Formation Of Students' Cartographic Competences In The Context Of Interdisciplinary Integration (On The Example Of Mathematics And Geography)

Ergashev Tolif Yuldashevich
Independent researcher at Namangan
State University, Namangan, 160107, Uzbekistan

Abstract
Ensuring mutual integration between academic subjects serves to consolidate students' knowledge and enrich their imagination on the topics being studied. Therefore, attention is paid to the use of mutual integration between academic subjects in the educational process. However, achieving interdisciplinary integration is a complex process in itself, and the teacher's work experience, professional competence and skills play an important role in achieving it. In the educational process, geography teachers need to pay attention to certain aspects in using the connection and unity between geographical and mathematical knowledge. The article discusses the aspects and factors that need to be paid attention to in ensuring the integration of mathematical and geographical subjects in the development of students' cartographic knowledge.
Keywords: students, cartographic knowledge, development, mathematical knowledge, geographical knowledge, integration, integration of mathematics and geography.

Geography and mathematics are close to each other in terms of the logical structure and theoretical foundations of knowledge. Because any geographical process, phenomenon or spatial situation relies on precise mathematical calculations, quantitative analysis and modeling. Taking into account this feature, the implementation of an integrative approach between mathematics and geography in the educational process will strengthen students' cartographic knowledge and skills, develop their logical thinking and expand their opportunities for effective mastery of new scientific concepts.
The development of students' cartographic knowledge based on the integration of mathematics and geography is ensured by completing the following tasks:
1. MAIN OBJECTIVE
└─ Development of cartographic knowledge
2. MAIN DIRECTIONS
├─ Integrating mathematical knowledge into curricula
├─ Strengthening collaboration among science teachers
├─ Connecting education with real life
3. PRACTICAL MECHANISMS
├─ Organization of practical training
└─ Use of innovative educational technologies

I. Development of cartographic knowledge. The development of cartographic knowledge is the process of systematically forming in students theoretical knowledge and practical skills related to working with maps, plans and other cartographic materials. This process serves to develop spatial thinking, understanding the location, interrelationships and quantitative characteristics of geographical objects and phenomena. Cartographic knowledge is based on the conscious mastery of basic cartographic concepts by students, such as scale, coordinate system, conditional symbols, contour lines, determining distance and area. Also, the development of skills in using maps as a source of information, analyzing them, comparing them and drawing conclusions is an important component of cartographic knowledge. As a result, students develop the competence to understand geographical processes, understand

the relationship between real space and the map, and effectively use cartographic knowledge in practical activities.

II . 1. Ensuring the reflection of mathematical knowledge in curricula. Ensuring the systematic reflection of mathematical knowledge in the curriculum of the subject “Applied Geography” intended for students of academic lyceums is an important condition for the effective implementation of interdisciplinary integration. In this process, the main attention is paid to identifying and revealing the interrelationship between mathematical and geographical knowledge in the content of the subject “Applied Geography”. In particular, the acquisition of concepts related to the scale and coordinate system, the formation of practical skills such as calculating area, distance and angles are of great importance. This approach serves to increase the efficiency of the integration process and allows students to further deepen their cartographic knowledge and skills.

II. 2. Establishing cooperation between subject teachers. Establishing continuous and systematic cooperation between mathematics and geography teachers is of great importance in ensuring effective interdisciplinary integration. This cooperation is one of the main factors in achieving positive results in the educational process, which is manifested in the joint development of integrated approaches in the planning, content definition and delivery of lessons. Cooperation between teachers serves to ensure the mutual harmonization of subject content, coordinate educational materials, and form complex knowledge and skills in students.

III. Practical lessons organization to grow. Effective organization of educational lessons is important in developing students' cartographic knowledge and skills. Involving students in active work with maps in this type of lesson, in particular, thematic maps (natural and socio-economic maps), as well as digital maps - practical activities such as calculating the scale and analyzing topographic data based on electronic models of geographic maps, significantly increases their learning and cognitive activity.

In addition, in the "Practical Geography" lessons, the introduction of Global Positioning System (GPS) and Geographic Information Systems (GIS) technologies into the teaching process and the formation of competencies in students to work with these systems are of important methodological importance. This approach ensures the practical orientation of the geographical knowledge acquired by students and expands their possibilities of applying them in real-life situations.

IV. Connecting education with real life. In the process of teaching the subject of "Practical Geography", it is of great pedagogical importance to organize the tasks given to students on the basis of issues that are often encountered in their daily lives, directly related to the subject of mathematics. Such an approach, on the one hand, ensures the practical orientation of the knowledge acquired by students, and on the other hand, serves to firmly assimilate the knowledge acquired on the basis of real-life situations and to store it in long-term memory.

