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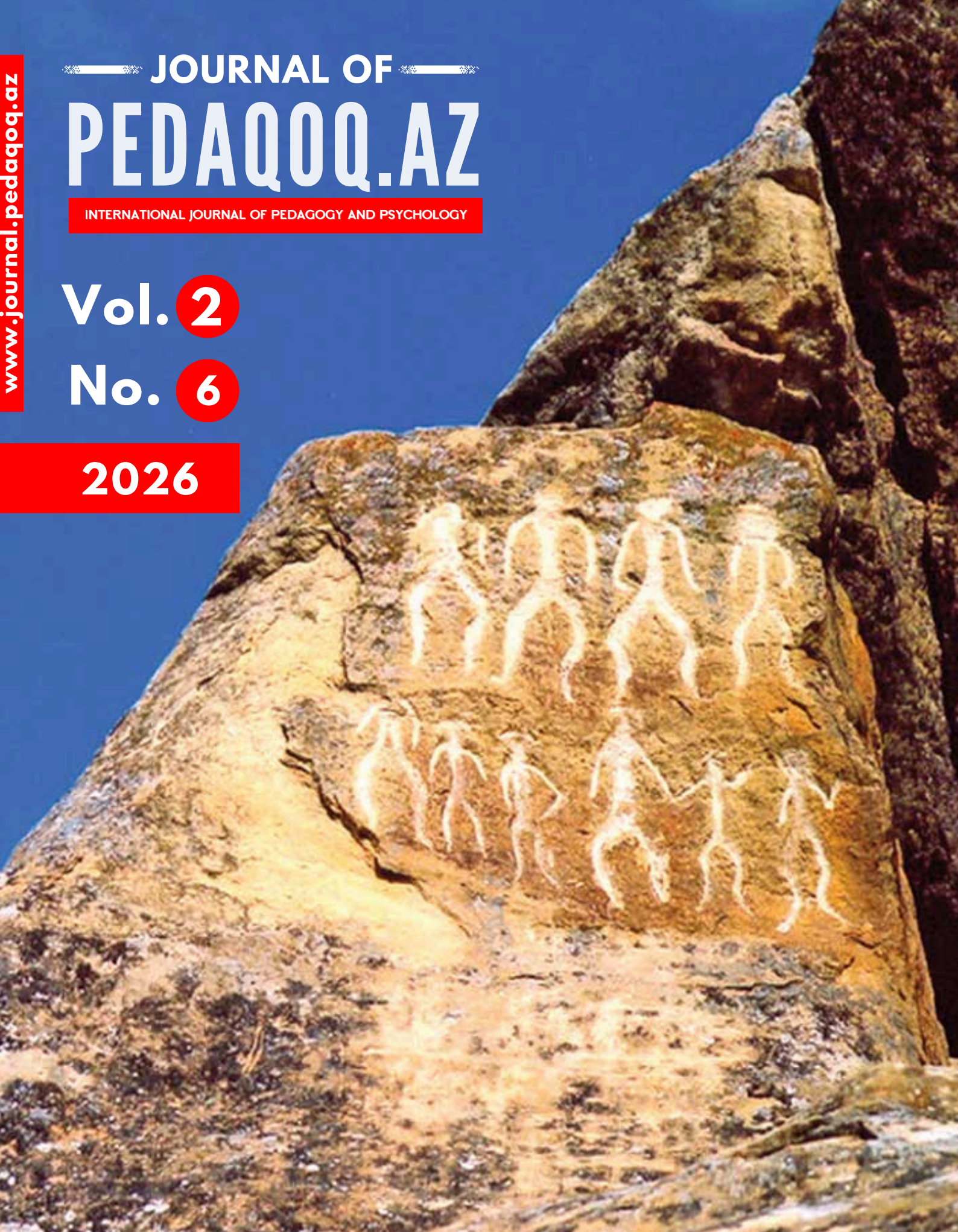
JOURNAL OF PEDAQOQ.AZ

INTERNATIONAL JOURNAL OF PEDAGOGY AND PSYCHOLOGY

Vol. 2
No. 6
2026



www.journal.pedaqoq.az
PEDAQOQ.AZ
ISSN 3080-3543

JOURNAL OF PEDAQOQ.AZ

Web: journal.pedaqoq.az
E-ISSN: 3080-3543 (Online)
E-mail: journal.pedaqoq.az@gmail.com

JOURNAL OF PEDAQOQ.AZ

Vol. 2, No. 6, 2026,
e-ISSN 3080-3543 (Online)
https://journal.pedaqoq.az

WEB: journal.pedaqoq.az
E-ISSN: 3080-3543 (Online)
E-mail: journal.pedaqoq.az@gmail.com

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CONTENT

JOURNAL OF PEDAQOQ.AZ | **WEB**: journal.pedaqoq.az | **E-ISSN:** 3080-3543 | **VOL. 2, NO. 6 (2026)**

-4-

PEDAGOGY

THE DIDACTIC ESSENCE AND FUNCTIONAL CHARACTERISTICS OF TRAINING AND SEMINARS IN A COMPETENCY-BASED MODERN EDUCATION SYSTEM

Rufat Huseynzade,
Doctor of Pedagogical Sciences, Professor
Department of General Pedagogy
Azerbaijan State Pedagogical University
Azerbaijan, Baku
ORCID: 0000-0002-8558-5858

Keywords: training, seminar, competency-based education, didactics, professional development, adult learning, constructive alignment, training transfer, higher education, assessment

Abstract. Academician Huseyn Ahmadov occupies a distinguished place in the history of Azerbaijani pedagogical science through his extensive research, academic achievements, and contributions to the development of educational thought. Although numerous studies have examined his scholarly legacy, comparatively little attention has been paid to his close relationship with the scientific and pedagogical environment of Nakhchivan. This article explores Huseyn Ahmadov's role in the formation and development of Nakhchivan's educational and academic traditions, emphasizing his contribution to teacher education, the study of the history of schools, and the advancement of pedagogical research in the region. The study examines his academic cooperation with Nakhchivan State University, his lectures on the history of Azerbaijani schools and pedagogical thought, and his influence on the preparation of scientific and pedagogical personnel. Particular attention is devoted to his research on the educational heritage of Nakhchivan from ancient times to the nineteenth and twentieth centuries. For a systematic analysis, Huseyn Ahmadov's relationship with the scientific and pedagogical environment of Nakhchivan is examined through four major stages, reflecting different dimensions of his scholarly and educational activities. The findings demonstrate that his work made a significant contribution to preserving the pedagogical heritage of Nakhchivan, enriching historical-pedagogical research, and strengthening the development of educational science in Azerbaijan.

Introduction

Academician Huseyn Ahmadov occupies a distinguished position in the history of Azerbaijani pedagogical science due to his extensive scholarly contributions to the study of education, the history of pedagogical thought, and teacher training. His scientific heritage has been widely recognized by researchers; however, one important aspect of his academic activity has received comparatively limited attention—his close relationship with the scientific and pedagogical environment of Nakhchivan. Throughout his academic career, Huseyn Ahmadov maintained active cooperation with Nakhchivan State University and made significant contributions to the development of educational research and teacher education in the region. Born on 17 July 1926 in Tokhluja village of the Krasnoselo (Chambarak) district of Western Azerbaijan, Huseyn Ahmadov received his early education under the guidance of his grandfather before continuing his studies in different educational institutions in present-day Armenia, Ganja, and Baku. Through continuous academic advancement, he earned the highest scientific qualifications, becoming a Doctor of Sciences, Professor, and Academician. His broad scholarly interests included the history of Azerbaijani education, pedagogical thought, and the development of educational institutions, areas in which he became one of the country's leading authorities. An important part of Ahmadov's scientific and pedagogical activity was devoted to Nakhchivan. He regularly delivered lectures at Nakhchivan State University on the history of Azerbaijani schools and pedagogical thought, participated in the preparation of scientific and pedagogical personnel, and made valuable contributions to the study of the history of schools and education in Nakhchivan. His research paid particular attention to the educational and pedagogical heritage of the region from ancient and early medieval periods to the nineteenth and twentieth centuries, thereby enriching the historiography of Azerbaijani education. The purpose of this article is to examine Huseyn Ahmadov's contribution to the scientific and pedagogical development of Nakhchivan. For a more systematic analysis, his relationship with the region is

discussed in four major areas: his role in teacher education in Nakhchivan, his contribution to the preparation of scientific personnel, his research on the history of Nakhchivan schools, and his studies on the history of education and pedagogical thought in Nakhchivan.

Main part. Huseyn Ahmadov's relationship with the scientific and pedagogical environment of Nakhchivan can be examined in four major dimensions:

1. Huseyn Ahmadov and Teacher Education in Nakhchivan
2. Huseyn Ahmadov and the Training of Scientific Personnel in Nakhchivan
3. Huseyn Ahmadov and the Study of the History of Schools in Nakhchivan
4. Huseyn Ahmadov and the Research on the History of Education and Pedagogical Thought in Nakhchivan

Although the principal focus of Huseyn Ahmadov's scholarly research was the history of nineteenth-century Azerbaijani schools and pedagogical thought, his academic works covered almost every historical stage of Azerbaijan's educational development. His studies comprehensively examined the educational and pedagogical heritage of the ancient, medieval, modern, and contemporary periods. Through numerous monographs and scientific publications, he introduced original historical evidence and revealed many valuable pedagogical facts that significantly enriched the historiography of Azerbaijani education.

