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THE USE OF PROBLEM-BASED LEARNING TECHNOLOGIES IN THE PROFESSIONAL TRAINING OF SPECIAL EDUCATION TEACHERS

Abstract

This study examines the effectiveness of integrating problem-based learning (PBL) technologies into the professional training of future special education teachers. With the increasing complexity of inclusive education environments, traditional models of teacher preparation often fall short in developing the diagnostic, corrective, and collaborative competencies needed in the field. This research investigates whether a technology-enhanced PBL framework can better prepare pre-service special educators by fostering critical thinking, professional autonomy, and practical problem-solving skills. A mixed-methods research design was employed. Quantitative data were collected through pre- and post-intervention assessments administered to both experimental and control groups consisting of fourth-year students enrolled in a special pedagogy training program. The experimental group participated in a 15-week intervention involving scenario-based learning, online simulations, and structured reflective exercises, while the control group followed the conventional curriculum. Results revealed statistically significant improvements in the experimental group's professional competencies, particularly in areas related to individualized diagnostics, corrective planning, and collaboration with parents. An independent samples t-test confirmed these findings (t (58) = 6.41, p < .001), with a large effect size (Cohen's d = 1.65). Qualitative data, drawn from student journals and focus group interviews, supported these results and highlighted increased motivation, cognitive engagement, and the formation of professional identity. Students emphasized that the authenticity of the scenarios and the use of digital tools were instrumental in deepening their learning. Limitations of the study include a restricted sample size, single-institution context, and a relatively short intervention period. Nevertheless, the findings offer valuable insights into the design and implementation of innovative instructional models in special education teacher education. The study concludes that when problem-based learning is supported by relevant technologies and guided facilitation, it holds significant potential to enhance the preparedness of special education teachers for the demands of inclusive and adaptive educational practice.

Keywords: problem-based learning, special education, professional competencies, technology integration, teacher training.

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АРНАЙЫ БІЛІМ БЕРУ СТУДЕНТТЕРІН КӘСІБИ ДАЯРЛАУДА ПРОБЛЕМАЛЫҚ ОҚЫТУ ТЕХНОЛОГИЯЛАРЫН ҚОЛДАНУ

Аңдатпа

Бұл зерттеу проблемалық оқыту (PBL) технологияларын болашақ арнайы білім беру мұғалімдерін кәсіби даярлауға біріктірудің тиімділігін зерттейді. Инклюзивті білім беру ортасының күрделене түсуіне байланысты мұғалімдерді даярлаудың дәстүрлі үлгілері осы салада қажетті диагностикалық, түзету және бірлескен құзыреттіліктерді дамытуда жиі жетіспейді. Бұл зерттеу PBL технологиясының жетілдірілген жүйесі сыни тұрғыдан ойлауға, кәсіби дербестікке және мәселелерді шешудің практикалық дағдыларына ықпал ете отырып, алдын ала дайындалған арнайы оқытушыларды жақсырақ дайындай алатынын зерттейді. Аралас әдістерді зерттеу дизайны

қолданылды. Сандық деректер педагогиканы оқытудың арнайы бағдарламасына қабылданған төртінші курс студенттерінен тұратын эксперименттік және бақылау топтарына жүргізілген араласуға дейінгі және кейінгі бағалау арқылы жиналды. Эксперименттік топ сценарийлік оқытуды, онлайн модельдеуді және құрылымдық рефлексиялық жаттығуларды қамтитын 15 апталық іс-шараға қатысты, ал бақылау тобы әдеттегі оқу бағдарламасын ұстанды. Нәтижелер эксперименттік топтың кәсіби құзыреттіліктерінің статистикалық тұрғыдан айтарлықтай жақсарғанын көрсетті, әсіресе жеке диагностикаға, түзетуді жоспарлауға және ата-аналармен ынтымақтастыққа қатысты салаларда. Үлгілердің тәуелсіз t-тесті бұл нәтижелерді растады ($t(58) = 6,41$, $p < .001$), үлкен эффект өлшемімен (Коэннің $d = 1,65$). Студенттік журналдардан және фокус-топтардағы сұхбаттардан алынған сапалы деректер осы нәтижелерді растады және мотивацияның жоғарылауын, танымдық белсенділікті және кәсіби сәйкестіктің қалыптасуын көрсетті. Студенттер сценарийлердің шынайылығы мен цифрлық құралдарды пайдалану олардың оқуын тереңдетуде маңызды рөл атқаратынын атап өтті. Зерттеудің шектеулеріне іріктеменің шектеулі мөлшері, бір мекеменің контексті және араласудың салыстырмалы түрде қысқа мерзімі жатады. Дегенмен, нәтижелер арнайы білім беру мұғалімдерінің білім беруіндегі инновациялық оқыту үлгілерін әзірлеу және енгізу туралы құнды түсінік береді. Зерттеу қорытындысы бойынша проблемалық оқыту тиісті технологиялармен және басшылыққа алынған жеңілдетумен қамтамасыз етілгенде, ол арнайы білім беру мұғалімдерінің инклюзивті және бейімделгіш білім беру тәжірибесінің талаптарына дайындығын арттыру үшін айтарлықтай әлеуетке ие болады.

Түйін сөздер: проблемалық оқыту, арнайы білім беру, кәсіби құзыреттілік, технологиялық интеграция, мұғалімдерді даярлау.

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ИСПОЛЬЗОВАНИЕ ТЕХНОЛОГИЙ ПРОБЛЕМНОГО ОБУЧЕНИЯ В ПРОФЕССИОНАЛЬНОЙ ПОДГОТОВКЕ ПЕДАГОГОВ СПЕЦИАЛЬНОГО ОБРАЗОВАНИЯ

