

Smailova E.K.^{1*}, Tilekova Zh.T.²

^{1,2}*Abai Kazakh National Pedagogical University, Almaty, Kazakhstan*

¹*ORCID: 0009-0008-3488-9318*

²*ORCID: 0000-0003-2342-8248*

**elya.smailova@mail.ru*

FORMATION OF GEOSPATIAL COMPETENCE IN 9TH GRADE STUDENTS: ECONOMIC GEOGRAPHY OF KAZAKHSTAN

Annotation

The economic geography section of the 9th-grade geography curriculum in Kazakhstan - industrial distribution, population dynamics, transport, agriculture, regional development - is spatial in nature but taught through descriptive, textbook-based methods. Students learn where phenomena are located but not how to reason about them spatially. This study develops and tests a methodology for forming geospatial competence through structured inquiry tasks embedded across the full course. A pedagogical experiment was conducted at the Republican Specialized School-Boarding for Gifted Children named after K. Baiseitova, Almaty (2024–2025) with 37 students: experimental group (n = 18) worked through purpose-designed geospatial tasks using Google My Maps, the electronic atlas of Kazakhstan, QGIS, and open data from stat.gov.kz; control group (n = 19) followed standard instruction. Geospatial competence was assessed at three points across three stages: localization, spatial correlation, and territorial analysis. Post-test results showed significant between-group differences ($t = 5.9$, $p < 0.001$, Cohen's $d = 1.94$, 95% CI [1.16, 2.73]): experimental group reached 76% of maximum score vs. 45% for controls. The widest gap was at Stage 3, independent territorial analysis: 64% vs. 22%, suggesting that within the conditions of this experiment conventional instruction developed map reading but was associated with only limited development of spatial reasoning. Findings offer geography teachers a curriculum-aligned task system covering all five sections of the 9th-grade course, tested in one specialised school and requiring replication in mainstream settings.

Keywords: geospatial competence, economic geography of Kazakhstan, spatial thinking, spatial reasoning, geospatial inquiry, secondary school, Kazakhstan.

Introduction. The economic geography section of Kazakhstan's 9th-grade geography curriculum - the fifth and final content block of the course - covers the distribution of industry, population, transport, and agriculture across the country's seventeen oblasts and three cities of republican significance. Unlike the preceding physical geography sections, this section is taught last and receives the fewest allocated hours, a structural constraint that shapes what instruction is realistically possible. This content is spatial by nature - yet most classrooms teach it through reading, note-taking, and textbook maps. Students learn *what* is where, but not *how to think* about why it is there, how it connects to other phenomena, or what the patterns reveal. The result is geographic knowledge without geographic reasoning.

This gap has a measurable dimension. Kazakhstan's Programme for International Student Assessment (PISA) 2022 results showed persistent weaknesses in applied reasoning tasks requiring students to interpret and analyze in real-world contexts [1]. Geography teachers surveyed across all regions of the country reported only moderate use of geospatial technologies in their lessons, with most relying on mobile applications rather than structured spatial inquiry; equipment costs, insufficient training, and time pressure were the primary barriers cited [2]. A parallel curriculum analysis of geography objectives for grades 7–11 confirmed that while geospatial competencies are implied in the learning goals, no explicit methodology exists for developing them systematically across a course.

Literature review. The National Research Council [3] defines spatial thinking as a structured cognitive capacity - the ability to represent, analyze, and reason about spatial relationships - and argues it must be taught explicitly rather than assumed to emerge from map use alone. Three terms are used throughout this article in a fixed sense. Spatial thinking denotes the general cognitive capacity described above. Spatial reasoning denotes its operational component, the relating of two or more spatial data layers and the derivation of a territorial explanation from them, and it is spatial reasoning that Stages 2 and 3 of the assessment address. Geospatial competence denotes the observable ability to carry out these operations on real geographic data using digital tools, and it is

this that the present study measures. Hickman [4] demonstrates that the capacity is both teachable and assessable: students who work through Geographic Information System (GIS)-based inquiry tasks show measurable gains in spatial reasoning that conventional map exercises do not produce. Gryl and Jekel [5] extend this to civic dimensions, arguing that the ability to read and critically use geographic information is a form of spatial citizenship that secondary schools have a specific responsibility to develop.

At Abai Kazakh National Pedagogical University, a research group has been building the methodological foundations for geospatial education in Kazakhstani schools since 2021, drawing on international frameworks for geospatial competence. Zwartjes and de Lázaro y Torres [6] identified the core components of geospatial thinking competence and defined ten spatial thinking competencies structured across complexity levels for secondary school students. Ussenov et al. [7] examined how geoinformation technologies can be used to develop students' geospatial thinking skills, providing a methodological basis directly applicable to grade 9–11 geography instruction. Kalkashev et al. [8] tested competency-based assessment models in natural science disciplines and found that criterion-referenced evaluation, when aligned with clearly defined skill stages, significantly improves student performance and engagement. Shakirova et al. [9] examined geography teacher preparation at Kazakh National Pedagogical University (KazNPU) and identified competency-oriented task design as the key variable distinguishing effective from ineffective technology integration.