The importance of studying the history of education has also been emphasized by the national leadership of Azerbaijan. National Leader Heydar Aliyev repeatedly stressed that every stage of the country's educational history constitutes an invaluable part of the nation's cultural heritage and should be carefully studied and preserved. Likewise, President Ilham Aliyev has highlighted that the history of Azerbaijani education is rich in achievements that serve as a source of national pride and contribute to strengthening historical consciousness and national identity.

One of Huseyn Ahmadov's most significant contributions was his initiative to develop the special university course «History of Azerbaijani Schools and Pedagogical Thought» during the 1970s. Introducing this course into higher education curricula was far from straightforward. At a time when Soviet educational policy largely discouraged independent research into national history and cultural heritage, the proposal to study the historical development of Azerbaijani schools and indigenous pedagogical thought encountered considerable ideological and administrative obstacles. Various procedural requirements, pilot implementations, and experimental teaching stages were imposed before the course could receive official recognition.

For these reasons, the ancient land of Nakhchivan, renowned for its commitment to preserving historical traditions and national-spiritual values, became the first region in which this course was experimentally introduced and taught. This decision was not accidental. According to historical studies and available scholarly sources, Nakhchivan occupies a unique place in the history of education. Some researchers associate the earliest educational center, referred to as «Skale,» with the Gamigaya cultural complex in Nakhchivan. The term Skale, derived from the Latin language, has been interpreted as referring to spiritual development, gradual education, or successive stages of learning. This interpretation symbolically reflects the concept of education as a progressive process of intellectual and moral development. Although such interpretations primarily belong to historical-pedagogical scholarship, they further emphasize the exceptional significance attributed to Nakhchivan in discussions of the origins and historical evolution of education in Azerbaijan.

The selection of Nakhchivan as the first place for teaching and discussing the history of Azerbaijani schools and pedagogical thought was a natural consequence of the region's rich historical traditions and its enduring commitment to preserving national and cultural values. It was within this intellectual environment that the proposed curriculum and the special university course received its first academic evaluation, gaining the support of local scholars and educators who recognized its scientific and pedagogical significance. Following its successful implementation in

Nakhchivan, the program was gradually introduced into other pedagogical higher education institutions throughout Azerbaijan.

During the 1970s, Huseyn Ahmadov was invited to the Yusif Mammadaliyev Nakhchivan State Pedagogical Institute (currently Nakhchivan State University) to deliver lectures on the course History of Azerbaijani Schools and Pedagogical Thought. For several years, he taught this subject while simultaneously conducting research on the history of educational institutions in Nakhchivan. The curriculum was first implemented and tested at this institution before being introduced at other pedagogical universities in Azerbaijan and later at the A. S. Pushkin Tbilisi Pedagogical Institute, where it also underwent further academic evaluation and practical application.

Covering the historical development of education in Azerbaijan from ancient times to the modern era, the course provided a systematic examination of the emergence and evolution of schools, educational traditions, and the pedagogical ideas of prominent educators and intellectuals. It became one of the first comprehensive academic frameworks for studying the history of Azerbaijani education and pedagogical thought and continues to serve as an important reference in teacher education.

The introduction of this curriculum stimulated extensive historical-pedagogical research. Building upon its conceptual framework, numerous scholars produced monographs, scientific publications, and doctoral dissertations devoted to the history of education and pedagogical thought in Azerbaijan. Owing to its importance in preparing competent and professionally qualified teachers, the curriculum was repeatedly revised and expanded. Updated editions were published in 1984, 1992, 1996, and 2010, reflecting new historical evidence, methodological developments, and changing educational priorities.

The revised versions of the curriculum introduced new perspectives on the history of Azerbaijani schools, education, and pedagogical thought, particularly in light of the country's independence and the emergence of modern pedagogical

approaches. These developments ultimately culminated in the publication of Huseyn Ahmadov's textbook History of Azerbaijani Schools and Pedagogical Thought in 2014, which remains one of the principal academic resources in this field [1].

Today, the curriculum has become firmly established in pedagogical universities and teacher education colleges across Azerbaijan. In particular, it occupies an important place within the Department of General Pedagogy of Azerbaijan State Pedagogical University, where, under the leadership of Associate Professor Farida Khudiyeva, the history of education and pedagogical thought is successfully taught as a fundamental component of the Pedagogy curriculum. The most recent revisions of the program reflect an independent national perspective on Azerbaijan's educational heritage, incorporating contemporary pedagogical thinking and responding to the evolving requirements of modern teacher education.

Huseyn Ahmadov did not limit his activities in Nakhchivan to teaching and researching the history of Azerbaijani schools and pedagogical thought. Equally important was his effort to disseminate the results of his research and translate them into educational practice. To facilitate the teaching of this subject and promote its wider adoption in higher education, he prepared textbooks and teaching materials that made the discipline more accessible to students and educators. These achievements reflected not only his many years of scholarly dedication, initiative, and academic perseverance but also his deep commitment to preserving Azerbaijan's national educational heritage.

Ahmadov's proposal in the 1970s to introduce the systematic study of the history of Azerbaijani schools and pedagogical thought represented an important milestone in the development of national pedagogical science. Despite the ideological restrictions of the Soviet period, he successfully established this academic field, and by the 1990s the course had become an integral component of teacher education programs throughout Azerbaijan. This achievement is widely regarded as one of the most significant contributions of his scientific and pedagogical career [1].

In addition to his scholarly work, Huseyn Ahmadov made a substantial contribution to the preparation of pedagogical and scientific personnel, both in Azerbaijan generally and in the Nakhchivan Autonomous Republic in particular. As a respected scholar with extensive expertise in pedagogy, he supervised doctoral research, served as scientific consultant and official opponent for numerous dissertations, and provided valuable academic guidance to young researchers. Many scholars from Nakhchivan obtained their academic degrees with his support and mentorship, thereby contributing to the further development of educational science in the region.

One notable example of his scholarly mentorship was his role as the first official opponent of Rufat Huseynzade's doctoral dissertation entitled School and Pedagogical Thought in Azerbaijan during the Early Middle Ages (Seventh–Eleventh Centuries). In his official review, Ahmadov emphasized that although the history of Azerbaijani pedagogical thought from the twelfth century onward had been studied to some extent, the earlier period — particularly the seventh to eleventh centuries — had remained largely unexplored. He described the dissertation as an original, highly relevant, and scientifically significant contribution that successfully filled an important gap in the historiography of Azerbaijani pedagogical thought. Ahmadov further noted that the research possessed considerable theoretical and practical value and substantially enriched the study of the history of education in Azerbaijan [2].

The successful completion of this research was supported by the author's extensive family archive and scholarly resources inherited from his father, Latif Huseynzade, a distinguished educator, orientalist, literary scholar, and recipient of the Istiglal Order. Having lived through four different political periods—Imperial Russia, the Azerbaijan Democratic Republic, the Soviet Union, and independent Azerbaijan - Latif Huseynzade possessed an exceptional educational background that combined traditional Islamic education with modern secular schooling. His personal library, rare manuscripts, historical documents on education, and valuable guidance created favorable conditions for conducting research on the educational and pedagogical

heritage of ancient and medieval Azerbaijan.

Ahmadov also supervised numerous studies devoted to the theoretical foundations of pedagogy, including educational theory, didactics, and moral education. The research conducted under his supervision introduced important theoretical and practical innovations that contributed to the further development of pedagogical science in Azerbaijan.

Another important aspect of Ahmadov's scholarly activity was his research on the history of schools. He devoted particular attention to documenting the histories of educational institutions with long historical traditions. Following his studies on schools such as the 100-Year-Old Yukhari Salahli Village School, the 100-Year-Old Garghabazar School, the 100-Year-Old Vandam School, and the 150-Year-Old Sheki School, he also conducted comprehensive research on the educational heritage of Nakhchivan. His article «The 170-Year-Old Nakhchivan School» represented a significant contribution to the historiography of Azerbaijani education by documenting the historical development of one of the country's oldest educational institutions. In this work, Ahmadov emphasized that the pace of educational development in the Nakhchivan Autonomous Republic was among the highest in the region, reflecting the growing importance attached to education in independent Azerbaijan [1].

The activities of the Gori Teachers' Seminary in preparing pedagogical personnel occupied an important place in Huseyn Ahmadov's research. Together with the distinguished educator and psychologist, Associate Professor Latif Huseynzade, recipient of the Istiglal Order and the honorary title Honored Teacher, as well as Academician Huseyn Ahmadov and Professor Abdul Alizadeh, he contributed to scholarly discussions on the historical role of the Seminary in teacher education. To commemorate the 100th anniversary of the Gori Teachers' Seminary, a major scientific conference was organized in 1979, highlighting the institution's exceptional contribution to the development of Azerbaijani education.

