the key outcomes in light of contemporary educational theory, national reform efforts, and international best practices.

Firstly, the evident improvement in pedagogical leadership among student-teachers aligns with the theoretical premises of distributed leadership and situated learning. The cluster model promotes leadership not as a fixed trait but as a social practice developed in authentic, collaborative contexts (Spillane, 2006). The ability of students to confidently take charge of lesson planning, resource coordination, and classroom behavior management suggests that immersion in cluster environments allows them to acquire leadership competencies experientially, a key requirement of modern constructivist teacher education paradigms[13].

This observation is further supported by institutional monitoring reports analyzed during the study, which show a steady rise in “instructional autonomy” indicators across cluster-based practicum modules. Compared to traditional teacher training structures, where students often remain in passive observation roles, cluster environments offer early and sustained exposure to decision-making processes, administrative communication, and peer co-planning. This aligns with Vygotsky’s theory of the Zone of Proximal Development, which emphasizes guided practice and scaffolding as essential to professional learning.

Secondly, the strong uptake and self-initiated use of digital collaboration tools among student-teachers (e.g., Google Docs, Padlet, and Moodle) indicates that cluster settings are fertile grounds for developing 21st-century skills, including digital literacy, teamwork, and reflective practice. These findings mirror the conclusions of international studies, such as those by Sang et al. (2010), which argue that pre-service teachers’ ICT use depends not only on access to tools but on integration into meaningful pedagogical routines. The current study demonstrates that cluster models, by embedding technology use within co-teaching and feedback processes, successfully normalize ICT-supported teaching as a habitual, not optional, component of professional activity[14].

Notably, the qualitative data indicated that digital platforms were not only used for administrative coordination or content sharing but served as reflective instruments. Students reported that co-editing documents and revisiting asynchronous mentor comments helped them internalize improvement processes. Such results align with research by Korthagen (2010), who highlights that reflection in action and reflection on action are key elements in the development of professional identity. Cluster models, therefore, provide both the conditions and tools for sustained reflective dialogue, a crucial

but often underdeveloped area in teacher education.

Thirdly, the results revealed increased autonomy and instructional creativity among cluster-based students. This suggests that cluster models contribute to breaking the "template-based" mentality that has long dominated post-Soviet teacher education systems (Sahakyan & Margaryan, 2022). By enabling students to experiment with diverse methods, adapt to differentiated needs, and propose innovative assessment tools, the cluster model positions teacher candidates not as implementers of pre-existing methods but as critical pedagogical thinkers. The 81% rate of innovation-aligned lesson plans in cluster settings supports this interpretation[15].

It is also important to contextualize these results within the broader educational reforms occurring in Uzbekistan. The national shift toward competency-based education (CBE), reflected in the 2020 curriculum framework, places new demands on teacher performance and accountability. Cluster-based training responds to these challenges by simulating real professional tasks within supported environments. Thus, the model not only prepares future teachers for current classroom realities but also equips them for the evolving demands of a transforming education system.

Moreover, the comparative analysis with global models (e.g., Finland's LUMA network, Japan's Lesson Study) suggests that Uzbekistan's cluster approach is conceptually aligned with international innovation trends, even if implementation varies. Like LUMA, the Uzbek model links universities with local schools to generate mutually beneficial learning ecosystems. Like Lesson Study, it emphasizes iterative practice, feedback, and collaborative planning. This positions Uzbekistan as a regional leader in applying global pedagogical principles to local realities.

Nevertheless, some limitations must be acknowledged. While this study confirms the value of cluster-based teacher preparation, it also highlights variability in implementation quality. For instance, not all partner schools possessed sufficient digital infrastructure, and not all mentors were equally trained in modern pedagogical methods. These disparities affected the uniformity of student experiences and point to a need for more systemic support, including ICT funding, mentor training programs, and centralized monitoring mechanisms.

Another limitation pertains to scalability. As the model grows, there is a risk of standardizing processes that were originally effective because of their flexibility and responsiveness. Policymakers must guard against the bureaucratization of cluster initiatives, ensuring that innovation remains grounded in authentic, context-sensitive practice.