International research shows the same pattern. Mašterová [10] reviewed 36 empirical studies on geospatial technology use in primary and secondary schools and found that inquiry-based approaches consistently produced gains in both digital literacy and geographic understanding - but only when teachers had received structured preparation. Lee [11] documented the integration of open data, big data visualization, and Artificial Intelligence (AI) tools into Korean high school geography, showing that students developed stronger spatial analysis skills when working with real territorial data than with textbook exercises. Bednarz and Kemp [12] established that spatial thinking develops incrementally through repeated practice - a single GIS lesson or one-off map activity produces no lasting competence.

The frameworks reviewed above share a structural feature that limits their applicability within a single school year. GI Learner distributes its ten competencies along a learning line spanning several grades of secondary education, with complexity levels assigned to each age group [6, pp. 45-47]; Hickman's levels likewise describe a progression measured over an extended period of sustained GIS work rather than a single course [4, pp. 143-145]. Both frameworks address the question of how spatial thinking matures across the whole of secondary education. Neither addresses the question facing a teacher at the start of grade 9: how to develop this competence within one course of five content sections, allocated fewer hours than any other block in the syllabus.

The methodology tested here departs from those frameworks in three respects. It compresses the progression into three stages rather than ten competencies, on the assumption that a scheme a teacher cannot hold in mind while planning will not survive a compressed timetable. It runs the progression horizontally rather than vertically: instead of one stage per year, all three stages recur inside each of the five content sections, so that a student meets localization, correlation and analysis five times over in different subject matter. And it ties tasks to sources a teacher can actually reach, the electronic atlas and the national statistics portal, rather than to datasets assembled for research purposes.

How far this constitutes a distinct model rather than an adaptation is a fair question, and the answer here is deliberately narrow. The cognitive progression is Hickman's, the stage descriptors stay close to the GI Learner line, and the contribution lies in the arrangement rather than in any new account of spatial thinking. What has not been tested before is whether such an arrangement produces measurable competence gains inside a single national curriculum course. Favier and Van der Schee [13] came closest, recording gains in relational thinking from GIS-based lessons at secondary level, but their intervention sat alongside the curriculum rather than being built into its content sequence.

Three points follow from this literature. Task design matters more than tool availability: a student who opens a map application and a student who maps regional GRP (Compare Gross Regional Product) disparities and explains them are doing different cognitive work. The 9th-grade economic

geography course is unusually well suited to spatial inquiry, since every section describes phenomena that only make sense spatially, yet delivery remains largely descriptive. And competence of this kind accumulates: single GIS lessons produce no lasting capacity, so the same analytical logic has to recur across the industry, population, transport and regional development units. This study develops and tests a methodology built on these three points.

Research Aim: to design and empirically validate a methodological approach to forming geospatial competence in 9th-grade students through the economic geography of Kazakhstan course.

Research Hypothesis: students taught through a systematically structured sequence of geospatial inquiry tasks embedded across all major sections of the economic geography course will show significantly greater geospatial competence development than students taught through conventional methods.

Practical significance: the study provides geography teachers with a concrete, curriculum-aligned system - specific task types, tools, and assessment criteria - for developing spatial analytical thinking in grade 9, rather than general recommendations about technology use.

Methods and materials. This study used a quasi-experimental design with a non-equivalent control group, combined with qualitative methods, to test whether a structured geospatial inquiry methodology produces measurable gains in 9th-grade students' geospatial competence during the economic geography of Kazakhstan course. The design is quasi-experimental rather than experimental because students could not be randomly allocated: they were already distributed into two intact parallel classes by the school before the study began, and breaking up existing classes was neither administratively possible nor pedagogically justified. Baseline equivalence was therefore established statistically rather than by randomization, and the limits this place on causal inference are set out below. The design combined quantitative pre- and post-testing with qualitative classroom observation and curriculum document analysis. Three methodological components are described below: research design and sample, instructional intervention, and assessment framework.

Research Design and Sample

The experiment ran across the full 2024–2025 academic year at the Republican Specialized School-Boarding for Gifted Children named after K. Baiseitova in Almaty. The school was selected on the basis of its stable digital infrastructure, availability of a dedicated computer classroom for geography lessons, and the qualification level of its geography teaching staff. The pre-test administered in September 2024, before any intervention, showed no significant difference in baseline geospatial competence between the experimental group (EG) and the control group (CG): EG mean score 11.4, standard deviation (SD) = 2.1; CG mean score 11.2, SD = 2.3; Student's t-test value $t = 0.28$ at 35 degrees of freedom (df), significance level $p = 0.78$. Both classes therefore entered the study at an equivalent starting level. The distribution of students across the two conditions is presented in Table 1. The two classes were parallel streams of the same intake year within a single specialized school, admitted through the same competitive selection procedure, following identical timetables and covering the same curriculum content over the same number of lesson hours. Both were taught by geography teachers with comparable formal qualifications. The study did not collect data on gender composition, prior academic attainment, learning motivation or baseline digital literacy, and these variables could not be controlled statistically - a limitation addressed in the Limitations section.

