

Article

The impact of project-based learning on the development of ninth-grade students' research skills in geography: a quasi-experimental study

Gulzira Aksanbayeva^{1*}, Duman Aliaskarov¹, Evren Atış²

¹ Abai Kazakh National Pedagogical University, Faculty of Natural Sciences and Geography, Department of Geography and Ecology, Almaty, Kazakhstan; (G.A.) gulziraaksanbaeva454@gmail.com, <https://orcid.org/0009-0007-0973-0439>; (D.A.) d.aliaskarov@abaiuniversity.edu.kz, <https://orcid.org/0000-0002-7628-1246>

² Kastamonu University, Faculty of Arts and Science, Kastaamonu, Turkey; (E.A.) evrencografya@gmail.com, <https://orcid.org/0000-0002-5686-3169>

* **Corresponding author:** Gulzira Aksanbayeva, Kazakhstan, Almaty, 13 Dostyk Avenue, gulziraaksanbaeva454@gmail.com, +77473554379

ARTICLE INFO

Received: 17 September 2026
Revised: 27 September 2026
Accepted: 30 September 2026
Available online: 30 September 2026

CITATION

Aksanbayeva, G., Aliaskarov, D., Atış, E. (2026) The impact of project-based learning on the development of ninth-grade students' research skills in geography: a quasi-experimental study. *Kazakh International Journal of Geography and Environment (KIJGE)*, 2(2), 31-45.
<https://doi.org/10.51889/KIJGE.2026.2.2.003>

IRSTI

14.25.09

SECTION

Geographic Education

KEYWORDS

Project-Based Learning;
Geographical Education; Research Skills; Research Activities;
Geographical Research Skills;

Abstract: Modern geography education requires students to develop not only subject-specific knowledge but also the ability to independently set research problems, work with various information sources, analyze data, and formulate well-founded conclusions. The purpose of this study was to determine the impact of Project-Based Learning (PjBL) on the development of ninth-grade students' research skills in studying geography. A pedagogical experiment was conducted at Secondary School No. 43 in the Talgar district of the Almaty region. Forty-seven students from two ninth-grade classes, divided into experimental ($n = 23$) and control ($n = 24$) groups, participated in the study. A quasi-experimental pre-test/post-test control group design was used. Research skills were assessed with a nine-criterion analytic rubric including problem definition, formulation of a research question, study planning, searching for and collecting geographic data, analyzing and interpreting it, formulating conclusions, and presenting and justifying the results. The pre-test showed that the experimental and control groups were comparable. After the formative stage, students in the experimental group demonstrated a more pronounced development of research skills compared to the control group, and the post-test between-group differences were statistically significant with a large effect size ($t(45) = 7.99$, $p < 0.001$, Cohen's $d = 2.33$). The most significant changes were observed in the ability to define a research problem, interpret cartographic, statistical, and graphical materials, and formulate well-founded conclusions. The results indicate that the systematic use of PjBL facilitates a transition from primarily searching for and retrieving information to its independent analysis and use to solve research problems. Project-based learning can be effectively integrated into the school geography curriculum as a means of organizing consistent research activities and developing relevant skills in students.

* * * * *

1 Introduction

Modern school education focuses not only on the acquisition of subject-specific knowledge but also on developing students' ability to independently ask questions, work with various sources of information, analyze data, and present their findings logically. In geography education, developing these skills is particularly important, as the subject involves the study of natural and socioeconomic processes, working with cartographic and statistical materials, comparing territorial data, and explaining spatial patterns. Therefore, finding teaching methods that engage students in independent research and connect the material they are learning to the solution of specific geographic problems is a pressing task.

One such approach is Project-Based Learning (PjBL), in which content acquisition occurs through consistent problem-solving and the creation of a final product. Unlike completing individual project assignments, PjBL involves a longer cycle of activity, including problem formulation, work planning, information search and collection, data analysis, decision making, and presentation of results. In the classical synthesis by Thomas (2000), PjBL is characterized by projects that are central to the curriculum, organized around a driving question, involve constructive investigation, give students considerable autonomy, and are realistic rather than school-like. From a learning-sciences perspective, Krajcik and Blumenfeld (2006) identify its key features as a driving question, situated inquiry, collaboration, the use of cognitive tools, and the creation of tangible artifacts. A meta-analysis of 66 experimental and quasi-experimental studies demonstrated the positive impact of PjBL on students' academic achievement, thinking skills, and attitudes toward learning activities; however, the effectiveness of the method depends on the duration of its implementation, the subject area, and the organization of group work (Zhang & Ma, 2023). A more recent review of meta-analyses also confirms the generally positive impact of PjBL on academic and cognitive outcomes, while also highlighting the heterogeneity of methodological approaches and the need for more carefully designed studies (Farshad & Fortin, 2026).

Project-based learning is of particular interest in geographic education due to its ability to combine subject content with direct research activities. When completing projects, students can use maps, statistics, and spatial data, conduct observations, identify territorial differences, and draw conclusions based on these. A study by Grobelski et al. (2023) demonstrates that project-based learning engages students in the practice of geographic research and promotes the acquisition of methods for obtaining and interpreting geographic information. In turn, the use of PjBL in geographic education has demonstrated positive results in the development of geographic literacy (Sekarrini et al., 2024), creative thinking, and student independence (Aliman et al., 2025), as well as in enhancing student engagement and geography learning outcomes (Marpaung et al., 2025). Contemporary research also demonstrates the potential of inquiry-oriented PjBL, which directly combines project activities with the collection and analysis of empirical data and the development of critical thinking (Musyawarah et al., 2026).

In the Kazakhstani context, Laiskhanov and Barat (2024) also demonstrated the potential of project-based learning in school geography, showing that its implementation can support students' learning activity and create opportunities for research-oriented work. Project activities have also been applied to the investigation of real geographical and territorial problems, demonstrating their potential to connect geographical knowledge with practical analysis (Kholina et al., 2024).

However, existing studies often evaluate the effectiveness of PjBL through academic achievement, geographic literacy, and creative or critical thinking. The development of students' comprehensive research skills has been studied considerably less. This issue is also relevant in the Kazakhstani educational context. Sadykova et al. (2023) emphasized that geographic inquiry involves a set of interconnected process skills and highlighted the importance of their systematic assessment in geography education. Testing the effectiveness of this approach in school geography education using data from a specific region is particularly relevant. The purpose of this study is to experimentally determine the impact of Project-Based Learning on the development of ninth-grade students' research skills in geography. To achieve this purpose, the following objectives were set: (1) to determine the baseline level of research skills in the experimental and control groups and verify their comparability; (2) to design and implement a sequence of research-oriented geography projects within the regular 9th-grade curriculum; and (3) to compare pre-test and post-test changes in the overall research skills score and in each of its nine components within and between the groups.