Аннотация

В данном исследовании рассматривается эффективность интеграции технологий проблемно-ориентированного обучения (PBL) в профессиональную подготовку будущих учителей специального образования. С усложнением условий инклюзивного образования традиционные модели подготовки учителей часто оказываются недостаточными для развития диагностических, корректирующих и совместных компетенций, необходимых в данной области. В этом исследовании исследуется, может ли усовершенствованная технологиями система PBL улучшить подготовку специальных педагогов до начала работы, развивая критическое мышление, профессиональную автономию и практические навыки решения проблем. В исследовании использовались смешанные методы. Количественные данные были собраны с помощью оценок до и после вмешательства, которые были проведены как в экспериментальной, так и в контрольной группах, состоящих из студентов четвертого курса, обучающихся по программе специальной педагогики. Экспериментальная группа участвовала в 15-недельном курсе, включавшем обучение на основе сценариев, онлайн-моделирование и структурированные рефлексивные упражнения, в то время как контрольная группа следовала обычной учебной программе. Результаты выявили статистически значимые улучшения в профессиональных компетенциях экспериментальной группы, особенно в областях, связанных с индивидуальной диагностикой, коррекционным планированием и сотрудничеством с родителями. Независимый выборочный t-тест подтвердил эти результаты ($t(58) = 6,41$, $p < 0,001$) с большим значением эффекта (d Коэна = 1,65). Качественные данные, полученные из студенческих журналов и интервью с фокус-группами, подтвердили эти результаты и подчеркнули возросшую мотивацию, когнитивную вовлеченность и формирование профессиональной идентичности. Студенты подчеркнули, что аутентичность сценариев и использование цифровых инструментов способствовали углублению их знаний. Ограничения исследования включают ограниченный размер выборки, контекст одного учебного заведения и относительно короткий период вмешательства. Тем не менее, полученные результаты дают ценную информацию о разработке и внедрении инновационных моделей обучения в системе подготовки учителей специального образования. В исследовании делается вывод о том, что, когда проблемное обучение поддерживается соответствующими технологиями и управляемой фасилитацией, оно обладает значительным потенциалом для повышения готовности учителей специального образования к требованиям инклюзивной и адаптивной образовательной практики.

Ключевые слова: проблемное обучение, специальное образование, профессиональные компетенции, интеграция технологий, подготовка преподавателей.

Introduction. In the evolving landscape of modern education, the integration of digital and problem-oriented pedagogical technologies has emerged not merely as an instructional enhancement, but as a transformative imperative—particularly in the preparation of special education teachers. As educational systems worldwide strive to respond to the growing heterogeneity and individualization of learner needs, the imperative to equip future educators with adaptive, research-driven, and technologically supported methodologies becomes increasingly urgent. Within this framework, the effective training of pre-service special educators represents a critical junction where pedagogical innovation must intersect with inclusive practice.

However, the integration of educational technologies into teacher training – despite its theoretical promise—remains marked by uneven implementation and significant contextual challenges. The literature suggests that while technology can enhance engagement, facilitate differentiated instruction, and support data-informed practices, its potential often remains unrealized in higher education institutions due to systemic constraints, pedagogical inertia, and a lack of targeted training initiatives [1]. These challenges are further magnified in special education contexts, where teachers are expected to work with students exhibiting a wide range of cognitive, communicative, behavioral, and sensory differences. The unique pedagogical demands of special education amplify the need for professional preparation that transcends traditional didactic approaches and embraces dynamic, responsive, and learner-centered models of teaching.

A recurrent theme in the literature is the insufficient preparedness of teachers to utilize technology meaningfully. Many pre-service and in-service educators report a lack of confidence and technical proficiency, which is exacerbated by minimal exposure to integrative digital pedagogy during their training [2]. Compounding this issue are deep-rooted beliefs about teaching and learning – often inherited from prior educational experiences – which shape educators' epistemological stances and their openness to innovation. Research shows that such beliefs, when left unexamined, can act as cognitive filters that resist the assimilation of new pedagogical paradigms, especially those involving student autonomy and technology-based facilitation.

In the case of special education teacher training, the complexity increases. Educators in this field must not only adapt content and method to individual learners' needs but also develop diagnostic, corrective, and collaborative competencies that are essential for inclusive practice. These competencies require not only theoretical knowledge but also procedural fluency, pedagogical tact, and the capacity for reflective problem-solving in real-time classroom contexts. Traditional lecture-based formats are ill-equipped to foster such multidimensional skillsets. Thus, an urgent pedagogical shift is warranted – one that promotes deeper learning through active inquiry, collaboration, and practical application.

Problem-based learning (PBL) represents one such approach. Rooted in constructivist learning theory, PBL emphasizes student-centered exploration of complex, ill-structured problems that mirror authentic professional challenges. Unlike linear, content-driven instruction, PBL scaffolds learning through collaborative investigation, hypothesis formulation, and iterative solution testing – processes that closely parallel the tasks special educators perform in their daily work. By situating learning within real-world problem contexts, PBL supports the development of critical thinking, adaptive reasoning, and professional judgment.

Despite the established pedagogical merits of PBL, its application in the training of special education teachers remains largely peripheral. Existing scholarship tends to focus on the use of PBL in medical, engineering, or general education programs, with minimal attention paid to its utility in special education contexts. Even fewer studies address how PBL can be systematically integrated with educational technologies to create enriched, multimodal learning environments that cater to the specific developmental trajectories of future special educators.

At the same time, the discourse on teacher effectiveness – particularly the "teacher value-added" model—has gained prominence in educational policy and research. This model posits that individual teacher contributions to student achievement can be quantified through longitudinal data and controlled metrics. Within this framework, teacher preparation programs are expected to demonstrably enhance the professional capital of their graduates. However, while correlations between teacher quality and student

outcomes have been extensively documented in general education, there remains a conspicuous absence of empirical evidence linking the quality of special education teacher preparation to measurable student gains in inclusive or special settings.

Seminal studies by Algozzine, Morsink, Sindelar, Daunic, Nougaret, and colleagues have laid important groundwork by identifying relationships between the structural quality of teacher training and instructional efficacy in special education [3; 4]. Nonetheless, these investigations tend to emphasize curriculum coverage, practicum length, and mentorship structures, rather than the underlying pedagogical processes that cultivate diagnostic acumen, adaptive expertise, and learner-sensitive instructional design. Moreover, such research often overlooks the transformative potential of technology-enhanced, problem-based learning as a vehicle for competency development in special education teacher education.

Technological integration in teacher training, while theoretically endorsed by numerous policy frameworks and institutional strategies, frequently falters at the point of operationalization. A major contributing factor is the lack of access to educational tools that are both pedagogically sound and responsive to the specific needs of learners with disabilities. Current digital platforms often prioritize standardized functions, overlooking the necessity for customizable features, alternative communication modes, or differentiated feedback systems. Consequently, pre-service teachers are seldom exposed to the kind of adaptive technologies they will need to utilize and evaluate in their professional practice. This pedagogical disconnect poses a serious risk to both teacher self-efficacy and learner outcomes [5].