Table 1. Sample Distribution Across Conditions

School	Experimental group (n)	Control group (n)	Total
Republican Specialized School-Boarding for Gifted Children named after K. Baiseitova, Almaty	18	19	37
Total	18	19	37

Note: Non-random allocation by the school administration into intact parallel classes. Baseline equivalence established on pre-test scores ($t = 0.28$, $p = 0.78$, $df = 35$).

Source: compiled by the authors.

Control classes followed the standard curriculum: teacher explanation, textbook reading, conventional paper map exercises, and reproductive written tasks. Experimental classes covered identical curriculum content through a purpose-designed sequence of geospatial inquiry tasks using Google My Maps, the electronic atlas of Kazakhstan, basic Quantum Geographic Information System (QGIS) functions, and open regional statistical data from stat.gov.kz and the Bureau of National Statistics of Kazakhstan [14]. The experimental group teacher attended a one-day methodological workshop before the experiment began, covering task logic, assessment criteria, and technical use of the platforms. The control group teacher was briefed only on data collection procedures and continued established practice without any change to teaching methods. This asymmetry is inherent to the design: the intervention consists precisely of the task system and the preparation needed to deliver it, so the two conditions cannot be equalised on teacher preparation without eliminating the intervention itself.

Curriculum and Task Design

The 9th-grade economic geography of Kazakhstan course comprises five major content sections: industry, population and urbanization, transport infrastructure, agriculture, and regional development. The five sections were taught in the order set by the curriculum: industry from September to November, population and urbanization in December and January, transport in February, agriculture in March, and regional development in April and May. For each section, a set of four to six geospatial inquiry tasks were developed, graded by cognitive demand across three competency stages (Table 2).

Table 2. Geospatial Task Design Across Course Sections and Competency Stages

Course section	Stage 1 tasks (localization)	Stage 2 tasks (correlation)	Stage 3 tasks (analysis)	Tools used
Industry	Map mining enterprise locations using atlas data	Overlay industry map with population density; identify patterns	Explain Karaganda region's industrial-demographic profile; assess policy implications	Google My Maps, electronic atlas
Population & urbanization	Locate major cities and population centers	Compare urbanization rates across regions; identify north-south disparities	Analyze causes of depopulation in northern oblasts using economic and migration data	stat.gov.kz, thematic maps
Transport	Map railway and road networks	Correlate transport density with economic output by region	Evaluate transport accessibility gaps and their effect on regional development	QGIS basic, Google My Maps
Agriculture	Identify agricultural zones on climatic and soil maps	Link agricultural specialization to physical geography factors	Assess water resource constraints on agricultural development in southern regions	Electronic atlas, stat.gov.kz
Regional development	Locate Kazakhstan's economic regions	Compare Gross Regional Product (GRP) per capita across regions; rank by development indicators	Construct an evidence-based analysis of one region's development trajectory	stat.gov.kz, QGIS basic

Note: Tasks at each stage used real data not reproduced in the textbook. Stage 3 tasks required students to produce written spatial analyses of 150–200 words with map-based evidence.

Source: compiled by the authors.

The three stages differ in kind, not in difficulty: Stage 1 asks for retrieval, Stage 2 for relating two data layers, Stage 3 for an independent explanation defended with map evidence.

All instructional task materials were developed by the research team in collaboration with the participating teachers, reviewed for alignment with the grade 9 learning objectives set out in the standard curriculum in Geography approved by the Ministry of Education of Kazakhstan [15], and piloted in one non-participating class before the experiment began. Pilot feedback led to the revision of three Stage 3 instructional tasks whose data requirements exceeded the available classroom time.

These instructional tasks are distinct from the assessment items described below, which were developed and trialled separately.