The graduates of the Gori Teachers' Seminary from Nakhchivan were of particular interest to Huseyn Ahmadov. Although he had already published detailed

studies on several of these educators, he was convinced that many important personalities had not yet been identified or adequately researched. He therefore encouraged further archival investigations into this subject. Subsequent research conducted in archival collections, including the archives of the Azerbaijan Education Museum and various memoirs and historical documents, led to the identification of numerous previously overlooked graduates and provided valuable new information about their educational and professional activities.

These investigations confirmed that among the Seminary's graduates from Nakhchivan were Mirza Alimammad Khalilov, Mirza Alakbar Suleymanov, Alasgar Sheikhhasanov, Jalil Mammadguluzadeh, Heydar Muradasilov, Mirza Abulgasim Sultanov, Alakbar Mammadkhanov, Karimbey Asad oglu Ismayilov, Mahammadali Sidqi Safarov (son of M. T. Sidqi), Alirza Rasizadeh (brother of Huseyn Javid), Rahim Kazimbeyov, Mahammadhuseyn Mirza Tagi oglu Khalilov, Khalil Ismayil oglu Hajilarov, Alakbar Tagi oglu Abbasov (Alakbar Garib), Ali Sabri Gasimov, and Gurban Hasanov. The identification and documentation of these educators further demonstrated Ahmadov's enduring commitment to investigating Nakhchivan's educational heritage and preserving its historical legacy.

Huseyn Ahmadov's outstanding scholarly achievements received both national and international recognition. In 1998, he was awarded the Jan Amos Comenius Grand Gold Medal of the International Academy of Pedagogical Sciences for his significant contributions to pedagogical research and the preparation of scientific and teaching personnel. In 1999, he was elected a Foreign Member of the Russian Academy of Education, and in 2005, he received the Golden Medal «Service to the Turkic World» from the International Academy of Sciences for Turkic World Studies. Earlier, he had been awarded the honorary titles Excellent Educator of the Azerbaijan SSR (1973), Excellent Educator of the USSR (1977), the Honorary Diploma of the Supreme Soviet of the Azerbaijan SSR, and Honored Higher School Worker of the Azerbaijan SSR (1981). Since 2007, he had also been a recipient of the Presidential Scholarship of the Republic of Azerbaijan and was recognized as a veteran of both labor and war.

Ahmadov's scholarly legacy is exceptionally rich. He was one of the principal contributors to the monumental work Anthology of Azerbaijani Pedagogical Thought, published in Moscow, as well as to Volumes I and IV of the multi-volume publication Essays on the History of Schools and Pedagogical Thought of the Peoples of the USSR (Moscow, 1989, 1991), the two-volume Russian Pedagogical Encyclopedia, and Volumes IV–X of the Azerbaijan Soviet Encyclopedia. Throughout his academic career, he authored nearly 500 monographs, books, textbooks, teaching manuals, methodological publications, and scientific articles, many of which were published in Azerbaijani, Russian, English, Turkish, Georgian, and Uzbek.

Today, Huseyn Ahmadov is remembered as one of Azerbaijan's most distinguished educational scholars and respected university teachers. His life, scientific achievements, research fields, and academic school have been comprehensively documented by Professor Farrukh Rustamov in the book Academician Huseyn Ahmadov and His Disciples [2]. Professor Rustamov has also compiled Ahmadov's bibliography, systematized his scientific and methodological publications, documented the dissertations he supervised or officially reviewed, and authored numerous studies devoted to his scholarly legacy

Conclusion

Academician Huseyn Ahmadov made an outstanding contribution not only to the development of Azerbaijani pedagogical science but also to the formation and advancement of the scientific and pedagogical environment of Nakhchivan. His long-standing cooperation with Nakhchivan State University, active participation in the preparation of pedagogical and scientific personnel, and extensive research on the history of schools, education, and pedagogical thought significantly enriched the historiography of Azerbaijani education and strengthened teacher education in the region.

The study demonstrates that Ahmadov's scholarly legacy extends beyond his numerous publications and research projects. His initiative in introducing the systematic study of the history of Azerbaijani schools and pedagogical thought into higher education laid the foundation for a new academic field that continues to play an important role in teacher education today. His mentorship of young researchers and his support for historical-pedagogical studies also contributed to the emergence of a new generation of educational scholars, particularly in Nakhchivan.

In conclusion, Huseyn Ahmadov's scientific, pedagogical, and organizational activities have left a lasting impact on the development of educational science in Azerbaijan. His work remains an important source for researchers studying the history of education and pedagogical thought, while his contribution to the scientific and pedagogical development of Nakhchivan constitutes a significant part of his enduring academic legacy.

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PSYCHOLOGICAL FACTORS IN THE INTEGRATION OF ARTIFICIAL INTELLIGENCE INTO THE EDUCATIONAL ENVIRONMENT AND ITS IMPACT ON LEARNING

Nurlan Mammadov,
Doctor of Philosophy in Pedagogy
Department of Pedagogy
Baku Slavic University
Azerbaijan, Baku
ORCID: 0000-0002-9673-0862

Keywords: artificial intelligence, learning psychology, motivation, cognitive load, self-regulated learning, AI-supported education, adaptive learning, metacognition, learner autonomy, human-AI interaction

Abstract. The widespread use of smartphones has significantly transformed contemporary educational practices, creating new opportunities as well as new psychological and pedagogical challenges. As one of the most accessible digital technologies, smartphones enable students to obtain information instantly, participate in interactive learning activities, communicate with teachers and peers, and access educational resources regardless of time and location. At the same time, excessive or inappropriate smartphone use may reduce attention, increase cognitive distraction, we aken self-regulation, and negatively influence academic performance and learning motivation. This study examines the psychological effects of smartphone use on students' learning and motivation during the educational process. The paper analyzes both the positive educational potential of smartphones and the psychological risks associated with their uncontrolled use. Particular attention is devoted to learning motivation, cognitive attention, self-regulated learning, digital engagement, and classroom participation. Properly managed smartphone use can enhance learner motivation, facilitate active participation, and improve educational outcomes, whereas uncontrolled use may impair concentration and academic achievement.

-16-

DRAGOȘ-MARIAN RUSU. THE EFFECT OF SMARTPHONES ON STUDENTS' LEARNING AND MOTIVATION DURING THE EDUCATIONAL PROCESS **(pp. 15-23)**

PSYCHOLOGY

Introduction

The increasing integration of artificial intelligence into education is transforming not only instructional technologies but also the psychological mechanisms underlying learning. AI-supported educational environments provide opportunities for adaptive instruction, individualized feedback, intelligent tutoring, continuous assessment, and personalized learning trajectories. At the same time, the growing involvement of artificial intelligence in cognitive and educational activities raises important questions concerning learner motivation, cognitive load, self-regulation, autonomy, critical thinking, and psychological dependence on technological assistance. This article examines motivation, cognitive load, and self-regulated learning as interconnected psychological dimensions of artificial intelligence-supported education. Particular attention is given to the ways in which AI-based systems may influence learners' engagement, perceived competence, goal setting, attention, decision-making, and regulation of their own learning activities. The study approaches artificial intelligence not as an autonomous substitute for the teacher or learner but as a pedagogical instrument whose psychological effects depend on the purposes, conditions, and methods of its use.

The analysis also considers the potential benefits and risks of personalized learning, generative AI, automated feedback, and human–AI interaction in educational settings. It is argued that the effectiveness of AI-supported learning should be evaluated not only in terms of technological functionality and academic performance but also through its capacity to preserve learner agency, encourage intellectual effort, and support sustainable motivation and self-regulation. In this context, a psychologically informed pedagogical approach is necessary to ensure that artificial intelligence enhances rather than replaces the cognitive and metacognitive processes essential to meaningful learning.

Main part. Artificial intelligence-supported education should be considered not only as a technological development but also as a transformation of the psychological conditions under which learning takes place. Traditional digital technologies mainly provide access to information and learning resources, whereas contemporary AI systems can interact with learners, generate content, adapt tasks, provide immediate feedback, and modify learning activities according to individual performance. As a result, the learner is increasingly engaged in an environment where part of the cognitive and organizational work may be shared with an intelligent system. This transformation makes motivation, cognitive load, self-regulation, and learner autonomy particularly important psychological dimensions of AI-supported learning.

Motivation determines the direction, intensity, and persistence of learning behavior. In educational environments supported by artificial intelligence, motivation may be influenced by personalization, immediate feedback, perceived competence, and the possibility of progressing at an individually appropriate pace. Adaptive systems can identify areas in which a learner experiences difficulty and modify the sequence or complexity of tasks accordingly. Such responsiveness may reduce repeated experiences of failure and help learners perceive academic goals as achievable. From the perspective of self-determination theory, sustainable motivation is closely related to the satisfaction of the psychological needs for autonomy, competence, and relatedness [Ryan & Deci, 2020].