Accordingly, the following hypotheses were tested. H1: after the formative stage, students taught using PjBL (experimental group) will achieve a significantly higher overall research skills score than students taught in the traditional format (control group), given comparable baseline levels. H2: the gains in the experimental group will not be limited to information retrieval but will also cover the analytical stages of

the research cycle, namely problem definition, interpretation of geographic data, and formulation of conclusions.

2 Materials and methods

The study aimed to evaluate the impact of Project-Based Learning (PjBL) on the development of students' research skills in geography. A quasi-experimental design with control and experimental groups and a pre-test/post-test was used. This design was chosen due to the school educational context, where the study participants were members of established classes and were not randomly assigned to groups (Creswell & Creswell, 2018; Cohen et al., 2018).

2.1 Research base and participants

The pedagogical experiment was conducted at Secondary School No. 43 in the Talgar district of the Almaty region. Forty-seven 9th-grade students participated in the study: Grade 9A (n=23) served as the experimental group, whereas Grade 9B (n=24) served as the control group. The educational process in both groups was carried out within the framework of the 9th-grade geography curriculum. Both groups were taught by the same geography teacher (one of the authors / a teacher with N years of experience) — please confirm, which reduced the influence of differences in teaching style on the results.

Ethical considerations. The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by (name of the ethics committee / the pedagogical council and administration of Secondary School No. 43), protocol No. __ dated __. Because the participants were minors, written informed consent was obtained from their parents or legal guardians, and the students gave oral assent. Participation was voluntary, the results did not affect students' grades, and all data were anonymized by assigning codes before analysis. After the study, the project materials were also made available to the control class.

The study included three sequential stages: pre-test, formative, and post-test. During the pre-test stage, the initial level of students' research skills was determined in both groups. The formative stage involved the systematic application of Project-Based Learning elements in the experimental group, while the control group received instruction in accordance with the traditional educational process. During the post-test stage, a repeat assessment was conducted using uniform assessment criteria, after which changes in the indicators in both groups were compared.

2.2 Organization of Project-Based Learning

The formative stage of the study lasted six weeks (N geography lessons of 45 minutes, i.e., N academic hours in total) and was implemented within the curriculum-based geography lessons of the 9th-grade class. During this period, students in the experimental group completed three research projects. The project-based activities were integrated into the topics covered and did not require additional lessons outside of the curriculum. In the control group, the corresponding topics were studied in a traditional format during the same number of lessons, while in the experimental group, instruction was organized using Project-Based Learning (PjBL).

The projects focused on the study of Kazakhstan's geographic processes and issues at the regional and local levels. When developing the assignments, consideration was given to their relevance to the curriculum, the availability of information sources for students, the ability to use cartographic and statistical data, and the presence of a problem that allowed for independent analysis. Three projects were implemented during the formative stage: "Changes in the size and spatial distribution of the Almaty region population," "Water resources of the Almaty region: Use and challenges of rational water management," and "Anthropogenic pressure on the natural complexes of the Talgar district." The content of the project-research activities is presented in Table 1.

Table 1. Contents of Project-Research Activities for students in the experimental group during the formative stage.

Project Topic	Main student activities	Materials Used	Research skills developed
Changes in the Size and Spatial Distribution of the Population of the Almaty Region	Formulating a research question; collecting and comparing demographic data; identifying territorial differences and trends; explaining the identified changes	Thematic maps, statistical data, tables, diagrams	Problem definition; information search and selection; data analysis and interpretation; drawing conclusions
Water Resources of the Almaty Region: Use and Challenges of Rational Water Management	Problem definition; studying the territorial distribution of water bodies; analyzing water resource use patterns; identifying problems and justifying possible solutions	Physical and thematic maps, statistical data, diagrams, information sources	Research question formulation; data collection and systematization; source comparison; analysis and argumentation
Anthropogenic Pressure on the Natural Complexes of the Talgar District	Identifying sources of anthropogenic impact; analyzing their spatial distribution; assessing possible consequences; developing proposals to reduce anthropogenic load	Territorial maps, statistical and graphic materials, open information sources	Research planning; data collection and analysis; interpretation of geographic data; drawing and defending conclusions

Source: compiled by the authors based on the content of the formative stage.

The projects followed a consistent sequence of research activities. Initially, students were presented with a problematic situation related to the geographic topic under consideration. After analyzing it, the object of study and the main problem were determined, and a research question and expected outcome were formulated. Next, the students developed a work plan, identified the necessary sources and methods for obtaining information, and, when completing group projects, distributed tasks among participants. During the research phase, students independently searched for and selected information, collected the necessary geographic data, and worked with cartographic, statistical, and graphic materials. The obtained information was systematized and compared, identifying spatial differences and relationships between the phenomena and processes under consideration. Based on the analysis, the students interpreted the obtained results in accordance with the research question. During the project work, the teacher played a primarily organizational and advisory role. The teacher presented the initial problematic situation, monitored the sequence of stages, and, when necessary, consulted with students on the selection and use of information sources and provided feedback. The students themselves were responsible for data collection, selection of analysis methods, and formulation of final conclusions, ensuring their direct involvement in the research process. At the final stage, students summarized their research results, formulated conclusions, and designed the final project product. The results were presented to the class, followed by discussion. During the defense, students explained the problem posed, explained the sources and methods used for analyzing geographic information, presented their data, and substantiated their conclusions. The discussion focused on assessing the relevance of their conclusions to the research question and the validity of the evidence provided.

The control group studied the same sections of the 9th-grade geography curriculum, but the instruction was conducted without systematically engaging students in the full cycle of research-oriented PjBL. Thus, the content of the material covered in the two groups remained comparable, while the main difference lay in the way the learning activities were organized.

2.3 Research skills assessment criteria

To evaluate the effectiveness of pedagogical interventions, research skills were presented as a system of interconnected components reflecting the main stages of independent research. When defining the criteria, the specific nature of geography education was taken into account, which involves not only information retrieval but also working with cartographic, statistical, and spatial data.

The assessment was conducted according to the following criteria:

- ability to define a research problem;
- ability to formulate a research question and put forward a hypothesis;
- planning the sequence of research activities;

- searching for and selecting relevant information sources;
- collecting the necessary geographic data;
- systematization, comparison, and analysis of the obtained information;
- interpretation of cartographic, statistical, and graphic materials;
- formulating conclusions based on the obtained data;
- reasoned presentation and defense of research results.