For example, tasks based on the integration of geography and mathematics knowledge could be as follows:

1. A task to determine scales by different sizes (1 mm, 1 cm, 10 cm).

Based on the given scale dimensions, express the actual distance on the Earth's surface in units of 1 mm, 1 cm, and 10 cm.

Setting scales for different sizes

No.	Scales	Dimensions on the map		
		1mm	1 cm	10 cm
1.	1:100,000			
2.	1:500,000			
3.	1:10000			
4.	1:5000			
5.	1:2000			

6.	1:1000			
7.	1:500			
8.	1:200			
9.	1:100			

2. Tasks related to calculating scale and distances.

2.1. Using the scale given on the map, determine the distance between the cities of **Samarkand and Bukhara** (Kattakurgan, Navoi, Zarafshan). During the measurement process, determine the straight-line distance in centimeters and convert it to a real distance .

2.2. On the given map, the distance between the cities **of Tashkent and Fergana** is 6.2 cm. If the scale of the map is **1:7,500,000** , calculate the actual distance between these cities in kilometers .

2.3. Using a 1:2,000,000 scale map, determine the total distance along **the Namangan - Andijan - Fergana** route. First, calculate the distance between each city separately, and then find the total distance .

3. Task on identifying objects in a coordinate system.

3.1. Determine the location of specific points in the geographic coordinate system (latitude and longitude):

A. Using a world map, determine the geographical location of the following cities: London, Paris, Berlin, Rome, Cairo, Tehran, Delhi, Tokyo, New York, Rio de Janeiro.

The world's major cities have
Geographic coordinates of

No.	Major cities of the world	Width	Length
1	London		
2	Paris		
3	Berlin		
4	Rome		
5	Cairo		
6	Tehran		
7	Delhi		
8	Tokyo		
9	New York		
10	Rio de Janeiro		

B. From the map of Uzbekistan, determine the location of the cities of Angren, Bekabad, Chiraqchi, Dangara, Guzar, Jizzakh, Koson, Margilan, Muynak, Nukus, Olot, Parkent, Kokand, Termez, and Yangiyer.

Geographic coordinates of cities in Uzbekistan

No.	Cities of Uzbekistan	Width	Length
1	Angren		
2	Bekabad		
3	Chiraqchi		
4	Dang'ara		
5	Guzar		
6	Jizzakh		
7	Koson		
8	Margilan		
9	Muynak		
10	Nukus		
11	Olot		
12	Parkent		

13	Kokand		
14	Termez		
15	Yangiyer		

3.2. Mark arbitrary objects on the map using a Cartesian coordinate system (the location of each point in a chosen spatial reference system is represented by three coordinates x, u, z).
3.3. World maps using the central points of different continents
Determine the geographical coordinates.
Central on different continents
of points geographical coordinates

No.	Name of continents	Geographic coordinates of central points	
		Width	Length
1.	Europe		
2.	Europe and Asia		
3.	North America		
4.	South America		
5.	Africa		
6.	Australia		
7.	Australia and Oceania		
8.	Antarctica		

3.4. Determine the coordinates of settlements in the local coordinate system:
A. Settlements of Samarkand region, Urgut district:
G'o's, Amonqo'tan, Karasuv, Mingchinor, Chumchuqli and Kamongaron Neighborhood Citizens' Assembly (NCA).

Settlements	Coordinates (X; Y)	Settlements	Coordinates (X; Y)
G'o's NCA		Mingchinar NCA	
Amonqo'ton NCA		Chumchuqli NCA	
Karasuv NCA		Kamongaron NCA	

B. Large population centers of the Jalalabad region of the Kyrgyz Republic: Jalalabad, Karakul, Maylisay, Tashkumir, Kokyongak, Kerben, Toktogul, Shamoldisay, Kuchkor-Ata, Bazarkurgan.

Settlements	Coordinates	Settlements	Coordinates
Jalalabad		Kerben	
Karakul		Toktogul	
Maylisay		Shamoldisay	
Tashkumir		Kuchkor-Ata	
Kokyongak		Bazarkurgan	

C. Find which cities are located at the following coordinates .

1. 41° north latitude, 69° east longitude
2. 40° north latitude, 71° east longitude
3. 39° north latitude, 66° east longitude
4. 37° north latitude, 67° east longitude
5. 43° north latitude, 59° east longitude
6. 51° north latitude, 0° longitude
7. 48° north latitude, 2° east longitude

8. 40° north latitude, 116° east longitude
9. 34° south latitude, 151° east longitude
10. 35° north latitude, 139° east longitude