AI-supported learning can strengthen perceived competence when feedback is timely and tasks correspond to the learner's current level of knowledge. It may also support autonomy by allowing students to make choices concerning learning pace, resources, or pathways. However, personalization should not be equated automatically with motivation. If the system makes most decisions for the learner, determines every subsequent activity, or provides solutions before sufficient intellectual effort has occurred, technological personalization may paradoxically reduce learner autonomy. This issue is particularly relevant to generative artificial intelligence. A student can

now obtain explanations, examples, summaries, draft texts, and solutions within seconds. From a motivational perspective, such accessibility can be beneficial when AI functions as a tutor that provides clarification and encourages further inquiry. Conversely, if the learner repeatedly delegates difficult cognitive tasks to the system, motivation may gradually shift from mastering a problem toward obtaining an immediate answer. The pedagogical value of AI therefore depends partly on whether it encourages intellectual participation or facilitates avoidance of intellectual effort. The transformative character of this relationship has also been discussed in Azerbaijani educational research. Aliyev and Mammadov consider AI as a factor capable of reshaping educational philosophy, pedagogical practice, and human–machine cooperation. Their analysis emphasizes personalized learning trajectories, adaptive instruction, real-time analytics, and the changing distribution of functions between teachers, learners, and intelligent systems [Aliyev & Mammadov, 2026]. From a psychological perspective, this transformation requires particular attention to how technological assistance influences students' responsibility for their own learning. Another important psychological dimension of AI-supported education concerns cognitive load. Working memory has limited capacity, and learning becomes less effective when instructional demands exceed the cognitive resources available to the learner. Cognitive load theory distinguishes between demands associated with the complexity of the learning material and unnecessary demands created by the way information or activities are organized [Sweller et al., 2019]. Artificial intelligence can potentially reduce unnecessary cognitive load. For example, an AI-supported system may divide complex material into manageable stages, provide explanations when difficulties arise, identify errors, or recommend relevant resources. Instead of spending substantial cognitive effort searching through large amounts of information, students may receive content corresponding more closely to their immediate learning needs. In this respect, AI can function as a form of cognitive support. Nevertheless, reducing cognitive load is pedagogically useful only when the system removes unnecessary difficulty rather than the intellectual effort required for learning itself. Productive

learning often requires learners to recall information, compare alternatives, formulate arguments, solve problems, and correct errors. If AI performs these processes on behalf of students, the immediate task may become easier while opportunities for developing independent cognitive abilities may decrease. This distinction is especially important in generative AI environments. The production of a coherent answer by an AI system does not necessarily mean that the learner has understood the underlying concepts. A student may obtain a high-quality response without engaging sufficiently in analysis, retrieval, synthesis, or evaluation. Thus, educational effectiveness should not be assessed solely by the speed or quality of the final product. The cognitive processes through which that product is achieved must also be considered.

Self-regulated learning refers to learners' active management of their goals, strategies, behavior, motivation, and progress. Self-regulated learners plan their activities, select appropriate learning strategies, monitor understanding, evaluate results, and modify their behavior when necessary [Zimmerman, 2002]. These processes become particularly significant in AI-supported environments because students are increasingly required to decide when, why, and how technological assistance should be used. Artificial intelligence can provide useful support for self-regulation. Adaptive platforms may display learning progress, identify recurring difficulties, suggest revision, provide formative feedback, and assist students in planning subsequent activities. Such functions can make learning processes more visible and help learners recognize gaps between current performance and intended goals. Research on AI in education has identified personalization, intelligent tutoring, assessment, and learner profiling among the major areas in which artificial intelligence can support educational processes [Zawacki-Richter et al., 2019].

At the same time, externally provided regulation should not replace self-regulation. If an intelligent system continuously selects tasks, identifies errors, proposes corrections, and determines what should be learned next, students may have fewer opportunities to develop their own planning and monitoring strategies. Therefore, an important pedagogical principle is the gradual transfer of responsibility

from technological support to the learner. AI should assist students in learning how to regulate their activity rather than permanently regulating that activity for them. Metacognition is closely connected with this process. Learners need to assess not only whether an AI-generated response appears convincing but also whether it is accurate, relevant, sufficiently supported, and consistent with the requirements of the task. Generative systems may produce plausible but inaccurate information, which makes critical evaluation an essential component of AI literacy. Consequently, interaction with artificial intelligence can become a valuable metacognitive activity when students are required to question, verify, compare, and improve generated responses rather than accept them automatically.

The psychological consequences of AI-supported education are also associated with the changing relationship between human agency and technological assistance. Educational technologies have historically supported learners through calculators, search engines, digital libraries, and learning management systems. Generative AI differs from many earlier tools because it can participate directly in activities traditionally associated with human cognitive production, including explanation, interpretation, writing, problem solving, and idea generation. Aliyev and Mammadov emphasize that contemporary AI creates new forms of human–machine cooperation in education and therefore requires reconsideration of the respective roles of the learner, teacher, and technology [Aliyev & Mammadov, 2026].

Psychologically, the central issue is not whether students use AI but whether they remain active agents in the learning process. The learner should retain responsibility for defining the problem, evaluating information, making decisions, and reflecting on the result. This principle is particularly important for maintaining critical and creative thinking. If AI-generated content is used as material for analysis, comparison, revision, or debate, it can stimulate higher-order thinking. For example, students may be asked to identify weaknesses in an AI-generated argument, compare several responses, verify claims against academic sources, or improve an initial solution.

In such cases, AI becomes an object and partner of cognitive activity rather than a substitute for it. The integration of artificial intelligence does not diminish the psychological importance of the teacher. On the contrary, as automated systems assume some functions related to information delivery, feedback, and routine assessment, the teacher's role in motivation, emotional support, pedagogical judgment, and the development of learner autonomy becomes increasingly significant. AI can identify patterns in performance, but the educational meaning of those patterns requires professional interpretation within the broader context of the learner's development. Teachers also play an essential role in establishing psychologically appropriate boundaries for AI use. Students need to understand which activities may appropriately involve technological assistance and which require independent performance. These boundaries should be determined by learning objectives rather than by a simple distinction between permitted and prohibited technologies. If the purpose of a task is to develop argumentation, for example, submitting an AI-generated argument without critical engagement undermines the educational objective. If the purpose is to evaluate arguments, however, an AI-generated text may provide useful material for analysis. Thus, AI literacy should include psychological and metacognitive competencies alongside technical skills. Students need to recognize when technological assistance supports learning, when it creates distraction or unnecessary dependence, and when independent cognitive effort is necessary. Teachers, in turn, require sufficient pedagogical competence to design AI-supported tasks that maintain these distinctions.

The effective integration of artificial intelligence into education ultimately requires a balance between technological assistance and human cognitive activity. Personalized recommendations, adaptive tasks, immediate feedback, and intelligent tutoring can contribute to motivation and reduce unnecessary cognitive demands. Yet the same mechanisms may become counterproductive if they remove productive difficulty, weaken learner autonomy, or encourage excessive dependence on external assistance. For this reason, the psychological effectiveness of AI-supported learning

should be evaluated through several interconnected indicators: whether learners remain motivated to understand rather than merely complete tasks; whether cognitive support facilitates rather than replaces meaningful mental effort; whether students progressively develop self-regulation; and whether interaction with AI strengthens critical evaluation and independent decision-making. These criteria shift attention from what artificial intelligence is technically capable of doing toward what learners psychologically and educationally gain from using it. The transformative potential of artificial intelligence in education therefore lies not simply in automation but in the possibility of reorganizing learning around more responsive forms of support and human–machine interaction [Aliyev & Mammadov, 2026]. From a psychological and pedagogical perspective, however, this potential can be realized only when technology is designed and used to strengthen human agency. Artificial intelligence should expand the learner's opportunities to understand, reflect, create, and regulate learning rather than become a substitute for these processes.

Conclusion

Artificial intelligence is creating new psychological and pedagogical conditions for learning by changing how students access information, receive feedback, solve problems, and regulate their educational activities. Its influence on learning cannot be evaluated solely in terms of technological efficiency, since the educational value of AI also depends on its effects on motivation, cognitive load, autonomy, and self-regulation. The analysis shows that AI-supported learning can strengthen motivation and provide individualized cognitive support when it is purposefully integrated into the educational process. At the same time, excessive reliance on automated assistance may reduce independent intellectual effort and limit opportunities for developing self-regulatory and metacognitive skills.

Therefore, artificial intelligence should support rather than replace the cognitive processes through which meaningful learning occurs. In conclusion, an effective model

of AI-supported education requires a balanced relationship between technological assistance and learner agency. The central objective should be to use artificial intelligence in ways that encourage active thinking, sustained motivation, critical evaluation, and responsibility for one's own learning. Such an approach allows the possibilities of AI to be integrated with the psychological principles of learning and the pedagogical objectives of contemporary education.

