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DEVELOPMENT OF PUPILS' CREATIVE ABILITIES THROUGH THE USE OF DIGITAL MODELING TECHNOLOGIES IN GEOGRAPHY EDUCATION

Abstract

This article explores the relevance of employing digital modeling technologies in the teaching of geography under the current conditions of educational digital transformation. Such technologies provide opportunities for the visualization of spatial processes, foster students' cognitive engagement, and increase their interest in the subject.

Within the framework of modernizing geographic education, the article substantiates the importance of digital modeling, analyzes the prospects of its integration into Kazakhstan's educational system, and identifies key challenges that hinder its effective implementation. Among the primary obstacles are the insufficient level of teachers' digital competence and the shortage of adapted instructional and methodological resources. For successful integration, it is essential to ensure teacher training, the development of 3D modeling skills, and systematic methodological support.

Furthermore, the article examines theoretical and practical aspects of applying digital modeling in higher education institutions. The results of an experimental study are presented, demonstrating the effectiveness of modeling technologies in enhancing students' learning motivation, developing creative abilities, and contributing to their emotional well-being.

The practical significance of the study lies in providing concrete recommendations for introducing digital modeling into the educational system. In particular, effective strategies are proposed for integrating these technologies into the teaching of geography at the university level, aimed at improving educational quality and fostering the creative potential of students.

Keywords: modeling, geography teaching, digital technologies, spatial thinking, learning motivation, creativity.

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ГЕОГРАФИЯЛЫҚ БІЛІМ БЕРУДЕ ЦИФРЛЫҚ МОДЕЛЬДЕУ ТЕХНОЛОГИЯЛАРЫН ҚОЛДАНУ АРҚЫЛЫ ОҚУШЫЛАРДЫҢ ШЫҒАРМАШЫЛЫҚ ҚАБІЛЕТТЕРІН ДАМЫТУ

Аңдатпа

Бұл мақалада қазіргі цифрлық трансформация жағдайында география пәнін оқытуда цифрлық модельдеу технологияларын қолданудың өзектілігі қарастырылады. Мұндай технология кеңістіктік үдерістерді визуализациялауға, білім алушылардың танымдық белсенділігі мен пәнге деген қызығушылығын арттыруға мүмкіндік береді.

Географиялық білім беруді жаңғырту аясында цифрлық модельдеу технологияларының маңызы сипатталып, Қазақстандағы білім беру жүйесінде аталған технологияларды енгізу перспективалары мен қолдануға байланысты мәселелер талданады. Модельдеу технологияларын оқу бағдарламасына сапалы енгізу үшін педагог кадрларды даярлау, 3D модельдеу құзыреттерін дамыту және әдістемелік қолдау қажеттілігі анықталады. Алайда зерттеу нәтижелері көрсеткендей, отандық педагогтардың цифрлық құзыреттілігінің төмендігі, бейімделген оқу-әдістемелік материалдардың жетіспеушілігі аталмыш технологияларды тиімді енгізуге кедергі келтіруде.

Бұл мақалада жоғары оқу орындарының білім беру процесінде модельдеу әдісін қолданудың теориялық және практикалық аспектілері қарастырылады. Мақалада модельдеу әдісінің студенттердің оқу мотивациясы мен шығармашылық қабілеттерін дамытудағы тиімділігін бағалау мақсатында жүргізілген эксперименттік зерттеу нәтижелері талданған.

Зерттеудің практикалық маңызы модельдеу бағдарламаларын қолдану арқылы оқыту әдістерін жетілдіруге, студенттердің оқу мотивациясын арттыруға және олардың эмоционалдық жағдайын жақсартуға бағытталған. Зерттеу нәтижелері модельдеу әдісін білім беру жүйесіне енгізу бойынша нақты ұсыныстар беруге мүмкіндік береді. Әсіресе жоғары оқу орындарында модельдеу технологияларын география пәніне интеграциялаудың тиімді жолдары мен нақты ұсыныстар берілген.

Түйін сөздер: модельдеу**,** географияны оқыту**,** цифрлық технологиялар**,** кеңістіктік ойлау**,** мотивация**,** креативтілік**.**

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РАЗВИТИЕ ТВОРЧЕСКИХ СПОСОБНОСТЕЙ УЧАЩИХСЯ ПОСРЕДСТВОМ ПРИМЕНЕНИЯ ТЕХНОЛОГИЙ ЦИФРОВОГО МОДЕЛИРОВАНИЯ В ГЕОГРАФИЧЕСКОМ ОБРАЗОВАНИИ

Аннотация

В статье рассматривается значимость применения технологий цифрового моделирования в преподавании географии в условиях современной цифровой трансформации образования. Подобные технологии открывают возможности для наглядной визуализации пространственных процессов, способствуют активизации познавательной деятельности обучающихся и повышают их интерес к предмету.