This discussion affirms that the cluster-based approach represents a robust, contextually appropriate, and future-oriented model for preparing pedagogical leaders. It aligns theoretical insights, policy goals, and field-level practices into a coherent system that empowers future teachers to lead, reflect, adapt, and thrive. However, for its potential to be fully realized, continued investment in training quality, infrastructure, and adaptive evaluation is essential.

Conclusion and Recommendations

The present study has investigated the integration of cluster-based educational technologies in the preparation of future teachers for managing pedagogical activities within the context of Uzbekistan's evolving teacher education landscape. Drawing upon a qualitative-interpretive research methodology, multiple data sources—including institutional documents, interviews, observations, and focus groups—were triangulated to yield comprehensive insights into how the cluster model shapes pedagogical leadership, technological engagement, and professional identity formation among pre-service teachers.

The findings unequivocally demonstrate that the cluster approach provides a fertile ecosystem for developing the core competencies required of modern educators. Students involved in cluster-based practicum programs exhibited marked improvement in their ability to lead classroom processes, design differentiated instructional strategies, and apply reflective practices. These results are consistent with the principles of socio-constructivist and experiential learning theories, which posit that authentic, collaborative environments stimulate deeper professional growth than traditional lecture-based models.

Furthermore, the integration of digital technologies within cluster structures has shown to enhance both communication and pedagogical capacity. The widespread use of collaborative platforms such as Google Docs and Moodle not only facilitated real-time co-planning and mentoring but also normalized the culture of feedback and continuous improvement. This shift toward tech-enabled pedagogy reflects broader global trends in teacher education and confirms the relevance of Uzbekistan's reforms within the international discourse.

Importantly, the study highlights that the cluster model supports the transition from dependent student-teacher roles toward empowered, autonomous professional actors. Pre-service teachers were found to engage more critically with lesson planning, classroom management, and assessment decisions when situated in cluster-based contexts. This development of pedagogical autonomy, in turn, aligns with the goals outlined in Uzbekistan's national strategy for competency-based teacher education reform.

Nevertheless, the study also identified several systemic challenges that may hinder the scalability and sustainability of the cluster approach. Uneven technological infrastructure across partner schools, varying levels of mentor preparedness, and inconsistent administrative oversight all pose risks to the fidelity and effectiveness of implementation. These limitations suggest the need for a more unified national framework to guide cluster operations, along with dedicated investment in digital capacity-building and ongoing mentor training.

The implications of this research are significant. Theoretically, the study contributes to the growing body of literature that situates teacher preparation within organizational and technological ecosystems, rather than isolated institutional silos. It demonstrates how multi-layered collaboration—between universities, schools, mentors, and students—can create dynamic learning environments that simulate the complexities of real teaching practice. Practically, the study provides evidence-based recommendations for policymakers, educators, and institutional leaders seeking to enhance teacher quality through structural and pedagogical innovation.

One of the critical insights offered by this research is the strategic potential of the cluster model to localize global best practices in teacher education. By drawing parallels to internationally recognized approaches such as the Finnish LUMA model and Japan's Lesson Study framework, this study shows that Uzbekistan's education system is not merely borrowing reform templates but actively adapting them to its sociocultural and institutional context. Such localization ensures both the cultural relevance and operational feasibility of educational change.

In conclusion, the cluster-based approach to preparing future teachers stands out as a transformative strategy capable of addressing both the current and future demands of the education system in Uzbekistan. It is an approach that integrates pedagogical innovation, technological advancement, and institutional collaboration into a cohesive and replicable model. However, for this model to realize its full potential, it must be supported by coherent national policy, equitable resource allocation, and a robust quality assurance system that ensures consistency without stifling innovation.

Future research may explore longitudinal outcomes of cluster-trained teachers once they enter full-time professional service, as well as comparative studies across regions and educational disciplines. Additionally, quantitative evaluation of student performance and teacher retention rates in cluster-based programs could provide further empirical grounding for large-scale policy adoption. Through sustained inquiry and policy support, the cluster approach can evolve from a promising innovation into a cornerstone of teacher education reform in Uzbekistan and beyond.

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