Furthermore, organizational culture within teacher education institutions can significantly influence the extent to which innovation is embraced or resisted. If the prevailing norms prioritize compliance over creativity, and procedural knowledge over pedagogical inquiry, then even the most advanced technologies or promising methodologies are likely to be marginalized. This cultural inertia is particularly problematic in special education, where the need for flexible, context-sensitive pedagogical thinking is most acute.

Special education pedagogy, by its very nature, is iterative and exploratory. It involves a constant interplay between planning, enactment, assessment, and revision. Effective instructional practice in this domain requires a repertoire of strategies for addressing diverse learner profiles, monitoring progress in nuanced ways, and adapting interventions responsively. Embedding educational technologies within such a dynamic and complex practice landscape demands not only technical competence but also pedagogical fluency, ethical sensitivity, and reflective adaptability.

In order to contextualize this study, it is important to review existing research on problem-based learning and its relevance to teacher education.

Recent academic discourse has increasingly emphasized the transformative potential of problem-based learning (PBL) methodologies within the broader landscape of contemporary education. Positioned at the intersection of constructivist learning theories and experiential pedagogical approaches, PBL has been lauded for its capacity to foster deep cognitive engagement, stimulate metacognitive awareness, and cultivate competencies that are transferable across diverse professional domains. In contrast to linear, algorithmic instruction typified by programmed learning models, PBL offers a dynamic pedagogical paradigm wherein learners construct meaning through iterative cycles of inquiry, reflection, and application – an approach particularly suited to the multifaceted realities of non-standard and inclusive educational settings.

The theoretical underpinnings of PBL have been rigorously articulated across decades of pedagogical research, with central constructs such as “problem” and “problem situation” serving as foundational elements of its design. A problem situation, in the context of learning, functions as a cognitively dissonant scenario that challenges students’ existing knowledge structures, thereby prompting intellectual exploration and the assimilation of new information. The work of A.M. Matyushkin, among others, has been instrumental in conceptualizing the problem situation as a stimulus for creative thought, wherein learners must transcend routine procedures to generate original, context-responsive solutions. These scenarios are not only epistemologically rich but also psychologically engaging, thereby enhancing motivation and long-term retention.

Implementation of PBL within the classroom environment requires a reconceptualization of the teacher's role from a transmitter of knowledge to a facilitator of inquiry. Teachers are tasked with curating complex, real-world problem scenarios that are pedagogically relevant and developmentally appropriate, while simultaneously scaffolding students' navigation of these problems without prescribing fixed pathways to resolution. Students, in turn, are expected to engage in collaborative inquiry, formulate hypotheses, conduct investigations, and critically evaluate potential solutions. This shift in classroom dynamics necessitates robust instructional design, where pre-planned and emergent problem scenarios are integrated seamlessly into the learning process. Prompts, case studies, and exemplars may be used to model problem-posing and foster higher-order questioning among learners, thus advancing their autonomy and analytical competence.

Empirical studies consistently highlight the pedagogical efficacy of PBL in enhancing a range of cognitive and affective outcomes. Research has demonstrated that students engaged in PBL exhibit greater improvements in critical thinking, knowledge retention, conceptual understanding, and self-directed learning compared to those exposed to traditional instruction. These findings are corroborated by large-scale meta-analyses and longitudinal studies which show that the authentic, situated nature of PBL facilitates deeper knowledge construction and transferable skill development. In particular, the ability of PBL to mirror real-life professional problem-solving processes renders it highly relevant for the training of future educators, especially those working in complex and adaptive environments such as special education.

The theoretical positions advanced by L.A. Volovich, G.I. Ibragimov, and G.V. Mukhametzyanova have further enriched the discourse on the role of PBL in cultivating qualified professionals. Their work underscores the notion that education should not be confined to the transmission of information but should actively develop intellectual independence, strategic thinking, and innovation—all of which are central to the professional identity of special educators. As A.M. Matyushkin posited, cognitive development in educational contexts must involve the learner’s capacity not only to acquire new information but to reconfigure it in ways that are both novel and functional in practice. The internalization of such cognitive processes is reflective of a learner’s broader epistemic disposition and is foundational to their capacity for adaptive expertise. [6].

In recent years, scholars have increasingly recognized the synergistic potential of integrating technology into PBL environments. Technological tools – ranging from simulation platforms and digital collaboration environments to adaptive learning systems and real-time assessment software – can serve as powerful enablers of the PBL process. These tools facilitate access to complex problem data, enable interactive scenario modeling, and support collaborative learning across time and space. Moreover, technology allows for the collection of process-oriented data, which can be used to provide formative feedback and personalize instructional pathways. This technological augmentation of PBL aligns closely with the demands of contemporary special education training, where teachers must navigate diverse learning needs, multimodal communication systems, and data-driven decision-making processes [7].

For example, the use of digital technologies to present problem scenarios, scaffold collaborative solution development, and track learners’ engagement through analytic dashboards can significantly enhance both the effectiveness and efficiency of PBL. Moreover, integrating accessible technology – designed according to Universal Design for Learning (UDL) principles – ensures that problem-based tasks are inclusive and sensitive to the sensory, cognitive, and linguistic diversity characteristic of special education populations [8]. In this sense, technology not only facilitates PBL but also expands its reach, enabling the design of personalized learning experiences that would otherwise be difficult to implement in conventional settings.

Despite its numerous advantages, the implementation of PBL in special education teacher training remains fraught with challenges. Educators must account for the unique cognitive, communicative, and emotional profiles of learners with special needs, which may necessitate significant adaptations to standard PBL procedures. This includes designing problem scenarios that are meaningful yet accessible, ensuring equitable participation during collaborative tasks, and providing differentiated supports to

scaffold learning. Furthermore, the use of technology in such contexts introduces additional complexities, as digital tools must be selected and deployed in ways that are pedagogically purposeful and universally accessible. Inadequate training in both PBL methodologies and assistive technologies can result in superficial or ineffective applications, thereby diminishing the intended benefits [9].

Nonetheless, the convergence of PBL and educational technology continues to represent a promising frontier in special education teacher preparation. When thoughtfully designed and effectively implemented, technology-enhanced PBL can provide a fertile environment for developing the critical, reflective, and responsive competencies that are essential to professional success in this field. The current literature, while rich in theoretical insights and general findings, reveals a significant gap in empirical studies that specifically examine the intersection of PBL, technology integration, and special education teacher training. This lacuna points to an urgent need for context-sensitive research that explores how such pedagogical innovations function in real-world teacher preparation programs and what outcomes they produce for both educators and their future students.