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MODERN RESEARCH METHODS FOR STUDYING THE ECOLOGICAL IMPACTS OF CLIMATE CHANGE

Gumru Balakhanova,
Doctor of Philosophy in Biology
Department of Biology and Biology Teaching Technology
Azerbaijan State Pedagogical University
Azerbaijan, Baku
ORCID: 0000-0002-1709-1442

Keywords: ecological impacts, ecosystem resilience, biodiversity, remote sensing, artificial intelligence, machine learning, ecological monitoring, sustainable ecosystem management

Abstract. Climate change has become one of the most significant drivers of ecological transformation, affecting biodiversity, ecosystem functioning, biogeochemical cycles, and environmental sustainability on a global scale. Understanding these complex ecological responses requires the application of advanced and interdisciplinary research methodologies capable of integrating large volumes of environmental data across different spatial and temporal scales. This study examines modern research methods used to investigate the ecological impacts of climate change and evaluates their theoretical significance and practical applications in contemporary ecological science. The study is based on a comprehensive methodological framework combining field investigations, laboratory analyses, remote sensing, Geographic Information Systems (GIS), climate modeling, unmanned aerial vehicle (UAV) monitoring, environmental DNA (eDNA) analysis, machine learning, artificial intelligence, and advanced statistical techniques.

The integrated use of these approaches enables accurate assessment of ecosystem dynamics, biodiversity changes, vegetation productivity, habitat degradation, species distribution shifts, and ecological resilience under changing climatic conditions. The findings indicate that climate change significantly influences ecosystem structure and function by altering vegetation composition, nutrient cycling, hydrological processes, soil characteristics, and species interactions. Modern research

technologies substantially improve the accuracy of ecological monitoring, facilitate early detection of environmental degradation, strengthen predictive ecological models, and reduce uncertainties associated with traditional ecological assessments. The integration of geospatial technologies, molecular ecology, and computational modeling provides a comprehensive understanding of ecosystem responses to current and future climate scenarios. The study concludes that multidisciplinary research approaches are essential for evaluating the ecological consequences of climate change and for supporting evidence-based environmental management, biodiversity conservation, ecosystem restoration, and climate adaptation strategies. Continuous technological innovation, international scientific collaboration, and long-term ecological monitoring will further enhance the effectiveness of ecological research and contribute to sustainable environmental management under rapidly changing climatic conditions.

Introduction

Climate change has become one of the most significant global environmental challenges of the twenty-first century, fundamentally altering the structure, functioning, and resilience of ecosystems across terrestrial, freshwater, and marine environments. The unprecedented increase in atmospheric greenhouse gas concentrations, primarily driven by anthropogenic activities such as fossil fuel combustion, industrialization, land-use change, and deforestation, has accelerated global warming and intensified climatic variability. These changes have resulted in rising average temperatures, altered precipitation regimes, increasing frequency and intensity of extreme weather events, ocean acidification, sea-level rise, glacier retreat, and widespread modifications of ecological processes. Consequently, climate change is no longer considered solely a climatological issue but rather a complex ecological phenomenon influencing biodiversity, ecosystem services, biogeochemical cycles, species interactions, and environmental sustainability on local, regional, and global scales. Ecological systems are inherently dynamic and continuously respond to environmental fluctuations through adaptation, migration, succession, and evolutionary processes. However, the current rate of climate change exceeds the adaptive capacity of many species and ecosystems, creating ecological imbalances that

threaten biological diversity and ecosystem stability. Numerous studies indicate that climate-induced alterations have already shifted species distributions toward higher latitudes and elevations, modified phenological events such as flowering, breeding, and migration, disrupted food webs, increased the occurrence of invasive species, and accelerated habitat degradation. These transformations have significant consequences not only for natural ecosystems but also for agriculture, forestry, fisheries, water resources, and human well-being [Balakhanova, 2024].

The ecological consequences of climate change extend beyond individual species responses. They encompass ecosystem-level processes including primary productivity, nutrient cycling, carbon sequestration, decomposition dynamics, hydrological regulation, and energy flow. Climate-driven disturbances such as prolonged droughts, wildfires, floods, hurricanes, and heatwaves increasingly reshape ecosystem composition and function. Forest ecosystems experience elevated tree mortality and pest outbreaks, grasslands undergo changes in vegetation composition, wetlands lose their capacity for water purification and carbon storage, while marine ecosystems suffer from coral bleaching, hypoxia, and declining fisheries productivity. These interconnected impacts demonstrate the necessity of comprehensive ecological research capable of capturing complex interactions among climatic, biological, chemical, and physical variables. Traditional ecological research methods have substantially contributed to understanding ecosystem dynamics; however, they often provide limited spatial and temporal coverage and may not adequately capture the complexity of climate-induced environmental changes. Rapid technological progress has therefore stimulated the development of modern research methodologies that integrate field observations, laboratory analyses, remote sensing technologies, geospatial information systems, environmental modeling, artificial intelligence, molecular ecology, and large-scale environmental monitoring networks.

These interdisciplinary approaches significantly improve the precision, efficiency, and predictive capacity of ecological investigations. Remote sensing has become one of the most influential technologies in climate change ecology. Satellite

observations provide continuous, high-resolution information on land cover dynamics, vegetation productivity, forest degradation, glacier retreat, soil moisture, ocean temperature, chlorophyll concentration, and atmospheric conditions. Data obtained from Earth observation satellites enable researchers to monitor environmental changes over extensive geographical regions while minimizing field costs.

The integration of satellite imagery with Geographic Information Systems (GIS) allows detailed spatial analyses of habitat fragmentation, biodiversity hotspots, ecological vulnerability, and landscape transformation under changing climatic conditions(Balakhanova, 2024). Geographic Information Systems have revolutionized ecological research by enabling the collection, storage, visualization, and spatial analysis of complex environmental datasets. GIS-based ecological modeling facilitates the identification of climate-sensitive habitats, ecological corridors, conservation priorities, and areas exposed to environmental risks. Spatial statistics combined with GIS support decision-making in ecosystem management, protected area planning, biodiversity conservation, and climate adaptation strategies. Furthermore, GIS technologies allow researchers to integrate climatic variables with ecological indicators, thereby improving the understanding of ecosystem responses across multiple spatial scales. Climate modeling represents another fundamental methodological advancement in ecological research. General circulation models (GCMs), regional climate models (RCMs), Earth system models (ESMs), and species distribution models (SDMs) are increasingly used to simulate future environmental scenarios and evaluate ecological responses under different greenhouse gas emission pathways. These predictive models enable scientists to estimate future shifts in species distributions, ecosystem productivity, carbon cycling, water availability, and biodiversity patterns. Scenario-based modeling provides valuable scientific evidence for developing adaptation and mitigation policies aimed at reducing ecological vulnerability. The rapid expansion of molecular ecology has introduced highly sensitive techniques for evaluating biodiversity responses to climate change. Environmental DNA (eDNA), DNA metabarcoding, genomic sequencing,

transcriptomics, and metagenomics enable accurate identification of species, genetic diversity, microbial communities, and ecological interactions without relying solely on traditional taxonomic surveys. Molecular techniques are particularly valuable for detecting rare, endangered, invasive, or cryptic species and assessing ecosystem health under changing environmental conditions. Artificial intelligence (AI), machine learning (ML), and big data analytics have recently emerged as transformative tools in ecological research.

These computational approaches can process massive environmental datasets generated by satellites, drones, sensor networks, genomic analyses, and climate models. Machine learning algorithms identify complex ecological patterns, classify habitats, predict species distributions, detect environmental anomalies, and improve the accuracy of ecological forecasting. AI-based ecological monitoring significantly enhances early warning systems for biodiversity loss, ecosystem degradation, wildfire risk, and climate-related disasters. Unmanned aerial vehicles (UAVs), commonly known as drones, have further expanded ecological monitoring capabilities by providing ultra-high-resolution imagery for vegetation mapping, wildlife surveys, forest health assessment, wetland monitoring, and habitat restoration evaluation. Drone-based observations bridge the spatial gap between satellite remote sensing and traditional field measurements while offering greater flexibility and cost-effectiveness. Long-term ecological monitoring networks constitute another essential component of modern climate change research. Continuous environmental observations collected through meteorological stations, ecological observatories, automated sensors, eddy covariance towers, hydrological monitoring systems, and biodiversity monitoring programs provide valuable datasets for detecting long-term ecological trends. Such monitoring enables researchers to distinguish natural variability from anthropogenic climate impacts and improves the validation of ecological models(Balakhanova, 2024). Field investigations remain indispensable despite technological advancements. Modern ecological field studies increasingly combine standardized sampling protocols with automated environmental sensors measuring temperature, humidity, soil

moisture, carbon dioxide fluxes, nutrient concentrations, and biological activity. Integrated field observations provide empirical evidence necessary for calibrating remote sensing products, validating predictive models, and interpreting ecological mechanisms operating within natural ecosystems. Experimental ecology has also evolved considerably through manipulative climate experiments, including warming chambers, rainfall exclusion systems, elevated CO_2 experiments (FACE), and controlled environmental facilities.

