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### **AI PRACTICES IN GEOGRAPHY TEACHING: AN EMPIRICAL STUDY**

**Annotation.** Artificial intelligence (AI) and computational thinking have opened up opportunities for transformation in the study of geography based on data and technology. However, most geography teachers do not yet have sufficient competence. This community service program aims to increase the proficiency of artificial intelligence and computational thinking among geography teachers through hands-on learning. The methods used include classical seminars and field trips, with materials: artificial intelligence workshop: introduction and practice of working with software based on geospatial examples, as well as direct field trips; training in computational thinking; and direct mentoring of teachers in the implementation of AI-based learning. The assessment was carried out using preliminary and final testing on indicators of artificial intelligence and computational thinking, as well as a public opinion poll. The results of Wilcoxon's analysis showed a significant increase in artificial intelligence scores (the average preliminary test score was 4.00 to 7.98) and computational thinking (from 3.57 to 7.73) with a p-value of <0.001. In addition, 90% of participants expressed willingness to implement AI-based approaches in the learning process. These results show that context-based and hands-on learning can effectively enhance teachers' competence. The Community Service Program recommends further mentoring, especially in technical aspects, to ensure the adoption and sustainability of innovations in geospatial and AI-based learning, as well as practical field work.

**Keywords:** AI literacy, computational thinking, geographic learning.

#### *Introduction*

The development of information and communication technologies has changed the paradigm of the learning process, including in geography. One of these technological advances is the emergence of deep learning, which mimics the work of the human brain using artificial neural networks. Deep learning makes it possible to analyze large-scale, extremely complex data, including spatial and temporal data, which makes it very promising for integration into geographical research. One example of the application of deep learning is mapping the dynamics of environmental changes and supporting data-driven decision-making.

The introduction of deep learning in education opens up opportunities for the use of artificial intelligence. AI is not just a tool, but a strategic approach to designing learning based on data analysis and research. In geographic learning, AI can be used to process satellite images, analyze land-use models, predict potential disasters, and even interactively visualize environmental changes [1]. The integration of AI into learning requires a shift from traditional approaches to learning to approaches based on data and technology. However, the level of AI literacy among geography teachers is relatively low. AI literacy implies a person's ability to understand the basic concepts of AI, think algorithmically, and use and evaluate AI applications ethically and effectively [2]. This competence also includes mastering computational thinking, a systematic approach to problem solving through decomposition, abstraction, pattern recognition, and algorithm design. Computational thinking is the ability to integrate technology into geography teaching based on geospatial data [3]. The results of a survey and focus group discussion (FGD) with the participation of 44 geography teachers revealed significant problems in the implementation of technologies based on artificial intelligence. Only about two teachers (5%) used tools such as QGIS, Google Earth Engine or other machine learning tools in their teaching activities. In turn, 31 teachers (70%) still relied on traditional methods, lacking the ability to accurately display spatial dynamics. This problem is compounded by teachers' limited understanding of computational thinking, making it difficult to design data-driven learning. The notion that AI and machine learning require knowledge of mathematics or programming undermines the interest and confidence of teachers, especially those who work in regions with limited access to technology [3].

In addition, differences in technological infrastructure between schools in urban and rural areas further widen the gap in the use of educational technologies. The Community Service program is designed to overcome the obstacles and challenges faced by teachers. The goal of this program is to increase the proficiency of artificial



intelligence among geography teachers in the field of computational thinking through intensive training based on field data. The training integrates the use of AI-based and machine learning-based tools, and helps teachers develop contextual curricula [4]. Using a science-based, interactive, and participatory approach, this community service program not only enhances the quality of geography studies, but also contributes to teacher development in the age of AI and geospatial technologies.