В контексте модернизации географического образования обосновывается роль цифрового моделирования, анализируются перспективы его внедрения в систему образования Казахстана, а также выявляются ключевые проблемы, препятствующие эффективной реализации данных технологий. Отмечается, что для качественной интеграции моделирования в учебные программы необходимо обеспечить подготовку педагогических кадров, развитие компетенций в области 3D-моделирования и системную методическую поддержку. Вместе с тем результаты исследования показывают, что низкий уровень цифровой грамотности отечественных педагогов и недостаток адаптированных учебно-методических материалов серьёзно ограничивают эффективность использования таких технологий.

Особое внимание уделяется теоретическим и практическим аспектам применения моделирования в образовательном процессе вузов. В статье представлены результаты экспериментального исследования, направленного на оценку влияния методов моделирования на учебную мотивацию и развитие творческих

способностей студентов. Установлено, что использование программ моделирования способствует совершенствованию методов преподавания, повышению учебной мотивации обучающихся, а также положительно влияет на их эмоциональное состояние.

Практическая значимость исследования заключается в разработке конкретных рекомендаций по внедрению цифрового моделирования в систему образования. В частности, предложены эффективные пути интеграции моделирования в преподавание географии в высшей школе, направленные на повышение качества образовательного процесса и раскрытие творческого потенциала студентов.

Ключевые слова: моделирование, преподавание географии, цифровые технологии, пространственное мышление, учебная мотивация, креативность.

Introduction. At present, the digitalization of education is not limited to the use of technical tools; it requires a fundamental transformation of teaching methodology, content, and structure. This is particularly relevant for geography, a subject that is inherently based on spatial thinking and visualization. Modeling, aimed at designing the educational space and learning processes through the use of digital technologies, constitutes the foundation of educational digitalization. Digital modeling technologies are becoming an effective tool that ensures visibility, accessibility, and the integration of theory with practice in the educational process. With their help, learning content is delivered not only in textual or graphical form, but also through interactive and visual models.

Digital learning tools allow for the interactive presentation of learning materials, the visualization of complex geographical concepts, and the real-time monitoring of global processes [1]. Modeling technologies, by superimposing virtual elements onto the real physical world, develop learners' understanding of space and time. They make it possible to visualize complex natural, social, and economic processes, landscape structures, climate changes, and geological phenomena. This contributes to a deeper comprehension of geographical interconnections, broadens students' scientific and technical outlook, and fosters the acquisition of digital competencies.

The modeling method is applied when direct study of the original is impossible or difficult, or when such study would require significant financial resources. This method fosters the development of higher-level theoretical thinking, encourages learners to move away from stereotypical approaches, ensures qualitative analysis of educational material, and promotes conscious problem-solving.

Digital modeling technologies improve traditional teaching methods and raise the quality of education to a new level. However, at present, the use of such technologies in Kazakhstan's educational system remains underdeveloped. An analysis of curricula and scholarly publications revealed that issues related to the selection of content, methodology, and approaches to the effective implementation of digital modeling technologies in education have not been sufficiently explored. Studies show that modeling technologies are not widely employed in geography teaching in Kazakhstan. This is due, firstly, to teachers' insufficient level of digital competence, and secondly, to the lack of adequate teaching and methodological resources. Further barriers include the absence of technical knowledge and experience required for developing 3D models, the inability of teachers to construct such models independently, the complexity of the modeling process itself, as well as the limited availability of ready-made resources. These factors collectively hinder the integration of modeling technologies into the educational process [2]. Consequently, the development of learners' digital literacy in accordance with contemporary requirements is impeded. Addressing this issue necessitates changes in the teacher training system. Effective use of these technologies requires specialized training for teachers, methodological guidelines, and accessible resources.

The lack of methodological resources for 3D object modeling in the educational process necessitates conducting specialized research in this field. Since learners' motivation and emotional states directly affect learning outcomes, investigating the influence of modeling on students' motivation and creativity emerges as a particularly relevant research task [3].