These experimental approaches allow researchers to isolate specific climatic drivers and directly investigate their effects on ecosystem structure, physiological processes, productivity, nutrient cycling, and species interactions under controlled conditions. Interdisciplinary integration has become the defining characteristic of contemporary ecological research. Modern investigations increasingly combine climatology, ecology, hydrology, geography, molecular biology, environmental chemistry, computer science, statistics, and socio-economic analysis into unified research frameworks. Such integrated methodologies provide a holistic understanding of ecosystem responses while supporting evidence-based environmental policies, sustainable natural resource management, biodiversity conservation, and climate adaptation planning. Furthermore, ecosystem resilience has emerged as a central concept in climate change ecology. Modern research focuses not only on documenting ecological degradation but also on understanding ecosystem resistance, recovery capacity, adaptive potential, and thresholds of ecological collapse. Quantitative resilience assessment employs ecological indicators, network analysis, functional diversity metrics, and ecosystem service evaluations to estimate the capacity of ecosystems to withstand climatic disturbances.

The increasing availability of open-access environmental databases, cloud computing platforms, and international scientific collaborations has significantly enhanced global ecological research. Large-scale initiatives facilitate data sharing, methodological standardization, and comparative analyses across continents and ecosystems. International monitoring programs enable comprehensive assessments of

climate impacts on biodiversity and contribute to the development of global conservation strategies aligned with sustainable development goals. In conclusion, studying the ecological impacts of climate change requires sophisticated, multidisciplinary, and technologically advanced research methodologies capable of addressing the complexity of modern environmental challenges. The integration of remote sensing, GIS, ecological modeling, molecular biology, artificial intelligence, field investigations, long-term monitoring, and experimental ecology provides unprecedented opportunities for understanding ecosystem responses to climate change. These innovative methods not only improve scientific knowledge but also strengthen environmental decision-making, support biodiversity conservation, enhance ecosystem resilience, and contribute to sustainable climate adaptation and mitigation strategies. As climate change continues to intensify, the development and application of modern ecological research methods will remain indispensable for safeguarding ecosystem integrity and ensuring the sustainable management of natural resources for future generations.

Main part. This study was conducted using an integrated multidisciplinary research framework designed to assess the ecological impacts of climate change through the combination of field observations, laboratory analyses, geospatial technologies, climate modeling, and advanced statistical approaches. The methodological design was based on internationally accepted ecological research standards and aimed to provide a comprehensive evaluation of ecosystem responses to changing climatic conditions across multiple spatial and temporal scales. The research adopted a mixed-methods approach that combined quantitative ecological measurements with spatial analysis and predictive modeling. The investigation included observational, analytical, and modeling components to examine relationships between climatic variables and ecological indicators. The methodological framework incorporated data collection from terrestrial, freshwater, and, where applicable, coastal ecosystems representing different climatic and environmental gradients.

Meteorological data, including mean annual air temperature, seasonal temperature variability, precipitation, relative humidity, solar radiation, wind speed, and extreme weather events, were obtained from national meteorological monitoring stations and internationally recognized climate databases. Long-term climatic records covering multiple decades were analyzed to identify trends in climate variability and their ecological implications.

Future climatic conditions were evaluated using Representative Concentration Pathway (RCP) and Shared Socioeconomic Pathway (SSP) climate scenarios derived from global and regional climate models. These scenarios enabled projections of future ecological responses under different greenhouse gas emission pathways.

Comprehensive field investigations were conducted to assess ecosystem structure and function. Vegetation surveys were performed using standardized quadrat and transect sampling techniques. Species composition, plant abundance, vegetation cover, biomass, and diversity indices were recorded systematically across representative sampling sites.

Wildlife observations included assessments of species richness, abundance, habitat utilization, and behavioral responses to environmental change. Standard ecological monitoring techniques such as point-count surveys, camera traps, direct observations, and acoustic monitoring were employed depending on the target taxonomic groups.

Soil samples were collected from multiple depths to evaluate physical, chemical, and biological properties, including soil moisture, pH, organic carbon, nitrogen, phosphorus, microbial biomass, and enzymatic activity. Water quality assessments included measurements of temperature, dissolved oxygen, electrical conductivity, turbidity, nutrient concentrations, and chlorophyll-a in freshwater ecosystems.

Satellite imagery acquired from Landsat, Sentinel, and MODIS missions was utilized to evaluate long-term environmental changes. Remote sensing analyses focused on land-use and land-cover dynamics, vegetation productivity, forest fragmentation, drought severity, surface temperature, and ecosystem degradation.

Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI), Land Surface Temperature (LST), and other spectral indices were calculated to quantify ecosystem condition and vegetation health. Geographic Information System (GIS) software was employed to integrate ecological observations with climatic and spatial datasets, allowing the identification of vulnerable ecosystems and climate-sensitive regions.

Drone-based aerial surveys were performed to obtain ultra-high-resolution imagery for vegetation mapping, habitat assessment, forest canopy analysis, wetland monitoring, and post-disturbance ecosystem evaluation. UAV imagery was processed using photogrammetric techniques to generate digital elevation models and high-resolution orthomosaic maps.

Species Distribution Models (SDMs) were developed to predict potential shifts in species ranges under future climate scenarios. Ecological niche modeling incorporated climatic variables, habitat characteristics, and species occurrence records to estimate future habitat suitability.

Ecosystem process models were applied to evaluate carbon sequestration, primary productivity, nutrient cycling, and hydrological dynamics under projected climate conditions. Regional climate model outputs were integrated with ecological datasets to simulate ecosystem responses to increasing temperatures and altered precipitation regimes.

Environmental DNA (eDNA) analysis and DNA metabarcoding techniques were employed to evaluate biodiversity and detect species that were difficult to identify through conventional surveys. Genetic analyses provided information on community composition, species richness, and ecosystem integrity while improving the detection of rare, endangered, and invasive organisms.

Statistical analyses were performed using R Statistical Software and IBM SPSS Statistics. Descriptive statistics were calculated for all environmental and ecological variables. Data normality was assessed using the Shapiro–Wilk test before selecting appropriate statistical procedures.

Differences among ecological communities were evaluated using one-way and two-way analysis of variance (ANOVA). Relationships between climatic variables and ecological indicators were examined using Pearson correlation analysis, multiple linear regression, generalized linear models (GLMs), and generalized additive models (GAMs). Multivariate analyses, including Principal Component Analysis (PCA), Canonical Correspondence Analysis (CCA), and Redundancy Analysis (RDA), were conducted to identify the principal environmental factors influencing ecosystem variability.

Machine learning algorithms, including Random Forest, Support Vector Machine (SVM), and Artificial Neural Networks (ANN), were applied to improve ecological prediction accuracy and identify key drivers of ecosystem change.

All field measurements were conducted following standardized ecological monitoring protocols to ensure consistency and reproducibility. Laboratory analyses included calibration of analytical instruments, duplicate sample analysis, certified reference materials, and quality-control procedures. Spatial datasets were validated through ground-truth observations, while predictive models were evaluated using cross-validation techniques and independent testing datasets. Statistical significance was determined at a probability level of $p < 0.05$.

The integration of field observations, remote sensing technologies, GIS analysis, molecular ecology, climate modeling, and advanced statistical methods ensured a comprehensive and scientifically robust assessment of the ecological impacts of climate change. This multidisciplinary methodology improved the reliability of ecological predictions and supported evidence-based recommendations for biodiversity conservation, ecosystem management, and climate adaptation strategies.

The integrated methodological framework employed in this study demonstrated that climate change exerts profound and multidimensional effects on ecosystem structure, biodiversity, ecological processes, and environmental sustainability. The combination of field observations, remote sensing, Geographic Information System (GIS) analysis, climate modeling, molecular ecological techniques, and advanced

statistical approaches provided complementary evidence regarding the ecological consequences of changing climatic conditions. The results indicate that the application of modern interdisciplinary research methods substantially improves the accuracy of ecological assessments while enabling the identification of complex relationships between climatic drivers and ecosystem responses.

Long-term climatic analyses revealed a consistent increase in mean annual air temperature accompanied by considerable variability in seasonal precipitation patterns. The frequency and intensity of extreme climatic events, including prolonged droughts, heatwaves, heavy rainfall, and floods, showed a marked increase during the observation period. These climatic changes altered hydrological processes, soil moisture availability, and ecosystem productivity(Balakhanova, 2024).

Climate projections generated using Representative Concentration Pathway (RCP) and Shared Socioeconomic Pathway (SSP) scenarios suggested that continued greenhouse gas emissions will further intensify environmental stress across terrestrial and aquatic ecosystems. Higher temperatures combined with irregular precipitation are expected to increase ecosystem vulnerability, accelerate habitat degradation, and reduce ecological resilience.

Field investigations demonstrated significant changes in vegetation composition, plant diversity, and ecosystem productivity. Climate-sensitive species exhibited reduced abundance, whereas drought-tolerant and thermophilic species expanded their distribution. Vegetation communities located in environmentally stressed regions showed lower species richness and reduced aboveground biomass compared with relatively stable habitats.

Satellite-derived vegetation indices, particularly the Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI), confirmed gradual declines in vegetation health within drought-prone ecosystems. Remote sensing observations also detected increasing forest fragmentation, land degradation, and reductions in primary productivity across several landscape types.