Research Gap

Although the literature has increasingly recognized the potential of problem-based learning and technology integration in improving teacher education, there is a paucity of rigorous, empirical studies that explore the combined impact of these innovations on the professional competency development of pre-service special education teachers. Most current research treats PBL and educational technologies as separate innovations, failing to explore their synergistic potential. Furthermore, existing studies often adopt generalized samples, leaving the specific needs of special education contexts underrepresented.

What remains underexplored is how technology-enhanced PBL can be operationalized to foster critical instructional competencies such as diagnostic reasoning, corrective strategy planning, and collaborative problem-solving among future special educators. The processes through which such an integrated approach contributes to professional identity formation, pedagogical agency, and inclusive practice readiness remain largely untheorized and untested.

This study seeks to fill this gap by investigating how problem-based learning technologies can be effectively utilized within special education teacher training programs to foster comprehensive professional preparedness. In doing so, it aims to generate a nuanced understanding of how pedagogical innovation, when appropriately contextualized and technologically supported, can reshape the future landscape of inclusive education.

Basic provisions. The use of modern pedagogical technologies can enhance students' learning motivation and the quality of their knowledge acquisition. A significant number of skilled researchers and educators have been and continue to be engaged in exploring innovative educational technologies. The primary goal of educational endeavors is to create conditions that foster each student's personal fulfillment, the disclosure of their abilities and inclinations, and the opportunity to experience success and believe in their own capabilities. In contrast to traditional learning, where competencies are formed through the assimilation of pre-existing scientific knowledge, the main objective of problem-based learning is the mastery of competencies through the activation of students' independent research and creative activities. Problem-based learning is designed to cultivate a unique style of mental activity, research engagement, and intellectual independence in students. The theoretical foundation of problem-based learning is the conceptualization of thinking as a productive process.

Problem-based learning involves the independent, complete or partial, resolution of feasible problems by students. To establish a problem situation, students should be given a practical or theoretical task, the completion of which requires the discovery of new knowledge and the acquisition of new skills.

The use of problem-based learning technologies has gained significant attention in the professional training of special education teachers due to its potential to enhance learners' problem-solving skills, critical thinking, and overall preparedness for the profession

Materials and Methods.

Research Design

This study employed a methodologically pluralistic design, integrating both qualitative inquiry and quasi-experimental intervention within a design-based research (DBR) framework to rigorously investigate the pedagogical efficacy of problem-based learning (PBL) technologies in the professional training of special education teachers. The adoption of a mixed-method strategy was not merely a pragmatic choice, but a deliberate epistemological alignment with the multifaceted nature of the research problem, which necessitates both theoretical elaboration and empirical validation.

The study was implemented in two interdependent phases, each serving complementary but distinct epistemic functions. The first phase, grounded in qualitative-exploratory methodology, entailed an integrative and critical review of the literature to construct a robust theoretical scaffold. This phase aimed to synthesize existing knowledge concerning (a) the pedagogical architecture and epistemology of PBL; (b) its application in teacher education contexts; and (c) the affordances and constraints of integrating educational technologies in inclusive instructional design. The qualitative phase provided the conceptual infrastructure required to inform the intervention logic, curricular design, and instrumentation of the subsequent experimental component.

The second phase adopted a quasi-experimental approach to empirically test the impact of a purposefully designed PBL intervention on the development of domain-specific professional competencies among pre-service special education teachers. This intervention was guided by core tenets of design-based research, including the iterative refinement of pedagogical strategies in authentic educational settings, stakeholder collaboration, and recursive cycles of implementation, evaluation, and redesign. DBR, as articulated by Cobb, Confrey, diSessa, and others, allows for the simultaneous generation of practical solutions and theoretical insights, thereby bridging the research–practice divide.

Critically, the use of DBR in this context underscores the necessity of embedding pedagogical innovation within real-world institutional and curricular structures. Rather than isolating the intervention in a controlled laboratory environment, the study positioned itself within the natural ecology of a teacher education program, thereby enhancing the ecological validity and transferability of its findings. Through this approach, the research captured both the complexity of professional learning in dynamic educational contexts and the situated challenges that accompany technological and methodological transformation in inclusive teacher preparation.

By triangulating multiple sources of data – literature-based analysis, diagnostic assessments, performance-based evaluations, and reflective student feedback – the study not only traced learning outcomes but also interrogated the processual dimensions of pedagogical change, including shifts in learner engagement, professional identity, and epistemological stance. The methodological design, therefore, served both descriptive and interventionist purposes, enabling a comprehensive understanding of how PBL technologies can be systematically integrated and optimized within special education teacher training.

Research Objectives and Hypotheses

The aim of this study is to examine the use of problematic teaching technologies in the professional training of special teachers, with a focus on how technology can be integrated to support the problem-based learning approach in this context.

The task of this study:

1. Understand the key principles and practices of problem-based learning, and how it can be applied in the context of special education teacher training.
2. Examine the potential role of technology in enhancing problem-based learning, particularly in the context of special education teacher training.
3. Identify the unique challenges and considerations associated with implementing problem-based learning in special education teacher training programs, and how technology can be leveraged to address these challenges.

The outcomes of this study will provide insights and recommendations for effectively integrating technology-enhanced problem-based learning in the professional training of special education teachers.

Subject of this research is the use of problematic teaching technologies in the professional training of special teachers.

This study anticipates that the integration of technology-enhanced problem-based learning can provide significant benefits in the professional training of special education teachers.

This study employed an experimental approach to investigate the use of problem-based learning technologies in the professional training of special education students. The key stages of the research involved:

1. Developing a methodology for integrating Problem-Based Learning Technologies into the professional training curriculum for special education students.

2. Conducting a detection experiment to assess the current use of problem-based learning technologies in the professional training of special education students.

3. Implementing a formation experiment to evaluate the effectiveness of the developed problem-based learning methodology in the professional training of special education students.

4. Analyzing the results to determine the efficacy of the problem-based learning technologies employed in the professional training of special education students.