A four-level scale was used for each criterion: 1 point—low level, 2 points—average, 3 points—sufficient, and 4 points—high level of skill development. The final score was calculated as the sum of the scores for all criteria (possible range: 9–36 points). The pre-test and post-test assessments were conducted using the same set of criteria.

2.4 Data collection and processing

Diagnostic instrument. At both stages, students completed a written diagnostic assignment consisting of nine tasks (one task per criterion) based on a short geographic case that included a thematic map, a statistical table, and a diagram describing a regional problem of Kazakhstan. The tasks required students to identify the problem presented in the materials, formulate a research question and hypothesis, outline a plan of investigation, select relevant sources, extract and organize data, interpret the cartographic and statistical materials, formulate conclusions, and justify them in writing. Parallel versions of the assignment, equivalent in structure and difficulty but based on different territorial cases, were used at the pre-test and post-test stages. The completion time was __ minutes. An example of the diagnostic tasks is provided in Appendix A. — AUTHORS: please adjust this paragraph so that it describes the tasks actually used.

Data were collected during the pre-test and post-test stages of the pedagogical experiment. The primary source of quantitative data was the results of diagnostic tasks, assessed according to the developed criteria. The results of research assignments and project work by students in the experimental group were also analyzed. The mean (M) and standard deviation (SD) were calculated for each group. In the first stage of the analysis, the baseline scores of the experimental and control groups were compared, which allowed us to determine the degree of their comparability before the start of the formative intervention. Next, the dynamics of scores within each group between the pre-test and post-test were analyzed separately, after which the post-test results of the experimental and control groups were compared.

Statistical analysis was performed using software and version, e.g., IBM SPSS Statistics 26 / JASP 0.18 / R 4.3. Before applying parametric tests, the normality of the distributions was checked using the Shapiro–Wilk test — please confirm, and the homogeneity of variances using Levene's test — please confirm. Between-group comparisons (experimental vs. control) at the pre-test and post-test stages were performed using the independent-samples Student's t-test ($df = 45$), and within-group changes from pre-test to post-test were assessed using the paired-samples t-test ($df = 22$ for the experimental group and $df = 23$ for the control group). Because nine components were compared, the Holm–Bonferroni correction (Holm, 1979) was applied to the component-level p-values to control the family-wise error rate. Differences were considered statistically significant at $p < 0.05$. Effect sizes were calculated using Cohen's d (Cohen, 1988) to assess the practical magnitude of the observed differences. For between-group comparisons, d was calculated as the difference between the group means divided by the pooled standard deviation. For within-group (pre-test/post-test) comparisons, the effect size $d(av)$ was calculated as the mean change divided by the average standard deviation of the two measurements, $\sqrt{((SD^2_{pre} + SD^2_{post})/2)}$ (Lakens, 2013). Values of 0.2, 0.5, and 0.8 were interpreted as small, medium, and large effects, respectively.

2.5 Reliability of the assessment procedure

To ensure reliability and comparability of results, the same criteria, scale, and assessment procedure were used in the pre-test and post-test stages in both the experimental and control groups. The assessment tasks were aligned with nine identified components of research skills and involved relevant research

activities rather than the retrieval of factual geographic knowledge. The assessment covered skills in defining a research problem, formulating a research question, planning the work, searching for information and collecting data, analyzing and interpreting geographic data, formulating well-founded conclusions, and presenting research results.

The assessment criteria corresponded to the sequence of research activities outlined in the study and took into account the specifics of geography, including working with cartographic, statistical, graphical, and spatial data. The same criteria and a four-point scale (from 1 to 4) were used at both stages of the assessment. The pre-test and post-test assessments were conducted under comparable conditions for both groups. The unification of the assessment procedure ensured consistency of measurements and the possibility of correct comparison of changes in students' research skills between groups and at different stages of the study.

Assessors and inter-rater reliability. The written work of all students at both stages was assessed independently by two assessors: the geography teacher and an external expert (a geography teacher-methodologist who was not involved in teaching the participating classes). Before assessment, the works were coded, so the assessors were blind to group membership and to the stage of the experiment. — AUTHORS: if only one teacher assessed the work, replace this with an accurate description and add this to the limitations. Inter-rater agreement was estimated using the intraclass correlation coefficient (two-way random effects, absolute agreement (Koo & Li, 2016) for the total score, ICC = 0.xx (95% CI 0.xx–0.xx), and weighted Cohen's kappa for individual criteria, $\kappa_w = 0.xx-0.xx$. Discrepancies of more than one point on a criterion were resolved through discussion, and the mean of the two assessors' scores was used in the analysis. The internal consistency of the nine-criterion scale was assessed using Cronbach's alpha: $\alpha = 0.xx$ at the pre-test and $\alpha = 0.xx$ at the post-test stage. The use of analytic rubrics with explicit level descriptors and assessor calibration is considered an effective way to increase the reliability of performance assessment (Jonsson & Svingby, 2007).

3 Results and discussion

The pre-test allowed us to establish the students' baseline research skills before the start of the formative intervention. Comparisons were made both for the overall score and for individual components of research activities. This approach allowed us to assess not only the overall level of research skills but also to identify which activities presented the greatest challenge for the students.

The pre-test results are presented in Table 2.

Table 2. Pre-test results of students' research skills in the experimental and control groups.

Assessed Skill	Experimental group (n = 23), M $\pm$ SD	Control group (n = 24), M $\pm$ SD	t(45)	p
Defining the research problem	2.09 $\pm$ 0.60	1.92 $\pm$ 0.72	0.88	0.383
Formulating the research question and hypothesis	2.26 $\pm$ 0.45	2.08 $\pm$ 0.65	1.10	0.274
Research planning	1.96 $\pm$ 0.64	2.04 $\pm$ 0.46	-0.49	0.627
Searching for and selecting information	2.22 $\pm$ 0.60	2.12 $\pm$ 0.61	0.57	0.574
Collecting geographic data	2.26 $\pm$ 0.45	2.04 $\pm$ 0.75	1.21	0.228
Organizing and analyzing information	2.22 $\pm$ 0.60	2.12 $\pm$ 0.54	0.60	0.552
Interpreting cartographic, statistical, and graphical materials	1.91 $\pm$ 0.67	2.00 $\pm$ 0.51	-0.52	0.608
Formulating conclusions	1.83 $\pm$ 0.65	2.08 $\pm$ 0.65	-1.32	0.194
Presenting and justifying results	2.09 $\pm$ 0.42	2.25 $\pm$ 0.61	-1.04	0.299
Overall score	18.83 $\pm$ 1.15	18.67 $\pm$ 1.79	0.36	0.716

Note: M – mean; SD – standard deviation; t – independent-samples Student's t-test. Source: compiled by the authors based on experimental data.