The integration of field measurements with satellite observations substantially

improved the reliability of vegetation assessments by providing continuous spatial monitoring and minimizing uncertainties associated with conventional ecological surveys.

Biodiversity assessments revealed considerable shifts in species composition and ecological communities. Numerous species exhibited poleward and elevational distribution shifts consistent with increasing temperatures. Changes in phenological events, including earlier flowering, breeding, migration, and reproductive activity, were observed across multiple taxonomic groups.

Environmental DNA (eDNA) analysis successfully detected several rare and cryptic species that were not identified through traditional field sampling methods. Molecular techniques significantly enhanced biodiversity monitoring by increasing detection sensitivity and reducing sampling bias.

The observed decline in biodiversity was closely associated with habitat fragmentation, increasing environmental disturbances, invasive species expansion, and changing climatic conditions. Functional diversity decreased within highly disturbed ecosystems, suggesting reduced ecological stability and diminished ecosystem resilience.

Laboratory analyses demonstrated that climate change significantly affected soil properties and nutrient cycling. Increasing temperatures accelerated organic matter decomposition while reducing soil moisture and microbial biomass. Carbon storage capacity declined in degraded ecosystems due to increased decomposition rates and reduced vegetation productivity.

Nitrogen mineralization and phosphorus availability exhibited substantial spatial variability associated with changing precipitation regimes. Microbial community composition also shifted in response to temperature increases and moisture deficits, influencing ecosystem nutrient dynamics and overall soil fertility.

These findings indicate that climatic alterations directly influence biogeochemical processes responsible for maintaining ecosystem functioning and long-term ecological stability.

Freshwater ecosystems showed measurable ecological responses to climate variability. Increasing water temperatures, declining dissolved oxygen concentrations, and altered streamflow regimes negatively affected aquatic biodiversity and ecosystem productivity.

Elevated nutrient concentrations promoted eutrophication, increasing algal biomass and reducing water quality in several sampling locations. Hydrological variability associated with irregular precipitation patterns altered habitat availability for aquatic organisms and disrupted ecosystem functioning.

The integration of continuous environmental monitoring with remote sensing provided valuable information regarding temporal fluctuations in water quality and ecological condition.

Remote sensing technologies proved highly effective for monitoring large-scale environmental changes associated with climate change. Multi-temporal satellite imagery successfully identified trends in vegetation degradation, land-use transformation, wildfire impacts, glacier retreat, wetland loss, and desertification.

GIS-based spatial analyses enabled the identification of ecological vulnerability hotspots and regions requiring conservation priority. Spatial overlay analyses demonstrated strong relationships between climatic stress indicators and observed ecological degradation.

Compared with conventional field surveys alone, the combined application of GIS and satellite observations significantly increased spatial coverage, reduced monitoring costs, and improved ecological forecasting capabilities.

Species distribution models predicted substantial future shifts in suitable habitats under projected climate scenarios. Cold-adapted species experienced considerable habitat contraction, whereas species with broader environmental tolerance expanded into newly suitable regions. Ecosystem process models indicated reductions in carbon sequestration potential, alterations in hydrological regulation, and decreasing ecosystem productivity under high-emission scenarios. Model validation demonstrated satisfactory predictive performance when field observations and

remotely sensed environmental variables were integrated.

The incorporation of multiple climate scenarios reduced uncertainty and provided more comprehensive projections for ecosystem management and climate adaptation planning.

Machine learning algorithms substantially improved ecological prediction accuracy. Random Forest and Artificial Neural Network models demonstrated high performance in predicting vegetation changes, habitat suitability, and biodiversity responses based on climatic and environmental variables. Artificial intelligence effectively processed large environmental datasets derived from satellites, drones, ecological monitoring stations, and molecular analyses. Automated classification methods accelerated environmental assessments while minimizing observer-related errors.

These findings highlight the growing importance of artificial intelligence as a powerful tool for ecological forecasting, biodiversity monitoring, and environmental decision-making. The results clearly demonstrate that no single research method is sufficient to comprehensively evaluate the ecological impacts of climate change. Instead, integrated methodological approaches combining field ecology, remote sensing, GIS, molecular biology, climate modeling, and artificial intelligence provide more reliable and scientifically robust assessments [Runting, Bryan, & others, 2021].

The complementary strengths of these methods improve data accuracy, increase spatial and temporal coverage, facilitate long-term monitoring, and strengthen ecological predictions. Such multidisciplinary approaches support adaptive ecosystem management, biodiversity conservation, environmental restoration, and sustainable natural resource planning.

The present findings are consistent with numerous international studies reporting increasing ecosystem vulnerability under accelerating climate change. Previous research has similarly documented shifts in species distributions, reductions in biodiversity, declining ecosystem productivity, altered nutrient cycling, and increasing habitat fragmentation.

However, this study extends previous work by demonstrating the substantial advantages of integrating modern technological approaches into ecological investigations. The combination of satellite observations, GIS analysis, molecular ecology, machine learning, and predictive climate modeling generated more comprehensive ecological assessments than conventional single-method studies.

The findings emphasize that modern research methods are indispensable for understanding the ecological consequences of climate change and supporting evidence-based environmental management. Advanced monitoring technologies facilitate early detection of ecosystem degradation, improve biodiversity conservation strategies, and strengthen national and international climate adaptation programs.

The integration of multidisciplinary ecological research contributes directly to sustainable ecosystem management, environmental policy development, ecological restoration planning, and global biodiversity conservation initiatives. Continued technological innovation and international scientific collaboration will be essential for improving ecological resilience and mitigating the long-term impacts of climate change on natural ecosystems.

Conclusion

Climate change has emerged as one of the most critical environmental challenges affecting ecosystems worldwide, influencing biodiversity, ecosystem functioning, biogeochemical cycles, and the provision of ecosystem services. The findings of this study demonstrate that understanding these complex ecological responses requires the integration of advanced scientific methodologies capable of analyzing environmental changes across multiple spatial and temporal scales. Modern ecological research methods provide significantly greater accuracy, efficiency, and predictive capability than traditional approaches, enabling researchers to investigate the interactions between climatic drivers and ecological processes in a comprehensive manner.

The integrated application of field investigations, laboratory analyses, remote sensing technologies, Geographic Information Systems (GIS), climate modeling, molecular ecological techniques, unmanned aerial vehicle (UAV) monitoring, environmental DNA (eDNA) analysis, artificial intelligence, machine learning, and advanced statistical modeling has considerably enhanced the quality and reliability of ecological assessments. These complementary approaches facilitate continuous environmental monitoring, improve biodiversity detection, strengthen ecosystem vulnerability assessments, and increase the precision of future ecological projections under different climate scenarios.

The results indicate that climate change significantly alters vegetation dynamics, species distributions, ecological interactions, soil properties, nutrient cycling, hydrological processes, and ecosystem productivity. Increasing temperatures, changing precipitation patterns, and the growing frequency of extreme weather events reduce ecosystem resilience and accelerate habitat degradation, biodiversity loss, and ecological instability. At the same time, modern monitoring technologies enable the early detection of these environmental changes and provide valuable scientific evidence for developing effective adaptation and mitigation strategies.

A major conclusion of this research is that no single methodological approach is sufficient to fully evaluate the ecological consequences of climate change. Instead, multidisciplinary and integrated research frameworks that combine ecological observations with geospatial technologies, predictive modeling, molecular biology, and computational analysis provide the most comprehensive understanding of ecosystem responses. Such integrated methodologies reduce uncertainty, improve ecological forecasting, and support evidence-based environmental decision-making.

Furthermore, advances in artificial intelligence, cloud computing, big data analytics, and automated environmental monitoring systems are transforming ecological research by enabling the processing of large and complex datasets with unprecedented speed and accuracy. These technological innovations are expected to play an increasingly important role in biodiversity conservation, ecosystem restoration,

climate risk assessment, and sustainable natural resource management in the coming decades.

In conclusion, modern research methods constitute an essential scientific foundation for studying the ecological impacts of climate change. Future ecological research should emphasize international scientific collaboration, long-term environmental monitoring, interdisciplinary integration, and the application of emerging technologies to ensure a more comprehensive understanding of climate–ecosystem interactions and to promote sustainable environmental management in the face of ongoing global climate change.