Participants and Context

The empirical phase of this study was situated within the institutional context of the South Kazakhstan Pedagogical University, specifically the Department of Preschool Education and Teaching Pedagogy, a faculty with a longstanding emphasis on inclusive pedagogical innovation and teacher preparation for special education. The study population consisted of undergraduate students enrolled in the "Training Specialists in Special Pedagogy" degree program (specialty code: 6B01901), who, at the time of data collection, were in their final year of academic coursework and on the cusp of transitioning into professional field placements.

A purposive stratified sampling technique was employed to select a representative cohort of 60 fourth-year students, ensuring a degree of homogeneity in terms of academic progression while allowing for variance in instructional exposure and pedagogical experience. These participants were subsequently divided into two equal groups: an experimental group (n = 30) and a control group (n = 30). The assignment was conducted using matched-pairs design principles, ensuring equivalence across key demographic and academic indicators such as cumulative GPA, practicum engagement, and coursework in special education methodology.

The rationale for selecting fourth-year students lies in their developmental readiness and curricular positioning: these individuals had completed the theoretical components of their training – including coursework in developmental psychology, inclusive education policy, and special needs diagnostics – and were thus pedagogically primed for immersion in applied, problem-oriented instruction. Their proximity to field experience further heightened the ecological validity of the intervention, allowing for more authentic engagement with practice-based problem-solving tasks.

The institutional context itself provided a favorable ecosystem for implementing a pedagogical intervention grounded in problem-based learning. The university's digital infrastructure – comprising virtual learning platforms, interactive classrooms, and access to simulation technologies – enabled the seamless integration of technology-enhanced learning activities. Moreover, faculty collaboration and administrative support ensured consistency in the delivery and monitoring of the experimental curriculum. These contextual conditions served as enablers of both the fidelity of implementation and the scalability of the pedagogical model under investigation.

Furthermore, the sociocultural and educational milieu of South Kazakhstan presents a particularly compelling backdrop for this study. The region is characterized by a growing emphasis on inclusive education reform, catalyzed by national policy shifts and global imperatives such as the United Nations' Sustainable Development Goals (SDG 4.5). Within this evolving landscape, the demand for highly qualified, technologically adept, and diagnostically competent special education professionals has intensified – rendering the present study not only timely but directly responsive to regional and systemic needs.

By situating the research within this authentic educational context and engaging participants at a critical juncture in their professional formation, the study was able to investigate the pedagogical affordances of PBL technologies in a manner that was both methodologically rigorous and

educationally consequential. The implications drawn from this cohort are thus relevant not only to academic theorists but also to curriculum designers, policymakers, and institutional leaders seeking to optimize teacher training for inclusive education systems.

Research Procedure

The research design was operationalized through a structured, three-phase experimental model, informed by principles of formative assessment, experiential learning, and reflective practitioner development. Each phase was deliberately sequenced to capture baseline competencies, implement a targeted pedagogical intervention, and systematically evaluate post-intervention outcomes. The duration of the experimental phase spanned four weeks, during which participants engaged in either traditional instruction (control group) or a technology-integrated problem-based learning curriculum (experimental group).

Diagnostic Phase: Baseline Assessment of Professional Competencies

The preliminary stage involved the administration of a diagnostic pre-assessment to both the experimental and control groups to establish a baseline profile of students' professional readiness across multiple competency domains. A custom-designed instrument was employed, featuring a multidimensional 40-point scale. The assessment was subdivided into the following components:

- Knowledge-Based Items (15 points): A series of 15 structured-response questions were designed to measure students' theoretical understanding of key concepts in special education, including developmental typologies, inclusive pedagogical strategies, and foundational legal frameworks.
- Scenario-Based Performance Items (15 points): Three open-ended, context-rich scenarios (5 points each) were developed to simulate real-life challenges encountered by special educators. These items assessed students' ability to: (a) conceptualize and implement corrective and developmental interventions for learners with speech impairments; (b) engage in constructive collaboration with parents and caregivers; and (c) conduct preliminary diagnostic procedures in cases of suspected speech-language disorders (e.g., dyslalia).
- Reflective and Attitudinal Items (5 points): Two self-reflective prompts measured participants' intrinsic motivation, professional self-concept, and perceived alignment with the values of the special education profession.

This initial diagnostic phase served as a critical foundation for identifying cognitive gaps, instructional needs, and affective orientations, thus informing the subsequent intervention design.

Formative Phase: Implementation of the Instructional Intervention

During the formative phase, a technology-enhanced, problem-based instructional program was implemented exclusively with the experimental group. The intervention was grounded in constructivist learning theory and scaffolded around authentic problem-solving experiences, with explicit alignment to the professional competency standards for special education teachers. The instructional model integrated four core components:

- Theoretical Foundations: A series of foundational lectures and seminar discussions introduced the epistemology of PBL, with particular attention to its cognitive mechanisms, pedagogical implications, and contextual relevance to special education. These sessions also established a shared conceptual vocabulary among participants.
- Problem-Centered Activities: Learners engaged with real-world case studies and simulated classroom dilemmas reflective of the inclusive education context. Problem scenarios were intentionally designed to be ill-structured, requiring students to synthesize interdisciplinary knowledge and apply diagnostic reasoning in ambiguous and open-ended contexts.
- Technology Integration: A suite of digital tools supported the learning process, including:
  - Virtual simulations of individualized education planning (IEP) meetings;
  - Interactive diagnostic platforms modeling speech-language assessments;
  - Online collaborative environments facilitating synchronous and asynchronous peer engagement;
  - Feedback-driven learning management systems enabling formative assessment and iterative learning.

• Reflective Practice: Throughout the intervention, students engaged in structured self-reflection through digital journals, participated in peer-debriefing sessions, and received metacognitive prompts designed to foster professional introspection and adaptive self-regulation. This component was critical for nurturing pedagogical identity and epistemic agency.

In contrast, the control group continued with the existing traditional curriculum, which emphasized lecture-based content delivery, summative assessments, and minimal technology use. No experimental manipulation was applied to this cohort.

Monitoring and Evaluation Phase: Post-Assessment and Triangulation

At the conclusion of the four-week intervention period, both groups were subjected to a post-intervention assessment using the same diagnostic instrument administered at the outset. This allowed for within-group (pre-post) and between-group (experimental-control) comparative analyses of change in professional competencies. Quantitative results were analyzed using descriptive statistics and inferential comparisons, with a focus on assessing developmental gains in the domains of knowledge, application, and reflective engagement.