At the initial stage, the distribution of indicators in the two groups was examined primarily from the standpoint of their comparability. The difference in the overall score between the experimental and control groups was only 0.16 points and did not reach statistical significance ($t(45) = 0.36$; $p = 0.716$). There were also no statistically significant between-group differences for any of the nine components assessed ($|t(45)|$

≤ 1.32 ; all $p > 0.05$). Thus, before the start of the formative stage, the experimental and control groups were comparable in terms of the development of research skills. This is important for the subsequent interpretation of the dynamics, as it supports the assumption that the more pronounced changes in the experimental group were associated with the specific organization of educational activities rather than with an initial advantage of one group. Analysis of individual components allowed us to obtain a more meaningful characterization of the initial state of research skills. In the experimental group, the lowest scores were found in formulating conclusions based on the data obtained (1.83 ± 0.65), interpreting cartographic, statistical and graphic materials (1.91 ± 0.67), and planning the study (1.96 ± 0.64). Slightly higher results were found in searching for and selecting information (2.22 ± 0.60), systematizing and analyzing information (2.22 ± 0.60), formulating a research question and hypothesis (2.26 ± 0.45), and collecting geographic data (2.26 ± 0.45).

The resulting distribution shows that students experienced greater difficulty not so much in finding the necessary information, but in transitioning to its investigative use: determining the sequence of work, interpreting the obtained data, and formulating an evidence-based conclusion. These operations distinguish investigative activity from the simple reproduction of discovered information. This distinction is essential for geographic education. A validation study by Sadykova et al. (2023), conducted among 826 Kazakhstani schoolchildren aged 13-18, demonstrated the need to assess geographic inquiry as a set of interrelated procedural skills, rather than reducing it to subject knowledge or spatial thinking. The authors also note a shortage of practically applicable tools for assessing geographic inquiry skills in the school environment. Therefore, the analysis of individual components in this study allows us to determine not only the final level but also the structure of changes that occurred during pedagogical intervention.

After completion of the formative stage, repeated diagnostics revealed different dynamics of the studied indicators. To assess changes, post-test results were compared with baseline values separately in each group (Figure 1).

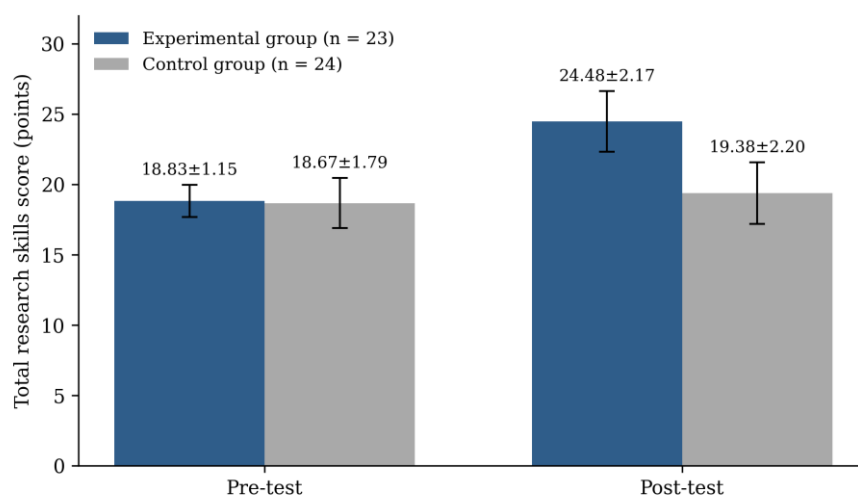


Figure 1. Overall research skills score of the experimental (n = 23) and control (n = 24) groups at the pre-test and post-test stages (M±SD; error bars show standard deviations; maximum possible score = 36).

Source: compiled by the authors based on experimental data.

In the experimental group, the overall research skills score increased from 18.83 ± 1.15 to 24.48 ± 2.17 points. This difference was 5.65 points, or 30.0% relative to the baseline score. The paired-samples t-test confirmed significant differences between the pre-test and post-test results ($t(22) = x.xx$; $p < 0.001$). The

within-group effect size ($d(av)$, see Section 2.4) was 3.25, indicating a very large practical effect of the pedagogical intervention.

In the control group, the score changed from 18.67 ± 1.79 to 19.38 ± 2.20 points, an increase of 0.71 points, or 3.8%. This change also reached statistical significance ($t(23) = 2.20$ — value back-calculated from $p = 0.038$; please verify with your output; $p = 0.038$), but its practical significance was considerably lower: the effect size was $d(av) = 0.36$ (small effect).

In this case, comparing the rates of change between the two groups is more significant than the actual increase in final scores. Some positive dynamics in the control group may be due to the natural mastery of the geography course content, the accumulation of learning experience, and repeated completion of research assignments. Moreover, the relative increase in the overall score in the experimental group was 30.0% versus 3.8% in the control group, almost eight times higher. Therefore, the primary evidence of the effectiveness of the experimental intervention is the more pronounced dynamics in the experimental group under comparable initial conditions.

To determine the nature of these changes, the results were examined separately for each of the nine research skills (Figure 2; Table 3).