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INCLUSIVE EDUCATION AS A CONTEMPORARY APPROACH TO ENSURING EQUAL LEARNING OPPORTUNITIES

Elena Marin
Faculty of Psychology and Educational Sciences
Moldova State University
Chișinău, Moldova
E-mail: elena.marin@usm.md
ORCID: 0000-0013-4161-8220

Keywords: educational inclusion, equal learning opportunities, learner diversity, special educational needs, inclusive school, teacher competence, differentiated instruction

Abstract. Inclusive education represents one of the significant directions in the development of contemporary educational systems, reflecting the transition from selective approaches to educational models based on accessibility, participation, and consideration of learner diversity. In its modern interpretation, inclusion is not limited to the placement of learners with special educational needs in mainstream schools. It requires the systematic organization of an educational environment in which differences in abilities, learning needs, social circumstances, language, and individual development do not become barriers to meaningful participation in education. The present article examines the theoretical and pedagogical foundations of inclusive education and discusses the conditions necessary for its effective implementation in contemporary schools. Particular attention is given to the principles of equal educational opportunities, differentiation of teaching, individualization of learning, social participation, teacher competence, interdisciplinary cooperation, and interaction between schools and families. The article considers inclusion as a process involving changes not only in teaching methods but also in school culture, professional relationships, educational planning, and approaches to assessing learners' progress. The analysis indicates that the effectiveness of inclusive education is closely associated with teachers' professional preparedness, availability of educational and psychological support, flexible organization of instruction, and cooperation among participants in the educational process.

Introduction

The development of contemporary education is increasingly associated with the recognition of learner diversity as a normal characteristic of the educational process. A modern school brings together learners who differ in their abilities, previous educational experiences, pace of learning, interests, social circumstances, and individual developmental characteristics.

These differences create a need for educational approaches capable of providing access to learning while maintaining meaningful educational expectations for every student. Inclusive education has developed in response to this need and has gradually acquired a broader pedagogical meaning. Its purpose is not simply to ensure the physical presence of different learners within the same classroom. Inclusion presupposes their meaningful participation in learning, communication, school life, and social relationships.

Therefore, the transition toward inclusive education concerns the organization of the entire educational environment rather than the situation of an individual learner alone. From this perspective, the effectiveness of inclusion depends on the interaction of several factors, including teachers' professional competence, differentiated instructional practices, cooperation with specialists and families, appropriate educational support, and the development of a school culture based on participation and respect for individual differences.

The problem is therefore both pedagogical and organizational. The purpose of this article is to examine inclusive education as a contemporary educational approach, clarify its principal pedagogical characteristics, and analyze the conditions that support its effective implementation in school practice. Particular consideration is given to the relationship between educational accessibility, learner diversity, teacher preparedness, individualized support, and participation in a common learning environment.

Main part. Inclusive education should first be understood as a process of transforming educational practice in response to learner diversity. In this sense, inclusion differs from an approach in which a learner is expected to adapt to an unchanged school environment. The central question is not whether a particular student is capable of functioning within an existing instructional model, but whether the educational environment provides sufficient flexibility for different students to participate and learn. This distinction has important consequences for curriculum planning, teaching methods, assessment, classroom organization, and professional cooperation. Research conducted in Eastern European educational contexts illustrates the practical importance of this systemic understanding. Studies in Serbia, for example, indicate that teachers generally recognize the value of inclusion, while its practical implementation continues to depend on professional preparation, specialist involvement, and the capacity to develop appropriate individualized educational support [Đukičin Vučković et al., 2019; Milošević & Maksimović, 2022].

Serbian research has also emphasized that a broader conception of inclusion should form part of teacher education rather than being treated exclusively as a specialized field concerned with particular categories of learners [Pantić et al., 2012].

An important principle of inclusive education is the combination of common educational goals with differentiated pathways toward their achievement. Equality in education does not necessarily mean that every learner should receive identical instruction, complete identical tasks under identical conditions, or demonstrate progress in precisely the same manner. Rather, equitable education requires the identification of barriers that prevent learners from participating effectively and the provision of pedagogically justified forms of support. Differentiation consequently becomes an essential component of inclusive teaching. It may involve variations in instructional materials, the complexity and sequence of tasks, forms of classroom participation, the amount of teacher support, methods of presenting information, or ways in which students demonstrate their learning. However, differentiation should not result in the social or academic isolation of learners. Its purpose is to enable

participation in a shared educational process while responding to relevant individual needs. Experience from Lithuania demonstrates the importance of this issue. Research involving teachers working in heterogeneous classes identified difficulties related to differentiated teaching and the inclusion of students with special educational needs in peer networks. The same research highlighted the importance of multiprofessional cooperation and constructive dialogue with parents [Lakkala et al., 2019].

These findings demonstrate that inclusive education cannot be reduced to the individual competence of one classroom teacher; it requires coordinated professional activity at the level of the school. Teacher competence therefore occupies a central position in the development of inclusive practice. Teachers working in heterogeneous classrooms need more than general acceptance of the principles of inclusion. They require practical competencies in observing students' learning, identifying educational barriers, differentiating instruction, managing classroom interaction, assessing individual progress, and cooperating with other professionals. Positive attitudes toward inclusion are important, but attitudes alone cannot replace methodological preparation. This distinction is particularly relevant because difficulties in inclusive education are sometimes interpreted primarily as characteristics of individual learners.

A pedagogical perspective requires a different analysis: difficulties may also arise from the complexity of instructional materials, inappropriate teaching methods, inaccessible learning environments, insufficient support, or patterns of classroom interaction. The identification of these factors makes it possible to move from a deficit-oriented understanding of the learner toward an educational analysis of the conditions under which learning occurs.

At the same time, inclusive education should not be interpreted as an expectation that one teacher must independently resolve every educational, psychological, social, or developmental difficulty. Effective inclusion requires cooperation among classroom and subject teachers, special educators, psychologists, school administrators, families, and, where necessary, other specialists. Such cooperation allows educational needs to be considered from several professional perspectives and reduces the risk that support

will consist of fragmented interventions.

The social dimension of inclusion is equally important. A learner may attend the same classroom as peers and nevertheless remain socially isolated or have limited opportunities for meaningful participation. For this reason, indicators of successful inclusion should extend beyond school enrolment and physical placement. Peer relationships, participation in collaborative activities, communication, sense of belonging, and involvement in school life are important dimensions of educational inclusion. Comparative and national research in Eastern Europe has repeatedly drawn attention to teacher attitudes, school conditions, and social participation as factors affecting the quality of inclusive practice [Jovanović & Rajović, 2013; Đukičin Vučković et al., 2019].

Family-school cooperation represents another necessary condition. Families possess information about children's development, previous educational experiences, strengths, interests, and difficulties that may be essential for appropriate pedagogical planning. At the same time, teachers can provide families with systematic information concerning participation, learning progress, and areas in which additional support may be required. Cooperation is most productive when parents are regarded as partners in educational decision-making rather than merely recipients of information. The development of inclusive education also requires attention to institutional conditions. School leadership, availability of specialists, class organization, access to methodological resources, opportunities for teachers' professional development, and cooperation among educational services directly influence what can be achieved in classrooms.

Serbian experience, for instance, shows that progress in inclusion has been associated with legislative and institutional reforms, while continued improvement requires attention to quality, equity, efficiency, and support mechanisms across different levels of the education system. Accordingly, inclusion should not be evaluated solely by whether a school formally implements an inclusive policy. The more important question concerns how inclusion is reflected in everyday educational

practice. A school may possess appropriate policy documents while teachers remain insufficiently prepared to differentiate instruction or cooperate with support specialists.

Conversely, individual teachers may develop effective inclusive practices even where institutional resources remain limited. Sustainable inclusion requires these levels to become mutually supportive. A further methodological consideration concerns assessment. Traditional assessment practices based primarily on comparison among learners may provide insufficient information about individual educational progress. Inclusive assessment should preserve clear academic expectations while enabling teachers to identify changes in knowledge, skills, participation, and independence. Formative assessment, systematic observation, feedback, and appropriately selected assessment tasks can provide a more comprehensive understanding of learners' development. It is equally important to avoid presenting inclusive education as a universal collection of methods that can be applied identically in every classroom. Educational environments differ, as do learners, schools, communities, and available professional resources. Inclusive pedagogy therefore requires continuous analysis of classroom conditions and adjustment of instructional decisions. Recent research from Serbian primary schools continues to show that the relationship between inclusive principles and their classroom implementation remains an important area of investigation, confirming that the transition from formal inclusion to sustainable practice is an ongoing process [Sretenović et al., 2026].

Taken together, these considerations suggest that inclusive education is best understood as a systemic and developmental process. Its effectiveness depends on the interaction between educational policy, institutional organization, professional competence, classroom methodology, and social relationships. The learner remains at the center of this process, but responsibility for inclusion cannot be assigned to the learner. It belongs to the educational system and to the professional community responsible for creating conditions in which meaningful learning and participation become possible for different students.

Conclusion

Inclusive education represents a comprehensive approach to organizing education in accordance with learner diversity and the principle of equal educational opportunity. Its successful implementation requires more than the placement of different learners in common classrooms. It depends on meaningful participation, differentiated teaching, professional support, appropriate assessment, cooperation with families, and a school environment capable of responding flexibly to individual educational needs.

The analysis shows that teacher competence and institutional support are among the central conditions determining the quality of inclusive practice. At the same time, inclusion should preserve meaningful educational expectations and promote both academic development and social participation. For this reason, the further development of inclusive education requires coordinated action at the level of educational policy, teacher education, school organization, and everyday classroom practice.

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E-ISSN: 3080-3543 (Online)
E-mail: journal.pedaqoq.az@gmail.com