To triangulate quantitative findings, qualitative data were also collected through:

• Focus Group Discussions (FGDs): Facilitated dialogues with experimental group participants explored their perceptions of the PBL experience, the utility of technology tools, and the development of their professional competencies.

• Reflective Logs: Students' written reflections were thematically coded to capture affective, cognitive, and behavioral indicators of learning progression.

This dual-method evaluation strategy enhanced the credibility and ecological validity of the findings, enabling a nuanced understanding of the pedagogical mechanisms through which PBL technologies influenced professional development outcomes.

Structure of Problem-Based Learning Technology

The implementation of the problem-based learning (PBL) methodology was guided by a five-stage pedagogical scaffold designed to develop core professional competencies in special education students. Each stage was systematically structured to support progressive cognitive engagement, collaborative inquiry, and reflective application.

1. Problem Scenario Design

Students were introduced to real or simulated problem situations reflecting authentic challenges encountered in special education practice. These scenarios were designed to be open-ended, ambiguous, and contextually grounded, encouraging learners to actively engage with pedagogical dilemmas requiring professional judgment.

2. Problem Identification

Through collaborative analysis, students identified the central issue embedded in the scenario. They drew on prior theoretical knowledge and field experience to define the problem clearly, formulate guiding questions, and establish a framework for inquiry.

3. Solution Development

In small groups, students engaged in discussion and hypothesis generation. They proposed multiple strategies, negotiated differing perspectives, and applied pedagogical reasoning to formulate actionable solutions. In this phase, dialogic learning and peer feedback were essential.

4. Evidence-Based Validation

Students critically evaluated their proposed solutions using current academic literature, inclusive education standards, and evidence-based practices. This phase emphasized professional accountability, alignment with ethical guidelines, and justification of instructional decisions.

5. Practical Application and Reflection

Solutions were implemented during microteaching sessions, simulated environments, or field-based tasks. Students then participated in guided reflection to assess the efficacy of their approaches, identify areas for growth, and consolidate learning outcomes.

We designed a problematic scenario to engage students and introduce a challenging situation. A problematic situation refers to a state of cognitive challenge stemming from the learner's insufficient prior knowledge and inadequate mental or practical strategies to address an emerging cognitive issue.

Problematic situations can be categorized into two types:

1. Situations with an element of surprise, where students exhibit divergent perspectives on the performance of a shared task.

2. Situations with inherent difficulty, where students are unable to competently manage a practical assignment involving unfamiliar subject matter [10].

Duration and Implementation

The experimental intervention was carried out over the course of one full academic semester (15 weeks). During this period, participants in the experimental group were systematically engaged in a sequence of problem-based learning cycles, each comprising scenario analysis, collaborative problem-solving, solution validation, and reflective synthesis. These cycles were interspersed with targeted theoretical instruction and thematic integration of digital technologies, including virtual simulations, diagnostic modeling tools, and interactive case platforms.

To ensure fidelity of implementation, a multi-tiered monitoring framework was employed:

- Instructor logs were maintained to document weekly instructional activities, adjustments to scenario delivery, and pedagogical reflections.
- Student artifacts—including solution plans, digital journals, and peer feedback - were collected to evaluate engagement, application of theory, and progression of professional reasoning.
- Observational protocols were utilized during sessions to assess adherence to the PBL methodology, group dynamics, and the effective use of technological tools.

This structured and rigorously monitored implementation ensured consistency across instructional delivery and enhanced the reliability of outcome evaluation.

Results. The findings from this study are presented in two dimensions: (1) quantitative analysis of student performance before and after the implementation of problem-based learning (PBL) technologies, and (2) qualitative insights drawn from students' reflective responses and group discussions. Together, these results illustrate the effectiveness of the PBL intervention in enhancing the professional competencies of future special education teachers.

Quantitative Results

The results from the control and experimental groups of the study examining the implementation of problem-based learning technologies in the professional training of special education students are presented below (Figure 1; 2).

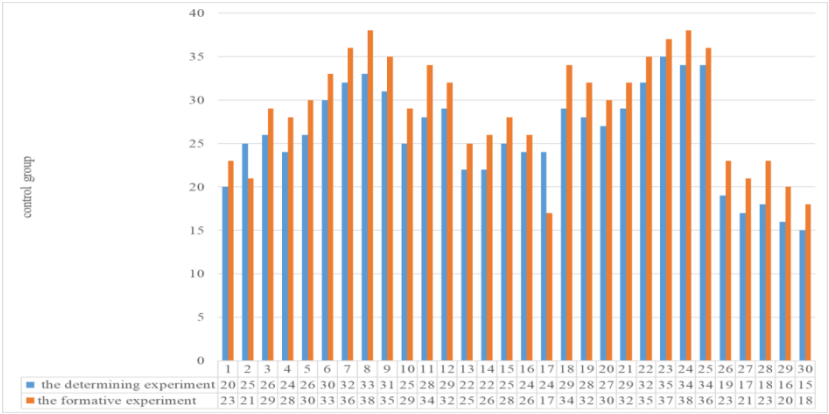

Figure 1 Control group

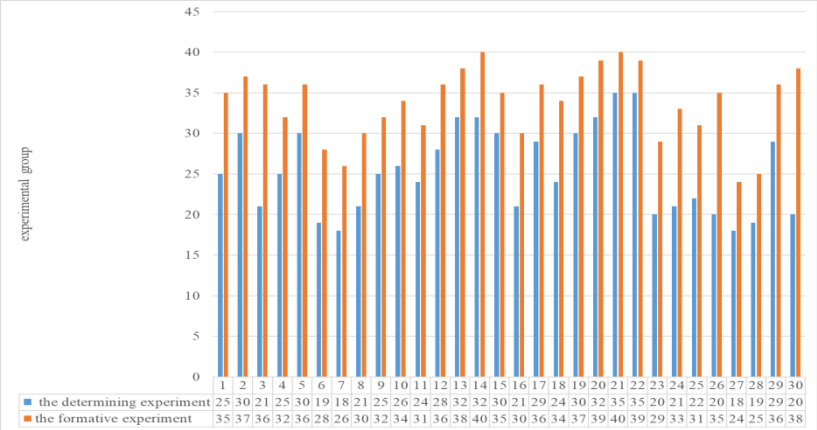

Figure 2 Experimental group

A pre- and post-test design was used to evaluate students' professional competencies in both the control and experimental groups. At the beginning of the study, the mean scores were statistically similar between the groups (Control: M = 24.1; Experimental: M = 23.6 out of 40), indicating a comparable baseline.