The essence of the study lies in revealing the possibilities for the effective use of digital modeling technologies in education and assessing the impact of the modeling method on the enhancement of learners' creative abilities. The central premise of the study is that integrating modeling into the learning

process at higher education institutions can increase students' interest in learning while fostering their critical thinking, communication skills, and creativity.

The practical significance of the research is that its results can be applied in designing educational processes in pedagogical universities (particularly in the development of academic programs) as well as in professional development courses for teachers. Furthermore, the findings may serve as a basis for developing courses aimed at cultivating students' meta-competencies.

The article provides empirical evidence that modeling technologies have a significant impact on strengthening students' learning motivation, improving the quality of knowledge acquisition, and developing learners' creative abilities. The research outcomes enable the formulation of concrete solutions for enhancing the quality of education [4].

Literature Review. Digital modeling technologies play a crucial role in the teaching of geography, particularly in the development of such cognitive abilities as spatial thinking, understanding cause-and-effect relationships, and perceiving phenomena in a dynamic context. A number of researchers have made significant contributions to the theoretical and methodological foundations of integrating digital modeling into education.

For instance, V.P. Bespalko, examining the integration of information and communication technologies (ICT) into the educational system and their implementation in pedagogical processes, characterizes digital modeling as an innovative teaching method [5].

Yu.N.Tatuyev and O.A.Kosheleva, in their studies, analyze digital modeling technologies as a tool for developing students' creative potential and outline methodological approaches to their integration into learning content [6]. They emphasize that through modeling, the learner becomes not merely a recipient of knowledge but a "constructor" of knowledge.

I.V.Robert, focusing on the role of ICT in education, scientifically substantiated the effectiveness of combining modeling methods with digital tools [7]. According to him, computer modeling contributes not only to the acquisition of subject-specific knowledge but also to the development of functional literacy and critical thinking.

A.I.Savenkov highlights the importance of digital modeling in the development of students' research skills. His research demonstrates that working with geographical maps, 3D models, and simulations significantly enhances practical thinking and analytical abilities [8].

Foreign scholars have also made substantial contributions. For example, the constructivist ideas of S. Papert form the theoretical basis for modeling. He pointed out that in a computer-based environment, learners assume the role of knowledge "constructors" [9]. This approach underpins modern STEM education, robotics, and 3D modeling technologies.

P.A.Kirschner, J.Sweller, and R.E.Clark, drawing on cognitive load theory, identified methodological limitations in the use of complex models [10].

T.Mikropoulos and A.Natsis systematically studied the effects of virtual environments and simulators in education, proving their positive influence on cognitive processes [11]. R.Moreno and R.E.Mayer, based on the theory of multimedia learning, demonstrated that the visual and interactive components of modeling enhance comprehension and long-term knowledge retention [12].

D.Jonassen emphasized that digital modeling is one of the most powerful tools for shaping learners as "knowledge creators," enabling them to transform, reconstruct, and apply knowledge in new contexts [13].

In summary, contemporary literature and practice confirm the effectiveness, functionality, and potential of digital modeling technologies in geography education. These technologies allow students to shift from being passive consumers of knowledge to becoming active researchers and creators. At the same time, researchers underline the importance of combining digital modeling technologies with traditional didactic principles such as visualization, accessibility, scientific validity, awareness and activity, as well as systematization and continuity [2].

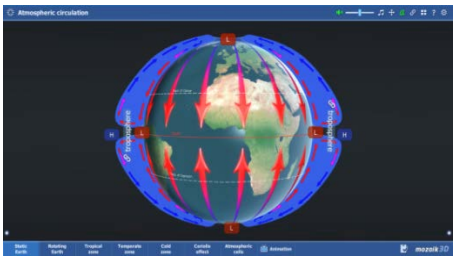
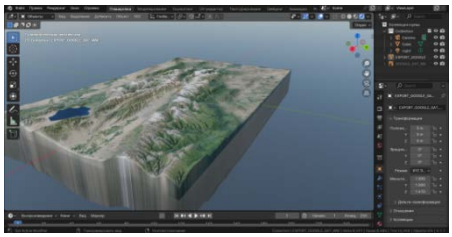
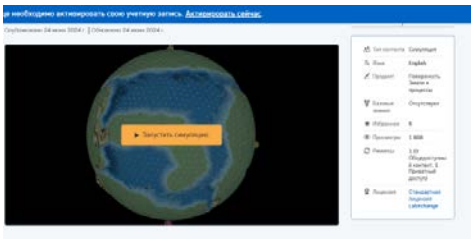
Materials and methods. The study employed methods and materials that made it possible to investigate the impact of digital modeling on the development of students' critical thinking, creativity, and motivation. To achieve this aim, surveys and pedagogical observation were applied, allowing objective conclusions to be drawn on the basis of collected data.