Assessment Instruments

Geospatial competence was measured at three points: before instruction (pre-test, September 2024), after the industry and population sections (intermediate test, January 2025), and after the full course (post-test, May 2025). Each test consisted of 12 tasks, four per competency stage, built directly from the three-stage model: Stage 1 items required locating and extracting data from an unfamiliar thematic map, Stage 2 items required relating two data layers, Stage 3 items required a written territorial explanation supported by map evidence. The assessment items were developed and trialled separately from the instructional tasks. They were drafted by the research team, checked for alignment with the grade 9 learning objectives of the standard curriculum [15, Ch. 3], and trialled in one non-participating class, after which three Stage 3 items were reworked because their data requirements exceeded the time available within a single lesson. The task system and the assessment items were subsequently reviewed by the subject methodological association of the participating school (minutes No. 6, 16 March 2026), which confirmed their correspondence to the curriculum content and their suitability for classroom use. These procedures constitute content review and trialling, that is, approbation of the instrument in use. They are not psychometric validation, and the two should not be read as equivalent: expert judgement of content coverage says nothing about internal consistency, form equivalence or construct validity, none of which was tested here.

The three tests used parallel forms with matched cognitive demand but different geographic content, so that no student met the same territory twice. Form equivalence was established by design rather than by measurement: the three forms carry the same number of items at each stage, the same response format and the same scoring rubric, but differ in the regions and datasets used. No empirical check of form equivalence was carried out, and no internal consistency coefficient was computed for the instrument. This is a limitation of the study, and the competence scores reported below should be read as measurements made with an instrument whose psychometric properties have not been formally established. The overall design of the assessment instrument is summarized in Table 3.

Table 3. Assessment Design Summary

Parameter	Specification
Measurement points	3 (pre, intermediate, post)
Tasks per test	12 (4 per competency stage)
Maximum score	48 points
Data used	Unfamiliar maps and statistics not used in instruction
Test forms	Parallel (equivalent demand, different content)
Scoring	0–4 scale (five levels) per task
Inter-rater reliability	Cohen's $\kappa = 0.81$ on 20% subsample
Scorers	2 independent educators (20% subsample); lead researcher (remainder)

Source: compiled by the authors.

Note: κ - Cohen's kappa coefficient of inter-rater agreement.

Each task was scored on a five-level rubric from 0 to 4: 0 - no spatial reasoning evident; 1 - correct localization only, no relational thinking; 2 - partial spatial correlation, reasoning largely absent; 3 - spatial correlation identified but reasoning incomplete; 4 - full spatial analysis with an evidence-based conclusion. All responses were coded by number before scoring, so that scorers saw neither the student's name nor the class. Two geography educators not otherwise involved in the study independently scored a random 20% subsample; inter-rater agreement, measured by Cohen's kappa coefficient (κ), was strong ($\kappa = 0.81$), and the few discrepancies were settled by discussion. The remaining responses were scored by the lead researcher against the same rubric. The lead researcher designed the intervention, which raises the possibility of expectancy effects in scoring. Coding of the scripts removed direct identification, but Stage 3 responses to tasks built around Google My Maps or QGIS output could still betray group membership through their content, so blinding was incomplete

for that part of the instrument. The κ value covers a fifth of the material and does not extend to the rest.

In addition to test scores, teacher observation logs were maintained throughout the experiment. Teachers recorded instances of unprompted spatial reasoning in classroom discussion - cases where students independently connected economic data to geographic distribution without teacher direction. These logs provided qualitative evidence of competence development between formal measurement points and were analyzed thematically at the end of the year.

Data Analysis

Quantitative data were processed in Statistical Package for the Social Sciences (SPSS), version 26. Between-group differences at each of the three measurement points were tested with independent samples t-tests ($df = 35$). Effect sizes are reported as Cohen's d computed from the pooled standard deviation, with 0.2, 0.5 and 0.8 taken as thresholds for small, medium and large effects. Because the sample is small, every between-group difference is reported with a 95% confidence interval, both for the difference in means and for d . A sensitivity analysis indicates that with $n = 37$ and $\alpha = 0.05$ the design has 80% power to detect effects of $d = 0.94$ or larger; smaller differences would not have been reliably detected.

Change over the year was analyzed with a 2×3 mixed ANOVA (Analysis of Variance). Group entered as the between-subjects factor and measurement point as the within-subjects factor. The interaction term carries the weight of the analysis: a comparison of trajectories is what distinguishes gains produced by the intervention from gains both groups would have shown anyway over nine months of schooling. Development inside the experimental group was then examined with repeated measures ANOVA and pairwise comparisons between successive measurement points.

Observation logs were coded thematically in two cycles. The first cycle marked discrete instances of spatial reasoning; the second grouped them into patterns across content sections and competency stages.

Ethical Considerations

Because the participants were minors aged 14–15, consent was arranged before any data were collected. Written informed consent was obtained from the parents or legal guardians of all 37 students, and the students themselves were told what the study involved, what would be recorded, and that they could stop taking part at any point without it affecting their marks. The experiment ran with the permission of the administration of the Republican Specialized School-Boarding for Gifted Children named after K. Baiseitova and under the supervision of the Department of Geography and Ecology at Abai Kazakh National Pedagogical University, where the research is being carried out.

Students appear in the dataset by number only. No names were recorded, and the teacher observation logs were kept in the same coded form. Test scores served research purposes alone and were never entered into school assessment.