Following the 15-week PBL intervention, significant improvement was observed in the experimental group. The post-test mean score for the experimental group increased to 37.2, whereas the control group's mean score rose modestly to 28.1. This reflects a 57.6% increase in the experimental group compared to 16.6% in the control group.

A statistical comparison using an independent samples t-test confirmed the significance of this difference:

t (58) = 6.41, $p < .001$, Cohen's $d = 1.65$

This large effect size suggests a robust impact of PBL technologies on students' competency development.

Further breakdown by professional sub-competencies revealed that the most pronounced gains were in:

- Diagnostic and assessment abilities (+62%)
- Corrective and developmental planning (+58%)
- Collaborative interaction with families and professionals (+49%)

These results indicate that technology-integrated PBL significantly enhances practical and reflective skills that are foundational for special education practice.

Qualitative Results

Qualitative data obtained from student reflective journals and post-intervention focus group discussions yielded rich insights into the cognitive, emotional, and professional transformations experienced by participants in the experimental group. Thematic analysis identified recurrent patterns that not only aligned with the quantitative outcomes but also illuminated the deeper pedagogical value of the problem-based learning (PBL) intervention.

A predominant theme emerging from the data was the development of professional confidence. Many students described a shift from passive reception of abstract theoretical content to active, situated engagement with real-world pedagogical challenges. This transition was consistently attributed to the immersive nature of the PBL framework, which required students to assume professional roles, diagnose educational difficulties, and construct actionable interventions. Learners articulated that such experiential engagement enabled them to "think like a teacher," rather than merely fulfilling the role of a student.

Furthermore, the problem-centered design of the course fostered a notable enhancement in students' problem-solving capacities. Participants emphasized that encountering authentic, ill-structured scenarios required them to reason critically, navigate uncertainty, and reconcile multiple variables – skills rarely

cultivated through conventional instructional approaches. This aligns with findings by P.K. Masuku and A. Mupawose, who demonstrated that writing-intensive, practice-driven platforms significantly enhance learners' critical thinking and applied reasoning in clinical and professional contexts [11].

In addition to cognitive gains, students reported heightened motivation and a strengthened sense of professional identity. Many participants conveyed a renewed sense of purpose and clarity regarding their role as future special educators. The iterative, inquiry-driven nature of the learning tasks was described as emotionally engaging and professionally validating, as it allowed students to see the direct relevance of their academic preparation to their future work. This process of identity formation through experiential engagement mirrors S. Bahri and M.Meisuri observation that performance- and process-based pedagogies catalyze deeper emotional investment and learner transformation [12].

Technology played a pivotal enabling role in this developmental trajectory. Interactive platforms were consistently described as intuitive, dynamic, and conducive to deeper learning. Simulations offered realistic practice environments for high-stakes tasks such as individualized education plan (IEP) development, speech-language screening, and interdisciplinary collaboration. Moreover, digital collaboration tools facilitated dialogic learning, real-time peer feedback, and collective knowledge construction—benefits students noted were largely absent in traditional lecture-based courses.

Taken together, the qualitative findings affirm that the PBL intervention was not merely effective in terms of measurable performance gains, but was also profoundly transformative in shaping students' professional dispositions, reflective habits, and pedagogical identities. Through the synthesis of practice, inquiry, and technology, the intervention fostered a learning environment in which future special educators could meaningfully develop the competencies, confidence, and commitment necessary for inclusive professional practice.

Discussion. The results of this study provide compelling evidence that the integration of problem-based learning (PBL) technologies into the professional training of special education teachers fosters significant improvements in critical areas of pedagogical competence. Participants in the experimental group demonstrated measurable gains in diagnostic assessment, individualized intervention planning, and collaborative engagement with families – competencies that are foundational to effective special education practice. These findings are consistent with prior research which has emphasized the transformative potential of PBL in enhancing student autonomy, reflective thinking, and applied problem-solving capacity [13].

Beyond quantitative improvement, the qualitative data suggest that PBL technologies contribute meaningfully to students' professional identity formation and motivation. Learners reported increased confidence in navigating complex instructional scenarios and a stronger sense of preparedness for the demands of inclusive education environments. This echoes the findings of H. Suwono, K. E. Dewi, who highlighted that PBL, when blended with online modalities, enhances student motivation, scientific communication skills, and higher-order thinking in diverse educational contexts [14].

The successful application of PBL in this study was supported by three interlocking instructional modalities: (1) guided problem-solving activities and case studies anchored in real-world special education practice; (2) technology-mediated learning environments such as virtual simulations, interactive diagnostic tools, and collaborative platforms; and (3) structured opportunities for reflective practice, enabling students to connect theoretical frameworks with practical application. These dimensions align with prior models that advocate for a combination of scaffolded facilitation, learner agency, and experiential immersion as key to meaningful professional learning [15]

The effectiveness of the PBL approach was also contingent upon several pedagogical conditions. Chief among them was the careful design of problem scenarios – they needed to be realistic, developmentally appropriate, and sufficiently complex to elicit sustained inquiry and collaborative negotiation. Additionally, learner motivation emerged as a mediating variable in the success of the intervention. This is in line with research indicating that meaningful engagement in PBL environments is significantly enhanced when students perceive tasks as relevant, challenging, and conducive to personal growth [16].

To ensure both depth and breadth of learning, this study employed a multi-tiered model of PBL implementation:

- In lecture-based formats, instructors framed core concepts and posed diagnostic challenges, while encouraging active student questioning and preliminary solution proposals.
- In partially guided formats, students engaged in small-group problem-solving under the direction of instructors who facilitated learning through carefully sequenced, inquiry-driven questioning.
- In independent research contexts, students formulated their own problem inquiries and investigated solutions through coursework, capstone projects, or case study analyses, culminating in feedback-driven evaluation.

Another notable finding of this study is the resilience-building function of PBL. Students reported that repeated exposure to ambiguous, cognitively demanding scenarios encouraged persistence, adaptability, and self-direction. Rather than disengaging in the face of difficulty, participants described the learning environment as one in which overcoming obstacles became central to their growth. This supports L.S. Vygotskian perspectives on the role of cognitive dissonance in developmental learning, as well as D.A.Kolb's experiential learning theory, which situates challenge and reflection as dual engines of transformative education.