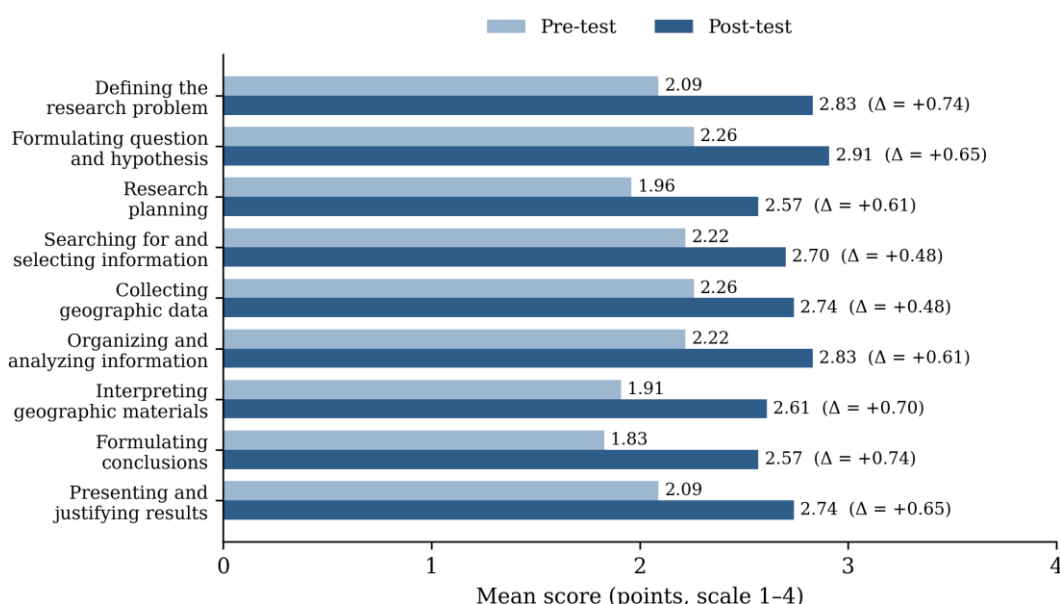


Figure 2. Mean scores of the nine research skill components in the experimental group ($n = 23$) at the pre-test and post-test stages (scale 1–4; Δ – absolute change; standard deviations are given in Table 3).

Source: compiled by the authors based on experimental data.

The data obtained show that the pedagogical intervention did not affect only individual skills, but rather shaped overall positive dynamics across all components of research activity. Statistically significant changes were found for all nine criteria ($p < 0.01$), and all of them remained significant after the Holm–Bonferroni correction — please confirm with exact p -values (Table 3). The largest absolute increase was observed in the ability to define a research problem (+0.74 points) and formulate conclusions based on the obtained data (+0.74 points). A significant change was also recorded in the interpretation of cartographic, statistical, and graphic materials (+0.70 points). Formulating a research question, hypothesizing, and presenting results increased by 0.65 points, while planning and analyzing information increased by 0.61 points.

The most pronounced increase in the ability to formulate conclusions is of particular interest, since this component had the lowest initial score - 1.83 ± 0.65 points. After the formative stage, its value increased to 2.57 ± 0.84 points. This indicates that the activities of analyzing data and formulating conclusions in the

context of project work are no longer isolated learning exercises for students. To complete the project, they were required to consistently use the information collected to solve the problem at hand and justify the conclusion reached. At the same time, an increase in the indicator of defining a research problem from 2.09 ± 0.60 to 2.83 ± 0.58 points and formulating a research question from 2.26 ± 0.45 to 2.91 ± 0.73 points indicates the positive dynamics of the early stages of the research cycle associated with the independent organization of cognitive activity.

Table 3. Pre-test and Post-test results for the nine research skill components in the experimental and control groups.

Assessed skill	Group	Pre-test, M $\pm$ SD	Post-test, M $\pm$ SD	Δ	t	p	d(av)
Defining the research problem	EG	2.09 ± 0.60	2.83 ± 0.58	+0.74	t	<0.01	1.25
	CG	1.92 ± 0.72	M $\pm$ SD	Δ	t	p	d
Formulating the research question and hypothesis	EG	2.26 ± 0.45	2.91 ± 0.73	+0.65	t	<0.01	1.07
	CG	2.08 ± 0.65	M $\pm$ SD	Δ	t	p	d
Research planning	EG	1.96 ± 0.64	2.57 ± 0.57	+0.61	t	<0.01	d
	CG	2.04 ± 0.46	M $\pm$ SD	Δ	t	p	d
Searching for and selecting information	EG	2.22 ± 0.60	2.70 ± 0.57	+0.48	t	0.006	d
	CG	2.12 ± 0.61	M $\pm$ SD	Δ	t	p	d
Collecting geographic data	EG	2.26 ± 0.45	2.74 ± 0.57	+0.48	t	0.008	d
	CG	2.04 ± 0.75	M $\pm$ SD	Δ	t	p	d
Organizing and analyzing information	EG	2.22 ± 0.60	2.83 ± 0.57	+0.61	t	<0.01	d
	CG	2.12 ± 0.54	M $\pm$ SD	Δ	t	p	d
Interpreting cartographic, statistical, and graphical materials	EG	1.91 ± 0.67	2.61 ± 0.84	+0.70	t	<0.001	0.92
	CG	2.00 ± 0.51	M $\pm$ SD	Δ	t	p	d
Formulating conclusions	EG	1.83 ± 0.65	2.57 ± 0.84	+0.74	t	<0.01	0.99
	CG	2.08 ± 0.65	M $\pm$ SD	Δ	t	p	d
Presenting and justifying results	EG	2.09 ± 0.42	2.74 ± 0.57	+0.65	t	<0.01	d
	CG	2.25 ± 0.61	M $\pm$ SD	Δ	t	p	d
Overall score	EG	18.83 ± 1.15	24.48 ± 2.17	+5.65	t	<0.001	3.25
	CG	18.67 ± 1.79	19.38 ± 2.20	+0.71	2.20	0.038	0.36

Note: EG – experimental group (n = 23); CG – control group (n = 24); Δ – post-test minus pre-test mean; t – paired-samples t-test (df = 22 for EG, df = 23 for CG); p – two-tailed p-value (Holm–Bonferroni-adjusted for the nine components); d(av) – within-group effect size (see Section 2.4). Source: compiled by the authors based on experimental data.

The smallest, although also statistically significant, increase was found in searching and selecting information (+0.48 points; $p=0.006$) and collecting geographic data (+0.48; $p=0.008$). This may be due to the fact that the corresponding indicators at the initial stage were relatively higher than a number of other research skills. The main change, therefore, occurred not so much in the ability of students to find information, but in their subsequent analytical use. Changes in skills for working with specific geographic sources also appear important. The average score for interpreting cartographic, statistical, and graphic materials increased from 1.91 ± 0.67 to 2.61 ± 0.84 points ($\Delta=+0.70$; $p<0.001$). Analyzing a map, table, or diagram in a typical academic assignment often has a predetermined goal, whereas in research, the choice of source and its use are determined by the question posed. As a result, cartographic and statistical information is no longer an object of reproduction, but a source of evidence. It is this shift that allows us to speak of the development of geographic research itself.

Modern research confirms the importance of such a work organization. In a study by Adipranata et al. (2026), conducted with 425 10th-grade students, the integration of geospatial technologies with PjBL within a quasi-experimental pre-test/post-test design ensured the development of students' spatial thinking. Although spatial thinking is not identical to research skills, this result is important for the interpretation of the present study: working with spatial data in a project creates conditions in which

geographic information becomes a tool for analysis and problem solving, and not just content to be remembered.