3.4. Find the distance between two objects located on the same meridian.
"The cities of Vladikavkaz and Baghdad are located almost on the same meridian, but at different latitudes. The difference in latitude is 10°. Find the length of the air route that can be carried out along the common meridian between these cities" [3, – p. 34].
4. An assignment to analyze demographic data (studying local or national population, population growth rates, population density).
4.1. Based on the table below, indicate which country has the highest percentage of the population under the age of 15 and which countries have the same percentage of the population over the age of 65.
Population size and composition (2019)

No.	Countries	Population, million people	Birth and death rates 1000 people	
			Birth rate	Death toll
1.	China	1387	12	7
2.	France	65	12	9
3.	Kenya	45	23	7
4.	Egypt	95	29	5

4.2. Calculate the population growth rate of Uzbekistan based on 5-year data and present the results of the calculation in a diagram.
Population growth rate of Uzbekistan (2019-2023)

No.	Years	Birth rate (thousand people)	Death toll (thousand people)	Overall growth (million people)
1.	2019			
2.	2020			
3.	2021			
4.	2022			
5.	2023			

4.3. Graph the 5-year population growth rate of Uzbekistan.
5. Assignment on natural resource analysis and mapping.
5.1. Calculate the total area of mineral-rich areas based on the map of Uzbekistan.
5.2. Express the ratio of the total area of mineral resources to the total area of the republic, calculated based on the map of Uzbekistan, in percentage.
5.3. Compare the total area of mineral-rich areas in Uzbekistan with the total area of mineral-rich areas in the Russian Federation.
5.4. Express the ratio of the total area of mineral-rich regions in Uzbekistan to the total area of mineral-rich regions in the Russian Federation in percentage.
6. Assignment on analyzing climate data.
5.1. Using the example of a specific year, show data on the amount of annual precipitation by region of Uzbekistan on a map.

Annual precipitation by region of Uzbekistan (2023)

No.	Provinces	Annual precipitation	No.	Provinces	Annual precipitation
1.	Andijan		8.	Surkhandarya	
2.	Bukhara		9.	Tashkent	
3.	Jizzakh		10.	Fergana	
4.	Navoi		11	Khorezm	
5.	Namangan		12.	Kashkadarya	
6.	Samarkand		13.	Karakalpakstan	
7.	Syrdarya		-		

5.2. Specific year in the example of Uzbekistan Annual precipitation by region Calculate the average, minimum, and maximum values based on the data.

Annual precipitation by region of Uzbekistan (2023)

Provinces	Annual precipitation			Provinces	Annual precipitation		
	Four .	Min .	Max .		Four .	Min .	Max .
Andijan				Surkhandarya			
Bukhara				Tashkent			
Jizzakh				Fergana			
Navoi				Khorezm			
Namangan				Kashkadarya			
Samarkand				Karakalpakstan			
Syrdarya							

5.3. For a specific year, plot the average, minimum, and maximum values calculated based on annual precipitation data for the regions of Uzbekistan.

5.4. Using the example of a specific year, display data on annual air temperature by region of Uzbekistan on a map.

Annual air temperature by region of Uzbekistan (2023)

No.	Provinces	Annual air temperature	No.	Provinces	Annual air temperature
1.	Andijan		8.	Surkhandarya	
2.	Bukhara		9.	Tashkent	
3.	Jizzakh		10.	Fergana	
4.	Navoi		11	Khorezm	
5.	Namangan		12.	Kashkadarya	
6.	Samarkand		13.	Karakalpakstan	
7.	Syrdarya		-		

5.5. Calculate the average, minimum, and maximum values based on annual air temperature data for the regions of Uzbekistan for the year 2023.

Annual air temperature by region of Uzbekistan (2023)

No.	Provinces	Annual air temperature		
		Average	Minimum	Maximum
1.	Andijan			
2.	Bukhara			

3.	Jizzakh			
4.	Navoi			
5.	Namangan			
6.	Samarkand			
7.	Syrdarya			
8.	Surkhandarya			
9.	Tashkent			
10.	Fergana			
11	Khorezm			
12.	Kashkadarya			
13.	Karakalpakstan			

5.6. Specific year in the example of Uzbekistan provinces according to annual air Represent the average, minimum, and maximum values calculated based on temperature data in a diagram.