#### *Methodology*

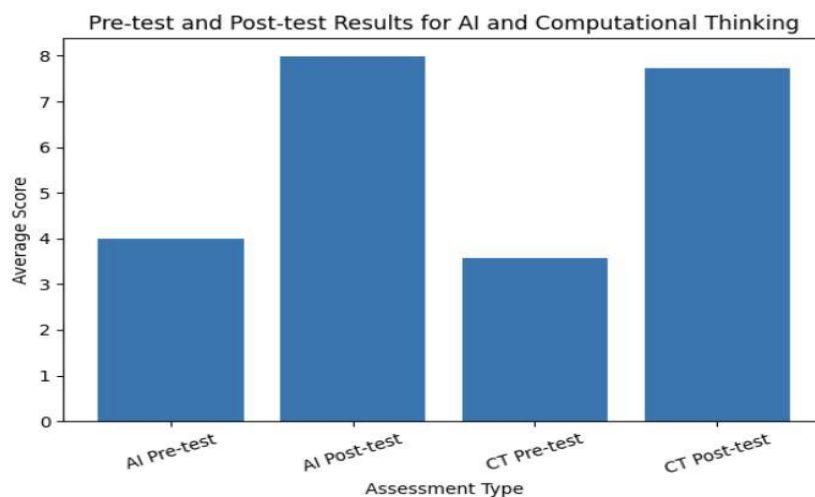
The team consists of 44 teachers from various schools. The implementation plan is based on a systematic capacity-building approach and includes four phases: planning, preparation, implementation and evaluation. Each stage is designed in such a way that the integration of AI and deep learning into the study of geography is carried out gradually, adaptively and contextually in accordance with local conditions. The program is implemented using a mixed method, namely online and offline. The planning, preparation and evaluation stages are conducted online to ensure effective coordination and subsequent implementation of the program. Geography. Feedback indicates the need for further program development and support, especially in technical areas.

#### *Discussion and results*

The results of this public work demonstrate the success of the training program in improving the competence of geography teachers in the field of literacy in the field of artificial intelligence and computational thinking. The average score of the preliminary test (AI: 4.00 and CT: 3.57) reflects the low level of understanding by teachers of data-based learning methods and technologies prior to the start of training. The increase in final test scores (AI: 7.98 and CT: 7.73) not only demonstrates the successful transfer of material, but also the effectiveness of a practical approach to learning.

The learning model used combines conceptual and contextual aspects. The program of the first day focused on providing material in the format of seminars. The workshops included theory and modeling using AI-based software as part of geospatial case studies. The program of the second day was devoted to a field trip, during which the teachers visited a real geographical environment. This integration of classroom and nature laboratory learning corresponds to a mixed approach to field pedagogy, which can strengthen teachers' knowledge and improve the accuracy of spatial interpretation of geographical phenomena [5].

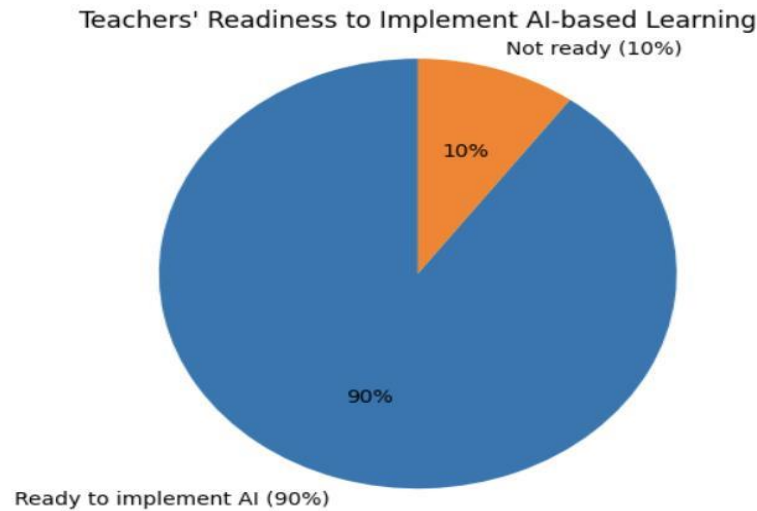
Sightseeing events serve as a bridge connecting the studied theory with real conditions. This can improve the skills of observation, primary data collection, and critical thinking [6]. Teachers are trained to integrate observation results into digital geospatial data based on maps. This activity can improve teachers' understanding of spatial data, such as environmental dynamics and the potential of local resources [7]. The integration of software and practical field experience can enhance teachers' technological literacy in real-world settings.