Control group students followed the full standard curriculum throughout and lost no instructional time. Once the post-test was complete, the task materials developed for the experimental group were handed over to the control group teacher.

Limitations

Five limitations apply to this study. First, the sample was drawn from a single specialized school in Almaty with stable technology infrastructure and a gifted student population; findings may not generalize directly to rural schools where equipment access and teacher preparation conditions differ substantially - a gap that Laishanov et al. [2, p. 6] identify as a persistent barrier in Kazakhstani geography education. Second, the experiment covered one academic year, which is sufficient to observe competence development across all five course sections but does not address whether gains are retained after the course ends. No delayed post-test was administered, so the durability of the measured effect is unknown, and the results speak only to competence at the point of course completion. A delayed measurement is planned for the same cohort in grade 10, using a fourth parallel form of the instrument, to establish whether the difference between the groups persists once the intervention has ceased. Third, while teachers in both conditions had comparable formal qualifications, individual instructional style and classroom management were not controlled

variables; teacher effect on outcomes cannot be fully separated from methodology effect with the current design. Fourth, several variables that could have shaped the outcome went unmeasured. Nothing was recorded on the students' motivation, their prior attainment in geography, or how confident they already were with digital mapping tools before the course started, which means none of these could be entered as covariates. Baseline equivalence rests on one indicator only - the September pre-test. Both classes were parallel streams of the same intake, selected through the same competitive admission procedure, so a large hidden gap between them is improbable; improbable, however, is not the same as ruled out. Anyone repeating this work would do well to collect these indicators in September alongside the pre-test, when it costs almost nothing to do so.

Fifth, the mixed ANOVA was reconstructed from the summary statistics in Table 4 together with the within-group repeated measures result, rather than computed from the individual score matrix. The between-subjects and interaction terms depend on the correlation between the three measurement points, which was recoverable for the experimental group but had to be assumed equivalent for the control group. A sensitivity analysis across the plausible range of that correlation, from 0.20 to 0.65, left the interaction significant at $p < 0.001$ at every value, with partial eta-squared (partial η^2) between 0.37 and 0.48. The substantive conclusion, that the two groups differ in trajectory and not only in level, therefore, holds across the whole range tested. The reported coefficients are nonetheless estimates rather than computed values and should be read as such.

Results and discussion. *Overall competence gains: experimental vs. control*

Pre-test scores confirmed baseline equivalence between the two groups. The EG ($n = 18$) scored a mean of 11.4 points out of 48 ($SD = 2.1$); the CG ($n = 19$) scored 11.2 points ($SD = 2.3$).

The difference was not statistically significant ($t = 0.28$, $p = 0.78$), confirming that both groups entered the study at the same competency level.

By the post-test the two groups had moved apart. The EG averaged 36.6 points out of 48 ($SD = 7.4$) against 21.6 for the CG ($SD = 8.0$), a difference of 15.0 points (95% confidence interval, CI [9.85, 20.15], $t = 5.9$, $p < 0.001$, $d = 1.94$, 95% CI [1.16, 2.73]). The gap was already open at the January measurement, taken after the industry and population sections: 24.6 points against 15.1, a difference of 9.5 points (95% CI [4.98, 14.02], $t = 4.3$, $p < 0.001$, $d = 1.40$, 95% CI [0.69, 2.12]). Growth in the EG therefore did not come in a late surge but built up across the course (Table 4). The confidence interval around the post-test effect size runs from 1.16 to 2.73, which is what a sample of 37 permits; the direction of the effect is firm, its exact magnitude much less so.

Table 4. Mean Test Scores by Group and Measurement Point

Measurement point	EG mean (SD)	CG mean (SD)	t-value	p-value	Cohen's d
Pre-test (Sept. 2024)	11.4 (2.1)	11.2 (2.3)	0.28	0.78	0.09
Intermediate test (Jan. 2025)	24.6 (6.5)	15.1 (7.0)	4.3	<0.001	1.40
Post-test (May 2025)	36.6 (7.4)	21.6 (8.0)	5.9	<0.001	1.94

Note: Independent samples t-tests, $df = 35$. Cohen's d computed from the pooled standard deviation. Confidence intervals for the between-group differences are given in the text.

Source: compiled by the authors based on test results of the experimental and control groups.

Competence stage distribution

The mixed ANOVA returned a significant group $\times$ time interaction (Fisher's F-test statistic, $F(2, 70) = 25.5$, $p < 0.001$, partial $\eta^2 = 0.42$). The groups differed not merely in level but in the shape of their development: the distance between them widened at every measurement point. Main effects were significant for time ($F(2, 70) = 144.4$, $p < 0.001$, partial $\eta^2 = 0.81$) and for group ($F(1, 35) = 27.0$, $p < 0.001$, partial $\eta^2 = 0.44$), but neither settles the question on its own. Both groups gained over nine months, and some of that gain belongs to ordinary schooling and to being a year older. The interaction is what separates the two sources. The breakdown of post-test performance by competency stage is presented in Table 5.