The most significant comparison for assessing the effectiveness of the approach used is the comparison of the results of the experimental and control groups after the completion of the formative stage (Figure 3).

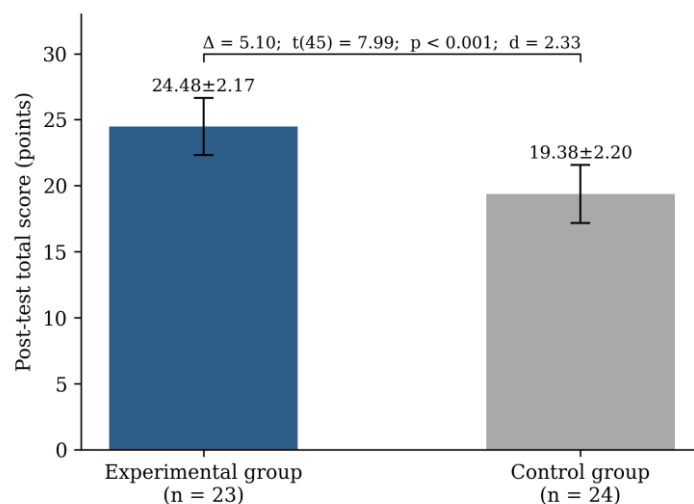


Figure 3. Post-test overall research skills scores of the experimental (n = 23) and control (n = 24) groups (M $\pm$ SD; error bars show standard deviations; independent-samples t-test).

Source: compiled by the authors based on experimental data.

Based on the post-test results, the average score of the experimental group was 24.48 $\pm$ 2.17 points, while in the control group it was 19.38 $\pm$ 2.20 points. The between-group difference was 5.10 points, or 26.3% relative to the post-test mean score of the control group. This difference was statistically significant ($t(45) = 7.99$; $p < 0.001$). The resulting effect size, Cohen's $d = 2.33$, indicates a high practical significance of the identified difference. A comparison of the pre-test and post-test scores further confirms the nature of the changes. Before the formative stage, the difference between the groups was only 0.16 points and was not statistically significant ($t(45) = 0.36$; $p = 0.716$). After the pedagogical intervention, it increased to 5.10 points, with $p < 0.001$. Thus, the advantage of the experimental group was not due to its higher initial level.

The statistically significant advantage of the experimental group confirms hypothesis H1 on a positive impact of PjBL on the development of research skills in geography studies. However, interpreting the effect solely as a consequence of increased student engagement would be insufficient. A more significant change appears to be the change in the structure of the learning activity itself: students sequentially progress from posing a question to obtaining and defending their own results, and the intermediate research activities acquire a functional interrelationship. A similar result was obtained by Nontol and Aguilar (2024) in a quasi-experimental study involving 71 schoolchildren. After implementing PjBL, 77.1% of students in the experimental group achieved a higher level of research competence; between-group differences in the final assessment were statistically significant ($Z = -7.259$; $p < 0.001$). Significantly, the authors examined research competence through cognitive, procedural, and communicative components. This is consistent with the logic of the present study, in which outcome is assessed not through a single indicator of academic performance, but through the totality of actions that comprise the research process.

However, direct comparison of absolute values between studies is inappropriate due to differences in the age of the participants, the content of the learning tasks, and the assessment instruments. The significance of this study lies primarily in confirming that the effect of project-based learning can manifest itself specifically at the level of research competence, and not only in final subject grades. These results should be considered within the context of their subject-specific nature. Research activities in geography

lessons include both general research operations and activities specific to the discipline itself. The former includes problem formulation, evidence search, analysis, argumentation, and conclusion; the latter includes reading and interpreting maps, comparing territories, using spatial and statistical data, and establishing spatial relationships.

It is the combination of these two levels that explains the structure of the observed dynamics. Positive changes were recorded across all nine components, but the most significant increases were observed in defining the research problem (+0.74), formulating conclusions (+0.74), and interpreting geographic data (+0.70). These three components reflect different parts of the unified research cycle: defining the problem, working with evidence, and obtaining a substantiated result. The observed increases in data analysis (+0.61) and research planning (+0.61) further confirm that the changes affected not only the final presentation of results but also the intermediate stages of the research cycle. Together, this pattern, in which the largest gains occurred in problem formulation, interpretation of geographic materials, and evidence-based conclusions rather than in information retrieval and data collection, supports hypothesis H2.

The results of a systematic review by Yusri et al. (2024), which covered PjBL studies published in Scopus-indexed journals, show that the most frequently reported outcomes of project-based learning are related to the development of critical thinking, problem solving, collaboration, communication, and creative and innovative thinking. This is important for the current study in two respects. First, research skills are not developed in isolation: data analysis requires critical evaluation, planning is associated with problem solving, and defending results requires argumentation and communication. Second, the broad range of skills developed in PjBL demonstrates the need for multi-component assessment, as a single achievement test may not reflect the nature of the changes occurring.

However, not every educational project can be automatically considered research-based. The content of the student's activity is key. If a project is limited to searching for existing information and presenting it, the opportunities for developing research skills remain limited. A more pronounced effect should be expected in a situation where the student is faced with a question that requires him to independently identify sources, obtain or select data, compare them, and justify his own conclusion. This position is supported by the results of a study by Musyawarah et al. (2026) on research-oriented PjBL in geography education. The authors consider the integration of research activities directly into the project structure as a prerequisite for the transition from the assimilation of theoretical material to working with empirical data and developing critical thinking. Consequently, the significant factor is not the existence of a project product itself, but the organization of the process for its production.

Additional support is provided by the results of Laiskhanov and Barat (2024), who studied the use of PjBL directly in school geography instruction. In an experiment with 10th-grade students, project-based learning was used over a nine-week period during the study of nature management and geoecology. Students in the experimental group demonstrated higher learning activity, and their final test score, on average, exceeded the control group's score by 3.07 points. The authors associate the use of PjBL not only with the deepening of students' geographical knowledge but also with the expansion of opportunities for students' research activities. For the Kazakhstani school context, this result is of particular interest, as it demonstrates the applicability of the project-based approach directly to the content of school geography. In the present study, the experimental group's final advantage was more pronounced: the difference between the groups was 5.10 points, compared to a baseline difference of only 0.16 points. However, a direct quantitative comparison of these values with the results of Laiskhanov and Barat (2024) is not possible, as the scales used, student ages, and duration of pedagogical intervention differ. The significant difference is the similarity in the overall direction of change.