A significant increase in the results of the post-test was confirmed by Wilcoxon analysis for related samples ( $p < 0.001$ ), indicating changes after participation in the community service program. In addition to demonstrating the positive impact of learning, these results also point to the potential for teacher development provided they are provided with an appropriate, structured and contextual approach to learning [7]. Weng's research [8] has shown that computational thinking and AI in education largely depend on meaningful learning, which is directly related to the needs and context of both students and teachers. A significant improvement was also noted in the emotional aspect of learning. 90% of teachers felt ready to implement AI-based learning in



geography lessons. This indicates that the training was not only cognitively effective, but also able to increase teachers' confidence in technologies that are often perceived as complex and difficult to access.



Negative perceptions persist that AI and computational thinking require a high level of mathematical or programming expertise. These results are supported by an interactive learning approach based on case studies and field trips. The seminar covered the basic concepts of artificial intelligence and the use of machine learning in geography studies. Computational thinking as a systematic approach to solving geospatial problems was also discussed. The workshop was interactive and included discussions, modeling, and case studies using satellite imagery.

The second day of the community service program included a field trip, which served as a natural laboratory for the application of the studied material. During this session, the teachers conducted a practical data collection.

The field data was analyzed to obtain field evidence or to enhance the results of spatial analysis. This process can strengthen conceptual understanding and analyze the material learned during field training. The assessment results, presented in the form of competence measurements before and after testing, showed significant improvement. A nonparametric statistical method was used to analyze the data, since the data on literacy in the field of AI and computational thinking did not have a normal distribution ( $p$ -value  $<.001$ ) and were not homogeneous ( $p$ -value  $<.001$ ). The results of the descriptive analysis and the Wilcoxon landmark rank criterion are presented below.

The result shows the difference between the average values of the preliminary and final tests for the variable "AI literacy", which is 3.98, while for the variable "computational thinking" the difference was 4.16. The results of the analysis show the value of the Wilcoxon  $p$ -test for the rank sums  $<0.001$ , which means that there is a significant difference between the results of preliminary and final testing. These results indicate that a community service program can enhance the proficiency of artificial intelligence and the development of computational thinking among geography teachers. In addition, the results of the public opinion poll showed that the majority of teachers considered the materials on socially useful activities to be very relevant and applicable in practice. Forty teachers (90%) declared their readiness to introduce AI-based learning into their educational process. However, the results of the evaluation of the public works program indicate that its implementation faces challenges in terms of the sustainability of the program, including technical and structural issues. Some teachers have encountered difficulties with equipment and Internet access, as well as constant support during the implementation of the program after training. These challenges demonstrate the importance of a sustainable mentoring system, a vocational training network, and political support from local governments to facilitate technology-based learning processes. As a model of community service, this program demonstrates that the digital transformation in geography studies can begin with community-based activities. Strengthening the capacity of teachers can play a significant role in creating an innovative and interactive learning environment based on technology [9]. The success of this program can be adapted or applied to other regions using a similar approach, namely integrating theory, technology, and demonstration through direct field practice. Meanwhile, the integration of geospatial technologies into geography education at the secondary school and university levels has been shown to strengthen



conceptual understanding and spatial thinking skills. Field research shows that the use of training materials based on web GIS and geographic information systems improves spatial thinking and motivation for learning among students, and can also increase their self-confidence in the context of learning programming and satellite image processing.