Table 5. Post-test Performance by Competency Stage

Competency stage	EG mean score / max (%)	CG mean score / max (%)	Between-group difference
Stage 1: localization	14.2 / 16 (89%)	11.5 / 16 (72%)	Moderate
Stage 2: spatial correlation	12.2 / 16 (76%)	6.6 / 16 (41%)	Large
Stage 3: territorial analysis	10.2 / 16 (64%)	3.5 / 16 (22%)	Very large
Total	36.6 / 48 (76%)	21.6 / 48 (45%)	Large

Source: compiled by the authors based on post-test results of the experimental and control groups.

This pattern has a clear interpretation. Conventional instruction - textbook reading, teacher explanation, paper map exercises - develops basic geographic literacy well enough. Students in the CG could locate and identify spatial phenomena on maps at a level approaching EG performance. What conventional instruction does not develop is the capacity to reason spatially: to hold two data layers simultaneously, identify the relationship between them, and construct an evidence-based territorial explanation. These are precisely the operations that Stage 2 and Stage 3 tasks required, and they are the operations that the experimental methodology was designed to build through repeated, cumulative practice across all five course sections.

Section-by-section analysis

Teacher observation logs allowed a more granular picture of where competence developed fastest in the EG. Unprompted spatial reasoning was recorded 84 times across the EG over the academic year, compared to 13 times in the CG. In the EG, instances were sparse during the industry section in the autumn term (10 recorded), grew through the population and urbanization section in December and January (20), and were densest in the regional development section in April and May (24). The transport and agriculture sections produced somewhat lower observation frequencies (16 and 14 instances respectively), which teachers attributed to greater difficulty in sourcing accessible real-data sets for these sections. The open statistics available through stat.gov.kz were richer for population and regional economic data than for transport network and agricultural productivity data, limiting the complexity of Stage 3 tasks in those sections. This is a methodological finding with practical implications: the availability and granularity of open regional data directly constrain the ceiling of spatial inquiry tasks that teachers can realistically assign.

Within-group development in the experimental group

Having established that the trajectories differ, the next question is how the experimental group moved between measurement points. Repeated measures ANOVA showed a significant rise in experimental group scores across the three measurement points ($F(2, 34) = 153.0$, $p < 0.001$, partial $\eta^2 = 0.90$). This coefficient should not be read as the share of competence produced by the methodology. Partial eta squared expresses the proportion of within-subject variance attributable to the time factor, and over nine months the time factor carries more than the intervention: a full year of general schooling, cognitive development at 14–15, and increasing familiarity with the test format all fall within it. Attribution of the gain to the methodology rests on the between-group comparison reported above, not on this figure.

Post-hoc comparisons showed significant gains between all three measurement points: pre-test to intermediate (mean gain 13.2 points, $p < 0.001$) and intermediate to post-test (mean gain 12.0 points, $p < 0.001$). The slightly larger gain in the first half of the year reflects the steeper initial learning curve when students are first introduced to spatial inquiry tasks - an observation consistent with Mašterová's [10, p. 47] finding that the early stages of geospatial technology integration require the most intensive teacher support. By the second half of the year, students in the EG were operating with greater autonomy, requiring less scaffolding for Stage 2 tasks and approaching Stage 3 work with more confidence.

The results are consistent with the research hypothesis: within the conditions of this experiment, systematic integration of geospatial inquiry tasks across all major sections of the 9th-grade economic

geography course was associated with significantly greater competence gains than conventional instruction, with a large effect size at post-test (Cohen's $d = 1.94$, 95% CI [1.16, 2.73], indicating that the experimental group's mean score exceeded the control group's mean by nearly two standard deviations). Because allocation was not random and motivational, digital and teacher-related factors were not controlled, this association cannot be read as a demonstrated causal effect of the methodology alone. Three findings warrant specific discussion.

First, the size of the between-group difference deserves comment, because $d = 1.94$ sits far above what interventions in geography education usually produce, and a value that large is more often a signal about design than about pedagogy. At least three factors inflate it here. The sample comes from a school that selects for academic ability, so the experimental students had the cognitive headroom to move a long way once the tasks demanded it, and a mainstream cohort would not start from the same position. The assessment also favours the intervention in a way that is hard to avoid: Stage 3 items ask for written territorial analysis with map evidence, which is exactly the operation experimental students rehearsed all year and control students never encountered in any form. Part of the gap therefore reflects familiarity with the task genre rather than spatial reasoning as such. Finally, the bulk of the scripts were scored by the researcher who designed the tasks, and Stage 3 answers are not fully anonymous in practice. None of this cancels the findings, which the widening interaction across three measurement points supports independently. It does mean the point estimate belongs to these conditions, and that the confidence interval, running from 1.16 to 2.73, is the more honest summary.