The survey was conducted to assess students' attitudes toward the modeling method, their motivation level, and their emotional state. Pedagogical observation was used to analyze students' behavior and reactions during lessons in which digital modeling programs were implemented [3].

The use of digital modeling tools such as simulations and interactive models created an immersive learning environment that revealed students' creative potential. Immersive interfaces, based on virtual and augmented reality technologies, provided full engagement in the learning process and contributed to the development of practical skills through the simulation of real-life situations in a virtual space [15].

During the study, digital modeling programs Mozaik 3D, PhET Simulation, Tectonic Explorer, and Blender were employed in teaching the subject *"Physical-Geographical Regions of the World"* to second-year students majoring in History and Geography at a pedagogical university.

Table 1 – Digital Modeling Software Used in the Lesson

Program	*Learning Content*	*Purpose of Use*	*Lesson Segment*
Mozaik 3D	Lecture: Climate and Inland Waters of Eurasia	Visualizing geographical objects and phenomena in space using 3D models	
Blender	Lecture: Mountain Systems of Kazakhstan	Active learning through working with 3D models by adding movement and animation	
PhET Simulator	Practical Lesson: Global Environmental Issues in the Territories of Continents and Oceans	Demonstrating changes in physical laws and phenomena through experiments	
Tectonic Explorer	Practical Lesson: Identifying Morphostructural Types of Landforms of Southern Hemisphere Continents on a Tectonic Map	Modeling plate movements based on custom scenarios	

Currently, 3D models are created through graphic software that enables the construction of three-dimensional graphics, modeling of virtual reality objects, and the generation of images based on these models. Among the most accessible tools is the Mozaik program, which was used to demonstrate a 3D model for the lecture topic *"Climate and Inland Waters of Eurasia."* During the session, students were able to visualize the actual global circulation of the atmosphere.

Blender, another program, provides highly detailed models that closely resemble reality. Models created in Blender can be embedded into any plane or environment. Learning Blender helps students develop logical thinking as well as computer graphics and design skills. For example, during the lesson *"Mountain Systems of Kazakhstan,"* students examined a 3D model of the Zhetysu Alatau mountain ranges and valleys.

PhET simulations thus provided opportunities for visualizing abstract concepts and processes, identifying cause-and-effect relationships. For instance, in the practical class on *"Global Environmental Problems of Continents and Oceans,"* students applied PhET to explain the greenhouse effect.

Tectonic Explorer, enables students to express their ideas in the form of 3D models, animations, and visual effects. This program allows learners to simulate various tectonic system scenarios. For example, during the practical class *"Identifying Morphostructural Types of Relief in the Southern Hemisphere on a Tectonic Map,"* students employed Tectonic Explorer. Following a step-by-step algorithm, they first identified the number of lithospheric plates, then mapped convergent and divergent boundaries, and modeled the movement of tectonic plates, thereby gaining a clear understanding of continental drift.

Through the use of these modeling technologies, students were able to acquire a deeper understanding of complex physical–geographical processes. Such visualization enhanced spatial thinking, stimulated scientific inquiry, and increased engagement with the subject matter.

Results and Discussion. Digital modeling technologies influence not only the perception of information but also students' active thinking, imagination, model construction, and creative decision-making. To assess the effectiveness of these technologies in developing students' motivation and creativity, an experimental study was conducted.

The research took place at the Faculty of History and Law of Abai Kazakh National Pedagogical University during the spring semester of the 2024–2025 academic year and lasted for five weeks. A total of 40 students participated in the study, divided into experimental and control groups:

- Experimental group: 20 second-year students majoring in History–Geography;
- Control group: 20 second-year students of the same program.

The experimental group was taught the course *"Physical-Geographical Regions of the World"* using digital modeling tools, while the control group studied according to the traditional curriculum.

Research objectives:

1. To apply digital modeling programs in the teaching process for students of pedagogical specializations;
2. To assess students' levels of creative thinking and motivation before and after the course using the Torrance Test of Creative Thinking (TTCT) and the Vallerand Motivation Scale;
3. To conduct a comparative diagnostic analysis of the results obtained in the experimental and control groups in order to evaluate the effectiveness of the applied methods [15].