When interpreting the obtained results, it is important to consider that the effectiveness of PjBL is determined not only by the chosen pedagogical model but also by the quality of its implementation. Recent reviews show significant variability in PjBL design: project duration, student autonomy, group work methods, the nature of the final product, and the role of the teacher vary. Yusri et al. (2024) found

significant diversity in research designs and PjBL implementation models, making direct comparison of results across studies difficult. Therefore, the changes identified in this work should be associated primarily with the specific organization of the research cycle, and not automatically extended to any form of project activity. The practical implication of the findings is that when teaching PjBL geography, it is useful to design around the research question and working with data. Creating a presentation, map or other product in this case is the final stage of the research, but not its main goal.

The question of the transferability of the proposed PjBL modules to other grade levels and regions also deserves attention. The modules are built on a generic research cycle (problem – question – plan – data – analysis – conclusion – defense) and on openly available cartographic and statistical sources, so their structure is not tied to a specific territory: the topics of population change, water resources, and anthropogenic pressure can be replaced by equivalent local problems in any region of Kazakhstan (e.g., urbanization, land degradation, or the use of transboundary rivers). For grades 7–8, the modules can be simplified by providing students with a prepared data set and a partially formulated research question, whereas in grades 10–11 they can be extended by including students' own field observations, GIS tools, and elements of spatial statistics. In rural schools with limited digital resources, printed maps and statistical yearbooks can replace online sources without changing the logic of the research cycle. However, the transferability of the effect itself requires empirical verification in other age groups and regions.

However, the study's results have several limitations. The sample included 47 students from two classes at a single secondary school, so the findings cannot be generalized to the entire ninth-grade population without further verification. The quasi-experimental nature of the design also requires the use of existing classes, making it impossible to completely exclude the influence of initial group characteristics, even in the absence of statistically significant differences on the pre-test. In addition, a testing effect associated with repeated completion of similar diagnostic tasks cannot be completely excluded, although it would have affected both groups equally.

Another limitation is the dependence of the results on the diagnostic instrument used. The nine identified criteria allow us to cover the main stages of research activity, but assessing a complex skill using a scoring rubric inevitably involves a certain degree of expert judgment, although this risk was reduced by independent blinded double assessment and satisfactory inter-rater agreement — adjust to the actual procedure. The reliability of the findings can be further enhanced by combining rubric assessment with analysis of research products, observation, and standardized instruments. In this regard, the scale of geographical research procedural skills developed and validated by Sadykova et al. (2023) represents a promising tool for subsequent research in the Kazakhstani educational context. Furthermore, measuring immediately after the completion of the pedagogical intervention allows us to establish short-term dynamics, but does not answer the question of the sustainability of the skills developed. A promising direction is to conduct a delayed assessment and expand the sample to include multiple schools and different age groups. This will help determine whether the PjBL effect persists after the project's completion and whether the developed research approach transfers to new geographic tasks.

4 Conclusion

The study demonstrated that the use of Project-Based Learning in geography teaching creates conditions for the consistent development of students' research skills. The most significant result is associated not with individual learning activities, but with the change in the nature of students' work with geographic information: from searching for and reproducing existing information to independently posing problems, meaningfully analyzing data, and justifying their conclusions.

Experimental data confirmed the effectiveness of the proposed approach. With a comparable baseline level, after completing the formative stage, the experimental group demonstrated a statistically significant advantage in the integrated research skills indicator ($p < 0.001$; $d = 2.33$), which confirms hypothesis H1. Positive changes encompassed all assessed components, with the most pronounced dynamics characteristic of defining the research problem, interpreting geographic data, and formulating

conclusions, which supports hypothesis H2. This demonstrates that project-based learning fosters the development of not only individual techniques for working with information but also the ability to construct a holistic research framework.

The practical significance of the obtained results lies in the possibility of integrating PjBL into the school geography curriculum without making project-based learning a separate element. A research project can be organized directly around the geographic problem being studied, using cartographic, statistical, and spatial data. The effectiveness of this approach is determined not by the creation of the project product itself, but by engaging students in the full research cycle and providing them with sufficient independence at its key stages.

Based on these results, the following practical recommendations can be offered. For geography curriculum developers: (1) to include in the 9th-grade geography curriculum at least one research project per term built around a local or regional geographic problem, with expected learning outcomes defined for each stage of the research cycle; (2) to include a criterion-based rubric of research skills, similar to the nine-criterion scale used in this study, in the assessment guidelines so that procedural research skills, not only subject knowledge, are assessed. For school teachers: (1) to formulate project assignments as research questions that require the selection and analysis of cartographic and statistical data rather than the compilation of ready-made information; (2) to provide targeted guidance and formative feedback at the stages of problem definition, data interpretation, and formulation of conclusions, which proved to be the most difficult for students at the pre-test stage.

These findings are relevant for improving geography teaching methods and can be used in developing research assignments and organizing project-based learning for secondary school students. Further research should be directed toward testing the sustainability of the acquired skills, expanding the sample, and assessing the transferability of the acquired research experience to new geographic problems.

Appendix A. Example of a diagnostic task

AUTHORS: replace this example with the task actually used. Case: "Population of the Almaty region". Materials: (a) a map of population density by districts of the Almaty region; (b) a table of district population in 2015 and 2024; (c) a diagram of the migration balance. Tasks: 1) What geographic problem do the materials reveal? (criterion 1); 2) Formulate a research question and a hypothesis (criterion 2); 3) Draw up a 4–5-step plan for investigating the problem (criterion 3); 4) Name two additional sources of information you would use and explain your choice (criterion 4); 5) Using the table, calculate the change in population for three districts (criterion 5); 6) Group the districts by the type of change and present the result in a table (criterion 6); 7) Using the map and the diagram, explain the spatial pattern of the changes (criterion 7); 8) Formulate a conclusion supported by at least two pieces of evidence (criterion 8); 9) Write a short argument (5–6 sentences) defending your conclusion (criterion 9).

Author contributions statement:

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Gulzira Aksanbayeva	✓	✓			✓	✓	✓	✓	✓	✓	✓			
Duman Aliaskarov	✓	✓		✓	✓	✓				✓		✓		
Evren Atış	✓			✓						✓		✓		

C : Conceptualization

M : Methodology

So : Software

Va : Validation

Fo : Formal analysis

I : Investigation

R : Resources

D : Data Curation

O : Writing - Original Draft

E : Writing - Review & Editing

Vi : Visualization

Su : Supervision

P : Project administration

Fu : Funding acquisition

Funding: This research received no external funding.