Second, the observation logs point towards transfer. Instances of unprompted spatial reasoning grew from ten in the industry section to twenty-four in the regional development section, which fits the idea that students carried the same cognitive moves from one economic theme to the next without being prompted. Bednarz and Kemp [12, p. 20] argue that spatial thinking becomes a stable disposition only after repeated practice across different content, and the pattern here is consistent with that. It is worth being clear about the weight this evidence can bear. The logs were kept by the teacher delivering the intervention, who knew what the study was testing, and no second observer checked the entries. A count of 84 against 13 is striking, but it comes from an unblinded observer, and the reading offered here is plausible rather than demonstrated.

Third, the data availability constraint identified in the transport and agriculture sections points to a problem no individual teacher can solve. The quality of spatial inquiry tasks is directly bounded by the granularity and accessibility of real regional data. Where open statistics are rich - population, GRP, urbanization - Stage 3 tasks can be genuinely demanding and analytically substantive. Where data are sparse or fragmented, task quality degrades. Laikhanov et al. [2, p. 7] identify infrastructure and cost as the main barriers to adopting geospatial technology in Kazakhstani schools. The present results add a barrier that survives after those are solved. The school studied here had the equipment, the trained staff and a dedicated computer classroom, and the ceiling on Stage 3 tasks still fell where the open statistics thinned out. Lee [11, pp. 4–6] describes Korean classrooms drawing on open data, big data visualisation and AI tools; the contrast is instructive, since the constraint there lies in what teachers can do with abundant data, and here in whether comparable data exist for a given theme at oblast level at all. A curated repository aligned to the school curriculum would address a problem that no amount of equipment purchasing reaches.

Conclusion. This study set out to answer a specific question: does a structured sequence of geospatial inquiry tasks embedded across all sections of the 9th-grade economic geography of Kazakhstan course develop students' geospatial competence more effectively than conventional instruction? Within the conditions of this experiment the results support an affirmative answer, with statistically significant between-group differences at both intermediate and final measurement points ($p < 0.001$) and a large effect size at post-test (Cohen's $d = 1.94$, 95% CI [1.16, 2.73]). The point estimate should be read with the reservations set out above: the sample was drawn from a school selecting for academic ability, the Stage 3 items matched the task genre rehearsed by the experimental group alone, and blinding at that stage was incomplete. The interval, rather than the point value, is the appropriate summary of the effect.

Three findings stand out. First, in the school studied, conventional instruction developed basic map reading adequately but was associated with markedly weaker spatial reasoning. The experimental methodology narrowed this gap without closing it: experimental students reached 64% of the maximum Stage 3 score. Whether the same pattern holds in mainstream schools remains open.

Second, the observation data point towards transfer across content domains, though on evidence weaker than the test scores and from an unblinded observer. Transfer remains a plausible reading of the pattern rather than a demonstrated result.

Third, the quality of spatial inquiry tasks is directly bounded by the availability of real regional data. A curated, curriculum-aligned open data repository for school geography in Kazakhstan would raise the ceiling of what geospatial instruction can achieve in practice.

The findings and the task system were presented to the subject methodological association of the participating school, which recommended the materials for continued use in grade 9 geography teaching (minutes No. 6, 16 March 2026). This constitutes practical uptake within the setting in which the methodology was developed, and it does not extend the evidential basis of the study beyond that setting.

Four directions follow for further work. The first is replication in mainstream schools outside Almaty, on a sample large enough to support randomised allocation. The second is psychometric validation of the diagnostic instrument: internal consistency, empirical equivalence of the parallel forms, and construct validity, none of which was established in the present study and all of which are prerequisites for using the instrument beyond this setting. The third is a delayed measurement after grade 9 to establish whether the gains hold. The fourth is teacher training models that let geography teachers build spatial inquiry tasks without specialised GIS expertise.

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Data availability. The anonymised test score data supporting the findings of this study are available from the corresponding author on reasonable request.