Taken together, these outcomes confirm that the integration of problem-based learning technologies is not merely a didactic innovation, but a paradigm shift in professional preparation, particularly in fields where responsiveness, diagnostic acumen, and collaboration are essential. This pedagogical orientation prepares special education teachers not only to transfer knowledge but to construct situated solutions to emergent classroom challenges.

Based on the theoretical analysis and experimental evidence, several key conclusions can be drawn:

1. The application of problem-based learning significantly enhances special education students' capacity to conduct corrective and developmental interventions, collaborate with parents, and implement context-specific diagnostic strategies.

2. PBL fosters intrinsic motivation, strengthens professional commitment, and stimulates positive attitudes toward the teaching profession.

3. The efficacy of PBL depends critically on the instructional design – especially the realism of problem scenarios, the quality of teacher facilitation, and the balance between guidance and autonomy in learner engagement.

It is important to acknowledge the study's limitations. Given the complexity of the research topic and the scope of available resources, the investigation was necessarily constrained to a single instructional framework within a single institutional context. Future research should expand this inquiry across diverse settings and explore longitudinal outcomes, including in-service applications and the impact on learner outcomes in inclusive classrooms.

Nonetheless, the present study contributes meaningful empirical and theoretical insights into the preparation of special education teachers through innovative pedagogical design. As the demands of inclusive education continue to evolve, so too must the models through which educators are trained. Problem-based learning – particularly when strategically integrated with digital technologies – offers a promising pathway for cultivating the reflective, resilient, and responsive professionals needed in today's educational landscape.

Conclusion. The present study investigated the pedagogical efficacy of problem-based learning (PBL) technologies in the professional training of special education teachers. The integration of PBL into the curriculum – supported by digital simulations, collaborative platforms, and real-world problem scenarios – significantly enhanced students' professional competencies, particularly in diagnostic reasoning, corrective intervention design, and collaborative practice. Quantitative results demonstrated substantial and statistically significant improvements in the experimental group compared to the control group, while qualitative findings revealed increased motivation, autonomy, and professional identity formation among participants exposed to the PBL model.

These outcomes underscore the transformative potential of learner-centered, technology-supported methodologies in developing the complex skill sets required for inclusive education. Moreover, the

study affirms that PBL, when implemented through a balanced blend of guided instruction, authentic problem engagement, and reflective inquiry, can foster not only technical proficiency but also critical thinking, creativity, and resilience – competencies that are essential for future educators operating in dynamic, diverse learning environments.

However, several limitations must be acknowledged. First, the scope of the study was limited to a single institutional context with a relatively small sample size, which may constrain the generalizability of the findings. Second, the duration of the intervention, though sufficient for initial analysis, may not fully capture the long-term retention or transferability of competencies developed through PBL. Third, while qualitative data provided valuable insights into student perceptions and experiences, it was based on self-reported reflections, which may be subject to social desirability or bias. Furthermore, the study did not explore the direct impact of teacher preparedness on student outcomes in inclusive classrooms, an important dimension for future inquiry.

In light of these limitations, several recommendations are proposed. Future research should expand the sample size and include multiple institutions to enhance external validity. Longitudinal studies are also warranted to investigate the sustainability of PBL-induced competencies over time and in professional field settings. Additionally, future investigations might explore differentiated PBL models tailored to specific categories of special needs education, examining how adaptive technologies and problem complexity levels can be optimized for diverse learner profiles.

For practitioners and curriculum designers, the study highlights the importance of embedding structured, technology-enhanced problem-solving tasks within teacher education programs. Designing realistic, open-ended scenarios; fostering peer collaboration; and ensuring consistent reflective practice should be central to professional preparation frameworks. Moreover, faculty training in PBL facilitation and digital tool integration is essential for maintaining instructional quality and alignment with inclusive education goals.

In conclusion, the findings of this study contribute to a growing body of literature that positions problem-based learning not merely as a method, but as a paradigm capable of reshaping teacher education. When designed and implemented thoughtfully, PBL technologies have the potential to produce reflective, competent, and resilient educators prepared to meet the evolving challenges of contemporary special education.

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ЦИФРОВАЯ ПОДДЕРЖКА ФИЗИЧЕСКОЙ КУЛЬТУРЫ СТУДЕНТОВ

Аннотация

В статье представлены исследования по выявлению влияния цифровых технологий на физическую активность и мотивацию занимающихся. В последние годы появилось множество разнообразных приложений, в том числе используемые в области физической культуры и спорта. И все большее количество пользователей разного возраста применяют мобильные приложения для физического совершенствования и повышения интереса к занятиям физическим упражнениями. Мобильные приложения получили большую популярность в молодежной среде и стали частью их повседневной жизни, что послужило основой проведения педагогического исследования с целью подбора и анализа их воздействия на физическую и мотивационную активность студентов в рамках учебных занятий. Статья основана на результатах исследования, проведенного в контексте управляемого педагогического эксперимента, имеющего прикладной характер с использованием научных, педагогических методов и математического анализа.

Практическая ценность проведенного педагогического исследования доказывает взаимовлияние применения мобильных приложений на физическое состояние и вовлеченность занимающихся в процесс физического воспитания, что способствует повышению эффективности проведения занятий физической культурой. Кроме этого, применение мобильных технологий согласно данным эксперимента, позволяет реализовать идею личностно-ориентированного подхода в преподавании дисциплины «Физическая культура».

Ключевые слова: цифровые технологии, мобильные приложение, физическая активность, мотивация, работоспособность.

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СТУДЕНТТЕРДІҢ ДЕНЕ ШЫНЫҚТЫРУЫН ЦИФРЛЫҚ ҚОЛДАУ

Аңдатпа

Мақалада цифрлық технологиялардың шұғылданушылардың дене белсенділігі мен уәждемесіне әсерін анықтау бойынша зерттеулер ұсынылған. Соңғы жылдары көптеген әртүрлі қосымшалар, оның ішінде дене шынықтыру және спорт саласында пайдаланылатын қосымшалар пайда болды. Әртүрлі жастағы пайдаланушылардың көбі дене шынықтыруды жетілдіру және дене жаттығуларымен айналысуға қызығушылығын арттыру үшін мобильді қосымшаларды қолданады. Мобильдік қосымшалар жастар ортасында үлкен танымалдыққа ие болды және олардың