Conflict of interest: The authors declare no conflict of interest.

Data availability statement: The data presented in this study may be obtained on request from the corresponding author.

Acknowledgments: The authors would like to thank the administration and teachers of Comprehensive School No. 43 in the Talgar district of the Almaty region for their support in organizing the study, as well as the students who participated in the research.

References

- Adipranata, Z., Fitriana, E., & Deffinika, I. (2026). The Effectiveness of Geospatial Technology-Integrated Project-Based Learning Model on Students' Spatial Thinking Skills Across Different Learning Styles. *ASANKA: Journal of Social Science and Education*, 7(1), 39-58. <https://doi.org/10.21154/asanka.v7i1.12332>
- Aliman, M., Supriyono, S., Halek, D. H., Marni, S., & Mike, M. (2025). Eksplorasi potensi kreatif siswa SMA melalui model project based learning dalam Kelas Geografi. *Geomedia Majalah Ilmiah dan Informasi Kegeografian*, 23(1), 1-13. <https://doi.org/10.21831/gm.v23i1.76143>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.
- Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th ed.). Routledge. <https://doi.org/10.4324/9781315456539>
- Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.
- Farshad, S., & Fortin, C. (2026). An umbrella review of meta-analyses on project-based learning: Effects on academic achievement, higher-order thinking, and 21st-century skills. *Educational Research Review*, 100809. <https://doi.org/10.1016/j.edurev.2026.100809>
- Grobelski, T., Versluis, A., & McClelland, J. (2023). Discovering geography through doing geography: Project-based learning in an introductory undergraduate world geography course. *Journal of Geography*, 122(2), 31-42. <https://doi.org/10.1080/00221341.2023.2189743>
- Holm, S. (1979). A simple sequentially rejective multiple test procedure. *Scandinavian Journal of Statistics*, 6(2), 65-70. <http://www.jstor.org/stable/4615733>
- Jonsson, A., & Svingby, G. (2007). The use of scoring rubrics: Reliability, validity and educational consequences. *Educational Research Review*, 2(2), 130-144. <https://doi.org/10.1016/j.edurev.2007.05.002>
- Kholina, V. N., Shumakova, G. Z., Sergeyeva, A. M., Abdullina, A. G., & Aliaskarov, D. T. (2024). Student's project activities: Developing urban strategies (a case study of districts in the city of Aktobe). *Journal of Geography and Environmental Management*, 75(4), 138-153. <https://doi.org/10.26577/JGEM.2024.v75.i4.11>
- Koo, T. K., & Li, M. Y. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine*, 15(2), 155-163. <https://doi.org/10.1016/j.jcm.2016.02.012>
- Krajcik, J. S., & Blumenfeld, P. C. (2006). Project-based learning. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 317-334). Cambridge University Press. <https://doi.org/10.1017/CBO9780511816833.020>
- Laishkanov Sh., & Barat Sh. (2024). Research on the effectiveness of project-based learning technology in geographic education. *Sciences of Europe*, 140, 13-19. <https://doi.org/10.5281/zenodo.11171343>
- Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. *Frontiers in Psychology*, 4, 863. <https://doi.org/10.3389/fpsyg.2013.00863>
- Marpaung, J. B., Napitupulu, E., & Sugiharto, S. (2025). Development of Geography E-Modules Based on Project-Based Learning to Improve Senior High School Students' Learning Outcomes. *FINGER: Jurnal Ilmiah Teknologi Pendidikan*, 4(2), 109-115. <https://doi.org/10.58723/finger.v4i2.429>
- Musyawah, R., Nasiah, N., Juanda, M. F., & Ningtyas, N. S. I. I. (2026). Transformasi Pembelajaran Geografi: Implementasi Project Based Learning Berbasis Riset dalam Meningkatkan Kemampuan Critical Thinking. *Jurnal Penelitian Pendidikan Geografi*, 11(1), 91-107. <https://doi.org/10.36709/jppg.v11i1.738>
- Nontol, W. J. N., & Aguilar, N. A. L. (2024). Aprendizaje basado en proyectos para el desarrollo de la competencia investigativa en estudiantes de educación básica. *Revista Tecnológica-Educativa Docentes 2.0 (RTED)*, 17(1), 283-294. <https://doi.org/10.37843/rted.v17i1.475>
- Sadykova, B., Yesnazarova, U., & Tokbergenova, A. (2023). The geographic inquiry process skills scale: A validation study. *Eurasia Journal of Mathematics, Science and Technology Education*, 19(9), em2319. <https://doi.org/10.29333/ejmste/13471>

- Sekarrini, C., Sumarmi, Bachri, S., Tarya, D., & Giofandi, E. (2024). Project-based learning: Does it affect geographic literacy skills and learning outcomes?. *Cypriot Journal of Educational Sciences*, 19(3), 241–254. <https://doi.org/10.18844/cjes.v19i3.7794>
- Thomas, J. W. (2000). A review of research on project-based learning. The Autodesk Foundation.
- Yusri, R., Yusof, A. M., & Sharina, A. (2024). A systematic literature review of project-based learning: Research trends, methods, elements, and frameworks. *International Journal of Evaluation and Research in Education (IJERE)*, 13(5), 3345–3359. <https://doi.org/10.11591/ijere.v13i5.27875>
- Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: A meta-analysis study. *Frontiers in psychology*, 14, 1202728. <https://doi.org/10.3389/fpsyg.2023.1202728>

Biographies of Authors



Gulzira Aksanbayeva

Master's student, Department of Geography and Ecology, Faculty of Natural Sciences and Geography, Abay Kazakh National Pedagogical University, Almaty, Kazakhstan
Geography Education
gulziraaksanbaeva454@gmail.com
<https://orcid.org/0009-0007-0973-0439>



Duman Aliaskarov

PhD, Associate Professor, Department of Geography and Ecology, Faculty of Natural Sciences and Geography, Abay Kazakh National Pedagogical University, Almaty, Kazakhstan
Earth and Environmental Sciences; Geography
d.aliaskarov@abaiuniversity.edu.kz
<https://orcid.org/0000-0002-7628-1246>
<https://www.scopus.com/authid/detail.uri?authorId=57197876414>
<https://www.webofscience.com/wos/author/record/JZD-9986-2024>



Evren Atış

Dr., Department of Geography, Faculty of Humanities and Social Sciences, Kastamonu University, Kastamonu, Türkiye
Geography; Engineering; Communication
evrencografya@gmail.com
<https://orcid.org/0000-0002-5686-3169>
<https://www.scopus.com/authid/detail.uri?authorId=57216887028>