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*Смаилова Э. К.¹, Тилекова Ж.Т.²

^{1,2} Абай атындағы Қазақ Ұлттық Педагогикалық Университеті

^{1,2} Қазақстан, Алматы

9-СЫНЫП ОҚУШЫЛАРЫНЫҢ ГЕОКЕҢІСТІКТІК ҚҰЗЫРЕТТІЛІГІН ҚАЛЫПТАСТЫРУ: ҚАЗАҚСТАННЫҢ ЭКОНОМИКАЛЫҚ ГЕОГРАФИЯСЫ

Аңдатпа

Қазақстанның 9-сынып география курсына экономикалық география бөлімі - өнеркәсіптің орналасуы, халық динамикасы, көлік, ауыл шаруашылығы, аймақтық даму - табиғаты жағынан кеңістіктік сипатта, бірақ сипаттамалық, оқулыққа негізделген әдістермен оқытылады. Оқушылар құбылыстардың қайда орналасқанын біледі, бірақ оларды кеңістіктік тұрғыдан талдай алмайды. Бұл зерттеу курс бойынша құрылымдық геокеңістіктік сұраныс тапсырмалары арқылы геокеңістіктік құзыреттілікті қалыптастыру әдістемесін әзірлейді және тестілейді. Педагогикалық эксперимент Алматыдағы Қ.Байсейітова атындағы Республикалық мамандандырылған мектеп-интернатта (2024–2025) 37 оқушымен жүргізілді: эксперименттік топ (n = 18) Google My Maps, Қазақстанның электрондық атласы, QGIS және stat.gov.kz ашық деректерін пайдалана отырып арнайы геокеңістіктік тапсырмалар орындады; бақылау тобы (n = 19) стандартты оқытуды жалғастырды. Геокеңістіктік құзыреттілік үш кезеңде бағаланды: локализация, кеңістіктік корреляция және аумақтық талдау. Қорытынды тест нәтижелері топтар арасындағы маңызды айырмашылықтарды көрсетті (t = 5,9, p < 0,001, Cohen's d = 1,94, 95%

СА [1,16-2,73]): эксперименттік топ максималды балдың 76%-ына жетті, бақылау тобы - 45%-ға. Ең үлкен айырмашылық 3-кезеңде - дербес аумақтық талдауда: 64% пен 22%, бұл зерттеу жүргізілген жағдайда дәстүрлі оқыту картаны оқу дағдыларын дамытқанымен, кеңістіктік ойлауды дамытуда шектеулі болғанын болжауға негіз береді. Нәтижелер география мұғалімдеріне 9-сынып курсының барлық бес бөлімі бойынша геокеңістіктік құзыреттілікті дамытуға арналған бір мамандандырылған мектепте сынақтан өткен, жалпы білім беретін мектептерде қосымша тексеруді қажет ететін тапсырмалар жүйесін ұсынады.

Түйінді сөздер: геокеңістіктік құзыреттілік, Қазақстанның экономикалық географиясы, кеңістіктік ойлау, кеңістіктік пайымдау, геокеңістіктік зерттеу, орта мектеп, Қазақстан.

*Смаилова Э. К.¹, Тилекова Ж.Т.²

^{1,2} *Казахский Национальный Педагогический Университет имени Абая*

^{1,2} *Казахстан, Алматы*

ФОРМИРОВАНИЕ ГЕОПРОСТРАНСТВЕННОЙ КОМПЕТЕНТНОСТИ УЧАЩИХСЯ 9 КЛАССА: ЭКОНОМИЧЕСКАЯ ГЕОГРАФИЯ КАЗАХСТАНА

Аннотация

Раздел экономической географии в курсе географии 9 класса Казахстана - размещение промышленности, динамика населения, транспорт, сельское хозяйство, региональное развитие - пространствен по своей природе, однако преподаётся преимущественно описательными, учебниково-ориентированными методами. Учащиеся знают, где расположены те или иные явления, но не умеют рассуждать о них пространственно. Данное исследование разрабатывает и апробирует методику формирования геопространственной компетентности посредством структурированных задач пространственного исследования, встроенных во весь курс. Педагогический эксперимент проводился в Республиканской специализированной школе-интернате для одарённых детей имени К. Байсеитовой, г. Алматы (2024–2025) с участием 37 учащихся: экспериментальная группа (n = 18) выполняла специально разработанные геопространственные задания с использованием Google My Maps, электронного атласа Казахстана, QGIS и открытых данных stat.gov.kz; контрольная группа (n = 19) обучалась по стандартной программе. Геопространственная компетентность оценивалась в три этапа: локализация, пространственная корреляция и территориальный анализ. Результаты итогового теста выявили значимые межгрупповые различия ($t = 5,9$, $p < 0,001$, Cohen's $d = 1,94$, 95% ДИ [1,16-2,73]): экспериментальная группа достигла 76% от максимального балла против 45% у контрольной. Наибольший разрыв зафиксирован на этапе 3 - самостоятельного территориального анализа: 64% против 22%, что даёт основание полагать, что в условиях проведённого эксперимента традиционное обучение развивало навыки чтения карты, но обеспечивало лишь ограниченное развитие пространственного мышления. Результаты предоставляют учителям географии систему заданий по всем пяти разделам курса, апробированную в одной специализированной школе и требующую проверки в общеобразовательных школах.

Ключевые слова: геопространственная компетентность, экономическая география Казахстана, пространственное мышление, пространственное рассуждение, геопространственное исследование, средняя школа, Казахстан.

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