The results of the study by Schulze et al. They confirm that the integration of geographic information systems (GIS) into the study of geography significantly improves students' learning outcomes, engagement, and spatial problem solving skills in various countries. At the university level, laboratory classes using Google Earth Engine (GEE) have also shown their effectiveness in expanding students' analytical skills [2]. However, significant challenges remain, such as limited access to infrastructure, lack of intensive teacher training, and limited integration of curricula that emphasize practical application. A prime example of these limitations are learning methods that still rely on desktop software. The study of ArcGIS is actually taught in laboratories, but this is often hindered by licensing issues, so teachers often switch to using the open source QGIS software. As a result, students do not have a structured experience working with cloud platforms such as Google Earth Engine and are not familiar with GeoAI practices. This indicates a gap between the development of modern geospatial technologies and the technical competencies acquired by students. This is due to a number of factors, such as students' limited experience in programming on cloud platforms, insufficient guidance on working with Google Earth Engine, and lack of knowledge in the field of geographic information.

The systems are still heavily focused on desktop software. This leads to the fact that students are not familiar with working with large amounts of spatial data, automated AI-based analysis and data representation using interactive dashboards. Therefore, more practical and focused training is needed to help students meet the requirements of modern geospatial research.

The development of geospatial research and the emergence of geospatial artificial intelligence (GeoAI) offer significant opportunities to enhance students' ability to identify spatial patterns and make predictions based on large amounts of data. Recent studies have demonstrated the success of using GeoAI in various environmental and agricultural issues, for example, in predicting the physical properties of soil or monitoring water quality, which demonstrates GeoAI's ability to efficiently process large amounts of geodata. The scientists also reported on the use of GeoAI in Google Earth Engine to map changes in earth's surface temperature, highlighting the relevance of GeoAI for coastal landscape change and urbanization. However, these results were not fully taken into account in the work of students studying geography in pedagogical educational institutions. The use of geoinformation AI in teaching and practical activities of students is still very limited, as lectures tend to focus on traditional geographic information systems and do not provide direct experience with AI-based analysis or cloud platforms such as Google Earth Engine. It is this limitation that creates a gap between the progress of research in the field of geoinformation AI at the national level.

#### *Conclusions*

This program of socially useful work has significantly increased the level of artificial intelligence proficiency and competence in the field of computational thinking among geography teachers. The program, implemented as a two-day training course combining a classical seminar and field trips, had a positive impact on both cognitive and affective aspects. An increase in final test results for both indicators, as shown by the Wilcoxon criterion for related samples ( $p < 0.001$ ), is an indicator of the success of a practice-oriented, contextual and interactive approach to learning. The introduction of classroom learning has allowed for the creation of conceptual learning spaces and the development of teachers' skills in observing, interpreting, and integrating spatial data into the study of geography. The high level of readiness of teachers (90%) to implement AI-based learning indicates that psychological barriers and negative perceptions of technology can be minimized. However, technical and structural problems were identified. These include limited infrastructure, access to software, and the need for mentoring after training. This highlights the need for systemic support to ensure the sustainable implementation of learned pedagogical innovations. Based on the results of the work of this service, the following recommendations can be made:

1. Implementation of theoretical, technological and practical learning models in other regions facing similar challenges in the field of artificial intelligence development to improve the quality of learning.
2. Strengthening mentoring after training, both through the formation of teacher communities to share experiences and by facilitating mentoring.