Experimental stages:

- *Stage 1: Pre-diagnosis* – identification of creativity and motivation levels;
- *Stage 2: Five-week learning module* – the experimental group was taught with digital modeling technologies (simulations, 3D modeling, map and scheme construction), while the control group followed traditional methods;
- *Stage 3:* Final diagnosis – comparison of the results of both groups [4].

During the study, all participants took the Torrance Test at the beginning to determine their initial level of creativity. After the learning process, both groups retook the test to assess changes. The Torrance Test was administered to 40 students across three dimensions:

1. *Fluency* – the number of responses generated;
2. *Originality* – the number of unique ideas differing from others;
3. *Flexibility* – the variety of ideas across different categories.

Table 2 – Manifestation of the Torrance Scale in the Study

Torrance Scale	Manifestation in the Study
Fluency – generating many ideas	The student attempts to create multiple models of a single natural phenomenon (e.g., different versions of the water cycle model).
Originality – unique solutions	Finds non-standard approaches when modeling geographical maps, landforms, or natural processes.
Flexibility – diverse thinking directions	Presents a single issue (e.g., causes and consequences of earthquakes) from different perspectives and proposes various solutions.

Table 3 – Research Results According to the Torrance Scale

Indicator	*Experimental Group*	*Control Group*
Fluency	34,14	28,67
Originality	31,89	26,87
Flexibility	32,89	28,20

The results of the study demonstrated that the creativity indicators of students taught with the modeling method— *fluency*, *originality*, *and flexibility* —improved significantly compared to the control group. The experimental group (students who used digital modeling technologies):

- achieved higher levels of creativity;
- enhanced their skills in constructing models in geography;
- developed stronger abilities in independent thinking, logic, and decision-making.

The Torrance Scale confirmed that modeling technologies have a substantial positive impact on the development of students' creative competencies.

It should be note that the study wasconducted within a single higher education institution and involved a limited number of participants, which restricts the generalizability of the results across the broader higher education system. While the findings are valid and wellsupported, further research is needed with a broader scope, including students from other universities in Kazakhstan.

Future research perspectives include expanding the experimental base, developing specialized simulation modules, and examining their influence on other aspects of teachers' professional development [15].

Conclusion. The study clearly demonstrated that the systematic integration of digital modeling methods into higher education contributes positively to the enhancement of students' creative thinking, cognitive activity, and intrinsic motivation. This confirms the effectiveness of the approach as a means of overcoming the limitations of traditional teaching methods [4].

Based on the findings, several conclusions can bedrawn:

- The modeling method stimulates students' interest in educational activities, fostering a motivational and creative learning atmosphere [4].
- The method contributes to the development of decision-making, alternative idea generation, and professional reflection skills.
- The modeling programs used in the study serve as effective tools for fostering creative thinking among future teachers.

The collected data confirm the high efficiency of modeling technologies as innovative tools in teacher training, highlighting the need for their integration into pedagogical higher education programs. However, successful implementation requires the enhancement of teachers' digital competence, the establishment of a methodological foundation, and the provision of adequate resources.

To ensure the wide adoption of these technologies, the following measures are recommende:

- Development of educational modeling resources in the Kazakh language tailored to geography;
- Organization of professional development courses for teachers (focusing on 3D modeling and AR tools);
- Provision of essential technical equipment (tablets, interactive boards, AR applications);
- Implementation of pilot projects to share best practices of teachers and students working with AR and modeling technologies.

Thus, the use of digital modeling technologies in the teaching of geography is one of the most effective tools for developing learners' creative abilities and fostering creative thinking.

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РАЗВИТИЕ STEM ОБРАЗОВАНИЯ В КАЗАХСТАНЕ: ПРИМЕНЕНИЕ МАЛОГО КОСМИЧЕСКОГО АППАРАТА В ОБРАЗОВАТЕЛЬНОМ ПРОЦЕССЕ

Аннотация

В статье рассматривается применение малого космического аппарата в образовательном процессе в средней школе. Анализируется опыт других стран в области STEM-образования и сопоставляется возможности и условия применения малых космических аппаратов в Казахстане, проведен контент - анализ учебных программ, методических материалов и образовательных проектов. Цель работы - рассмотреть возможности внедрения малых космических аппаратов в образовательный процесс, для повышения качества образования обучающихся. Это позволит у обучающихся сформировать ключевые STEM навыки и получить практический опыт по сборке, запуску, анализу данных.

Авторы утверждают, что применение малого космического аппарата на уроках физики в средней школе способствует повышению интереса обучающихся к STEM-образованию и космической инженерии в целом,