6. Assignment on historical geographical knowledge.

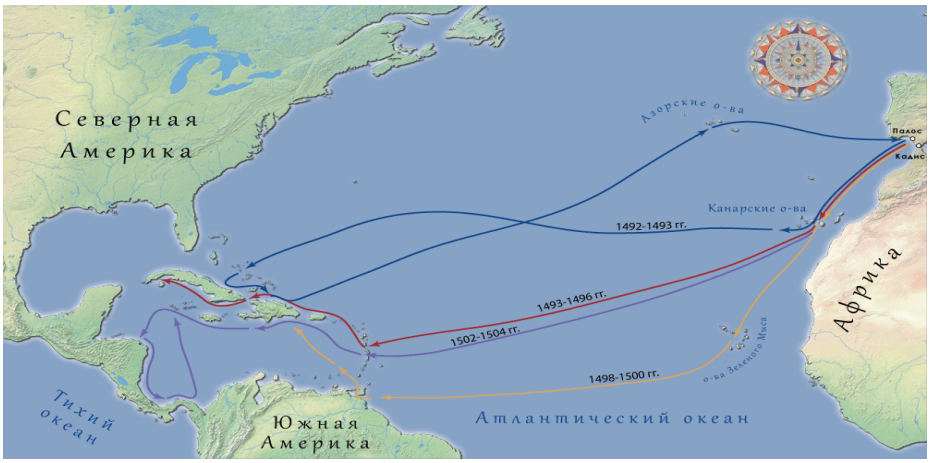
6.1 . Abu Rayhan Al-Biruni's information on determining geographical coordinates [2, – Compare the indicators that determine the location of the given places [p. 24] and show the differences.

To determine geographical coordinates

Comparative study of related information

No.	Place names	Geographical latitude		
		According to Abu Rayhan Al-Biruni	According to modern measurement	Intermediate difference
1.	Bukhara	39 o'clock 20'		
2.	Samarkand	40 o'clock 00'		
3.	Baku	39 o'clock 00'		
4.	Darband	66 º 00'		
5.	Fergana	92 o'clock 00'		
6.	Lost	92 o'clock 00'		

6.2. The 1st, 2nd, 3rd and 4th expeditions of Christopher Columbus according to the coordinate system [5] Measure the distance of the sea route using these maps illustrated.



Christopher Columbus's 1st, 2nd, 3rd and

Sea routes of the 4th expedition

6.3 . Calculate the diesel fuel consumption of Christopher Columbus for his 1st, 2nd, 3rd, and 4th expeditions at current prices, based on the measured sea route distance.
Ship model: Teplokhod 457
Engine model (power, kW) – K -161-2
Consumption, l/machine-hour – 15.7 D
The average is 30 liters per hour [4] .
The price of diesel fuel is 11,955.6 soums (December 9, 2024) [6] .
Christopher Columbus spent on his 1st, 2nd, 3rd and 4th expeditions diesel fuel (at current price; 09.12.2024)

No.	Expeditions order	Required diesel fuel (in l/machine-hour)	Amount spent on diesel fuel
1.	Expedition 1		
2.	Expedition 2		
3.	Expedition 3		
4.	Expedition 4		

V. Application of innovative technologies in the teaching process . In modern educational conditions, the use of innovative technologies in the process of developing students' cartographic knowledge and skills based on the integration of mathematics and geography is of great pedagogical importance. The introduction of innovative technologies in this process, on the one hand, reflects the development of geography in accordance with the requirements of an information society, and on the other hand, serves to form competencies in students to effectively operate in a digital environment. Today, the use of geographic information systems (GIS) technologies in geography education based on mutual integration with mathematics is increasingly being used. In the process of completing educational tasks based on these systems, the theoretical knowledge available to students is transformed into practical skills and competencies using innovative technologies, which ensures deep and sustainable mastery of cartographic knowledge.
Involving students in tasks based on innovative technologies in the process of teaching the subject of "Applied Geography" significantly expands the possibility of achieving the expected educational results. In particular, using geographic information systems (GIS) programs, students can determine information about the area of the territory in which they live (village, city or district), create a map based on this information, as well as analyze the directions of movement of modes of transport used in everyday life and present them in the form of a map, which serves to form cartographic knowledge and practical skills in students. Such tasks increase the practical significance of students by linking their theoretical knowledge with real geographical space.
Ensuring mutual integration between academic disciplines helps to consolidate students' knowledge, expand their imagination on the topics being studied, and understand the interrelationships between disciplines. At the same time, interdisciplinary integration is a complex and multifaceted pedagogical process that requires carefully planned educational activities. Systematic and effective implementation of the above tasks increases the effectiveness of the interdisciplinary integration process and serves to deepen students' cartographic knowledge and skills.
Therefore, the teacher's work experience, professional competence and pedagogical skills are of decisive importance in achieving effective integration between academic subjects. The development of students' cartographic knowledge based on the integration of mathematics and

geography is ensured, first of all, by implementing complex tasks such as ensuring sufficient reflection of mathematical knowledge in curricula, establishing effective cooperation between subject teachers, organizing practical lessons, linking the educational process with real life, and using innovative technologies in the teaching process.

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