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#### **ГЕОГРАФИЯ ПӘНІН ОҚИТУДАҒЫ ЖИ ТӘЖІРИБЕСІ: ЭМПИРИКАЛЫҚ ЗЕРТТЕУ**

**Андатпа.** Жасанды интеллект (АИ) және есептеу ойлауы деректер мен технологияларға негізделген Географияны зерттеуге айналу мүмкіндіктерін ашты. Дегенмен, география мұғалімдерінің көпшілігі әлі жеткілікті құзыретке ие емес. Бұл қоғамдық жұмыс бағдарламасы Практикалық оқыту арқылы география мұғалімдерінің жасанды интеллект пен есептеу ойлауын меңгеру деңгейін арттыруға бағытталған. Қолданылатын әдістерге классикалық семинарлар мен далалық экскурсиялар кіреді, материалдармен: жасанды интеллектті меңгеру семинары: геокеңістіктік мысалдарға негізделген бағдарламалық жасақтамамен танысу және тәжірибе, сондай-ақ тікелей далалық экскурсиялар; есептеу ойлауын үйрету; және мұғалімдерге АИ негізіндегі оқытуды жүзеге асыруда тікелей тәлімгерлік. Бағалау жасанды интеллект пен есептеуші ойлауды меңгеру көрсеткіштері бойынша алдын ала және қорытынды тестілеу, сондай-ақ қоғамдық пікірді сұрау арқылы жүргізілді. Вилкоксон талдауының нәтижелері жасанды интеллектті меңгеру ұпайларының (орташа алдын ала тестілеу ұпайы 4,00-ден 7,98-ге дейін) және р-мәні <0,001 болатын есептеу ойлауының (3,57-ден 7,73-ке дейін) айтарлықтай өскенін көрсетті. Сонымен қатар, қатысушылардың 90% - ы оқу процесіне АИ негізіндегі тәсілдерді енгізуге дайын екендіктерін білдірді. Бұл нәтижелер контекстке бағытталған және практикалық оқыту мұғалімдердің құзыреттілігін тиімді арттыра алатынын көрсетеді. Қоғамдық жұмыстар бағдарламасы геокеңістіктік деректер мен АИ негізінде оқытуда инновацияларды енгізу мен тұрақтылықты қамтамасыз ету үшін, әсіресе техникалық аспектілерде, сондай-ақ далада практикалық жұмыс істеу үшін одан әрі тәлімгерлікті ұсынады.

**Кілт сөздер:** ЖИ саласындағы сауаттылық, есептеу ойлауы, географиялық оқыту.

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#### **ПРАКТИКИ ИСПОЛЬЗОВАНИЯ ИИ В ПРЕПОДАВАНИИ ГЕОГРАФИИ: ЭМПИРИЧЕСКОЕ ИССЛЕДОВАНИЕ**

**Аннотация.** Искусственный интеллект (ИИ) и вычислительное мышление открыли возможности для трансформации в изучение географии на основе данных и технологий. Однако большинство учителей географии, пока не обладают достаточной компетенцией. Эта программа общественной работы направлена на повышение уровня владения искусственным интеллектом и вычислительным мышлением у учителей географии посредством практического обучения. Используемые методы включают классические семинары и полевые экскурсии, с материалами: семинар по владению искусственным интеллектом: ознакомление и практика работы с программным обеспечением на основе геопространственных примеров, а также непосредственные полевые экскурсии; обучение



вычислительному мышлению; и непосредственное наставничество учителей в реализации обучения на основе ИИ. Оценка проводилась с помощью предварительного и итогового тестирования по показателям владения искусственным интеллектом и вычислительного мышления, а также опроса общественного мнения. Результаты анализа Вилкоксона показали значительное увеличение баллов по владению искусственным интеллектом (средний балл предварительного тестирования 4,00 до 7,98) и вычислительному мышлению (с 3,57 до 7,73) с  $p$ -значением  $<0,001$ . Кроме того, 90% участников выразили готовность внедрять подходы на основе ИИ в учебный процесс. Эти результаты показывают, что контекстно-ориентированное и практическое обучение может эффективно повысить компетентность учителей. Программа общественных работ рекомендует дальнейшее наставничество, особенно в технических аспектах, для обеспечения внедрения и устойчивости инноваций в обучении на основе геопространственных данных и ИИ, а также для практической работы на местах.

**Ключевые слова:** грамотность в области ИИ, вычислительное мышление, географическое обучение.