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The Effect of Using Geographic Information Systems (GIS) in Teaching Geography on Developing Students' Map Reading and Interpretation Skills

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Research Article

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Abstract

Background/purpose. This study aimed to examine the effect of using Geographic Information Systems (GIS) in teaching geography on developing students' map-reading and interpretation skills.

Materials/methods. The study employed a quasi-experimental design based on two groups: an experimental group and a control group. The study population consisted of all eighth-grade students at Bushra Secondary Comprehensive School for Boys, affiliated with the Directorate of Education in Qasabat Irbid District, during the second semester of the 2024/2025 academic year. The study sample was purposefully selected from the population, and the two groups were randomly assigned. The experimental group consisted of 20 students who were taught using GIS-based instruction. The researchers developed a test to measure students' map reading and interpretation skills, which included the following components: map reading, map analysis, map interpretation, and concluding the map.

Results. The results showed that using Geographic Information Systems (GIS) in geography teaching significantly improved students' map reading and interpretation skills. The experimental group achieved a higher mean score on the post-test compared to the control group. The teaching strategy variable explained a large proportion of the variance in post-test scores on the map reading and comprehension test.

Conclusion. The study explores the use of Geographic Information System (GIS) in teaching geography as an educational content. GIS is a digital tool that engages students and enhances their interaction with the subject. The study found that the experimental group performed better in map reading and comprehension skills due to the interactive features provided by GIS. This enhances their ability to recognize spatial relationships, analyze geographical data, and interpret phenomena. The study emphasizes the importance of GIS in developing critical and analytical thinking skills.

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1. Introduction

Social studies is a comprehensive educational field that contributes to enhancing students' awareness and understanding of the world around them by integrating geographical, historical, and social knowledge. In this context, the use of Geographic Information Systems (GIS) in geography teaching is an effective tool for developing the ability to read and understand maps. One of the skills that geography curricula aim to develop in students is "map skill," given its importance in organizing, storing, and presenting data and information. Furthermore, the process of map production provides learners with the opportunity to practice additional skills, such as reading, analyzing, interpreting, and drawing conclusions from maps.

Over the past several decades, particularly since the creation of the first electronic computer, the field of geography has undergone significant transformations due to advances in technology and information systems. These innovations have not only facilitated the creation and utilization of maps but have also profoundly influenced geographic research and analysis. The integration of information technology into geographic practices has enhanced the efficacy of spatial data handling and has elevated the role of maps, making them essential tools in geographical studies. Geographers have leveraged these technological breakthroughs to improve data collection, analysis, and visualization, thereby enriching our understanding of spatial relationships and geographic phenomena (Dawood, 2012).

Al-Njadat (2011) emphasizes the importance of students mastering the skill of map production, as it contributes to the development of their spatial sense and understanding of the environments they belong to. In addition, this skill enhances their awareness of distant areas, provides them with a source of experiences, and helps them summarize large amounts of information and develop their perception of natural and human phenomena, thereby enhancing their geographical thinking abilities.

Therefore, geographers sought strategies, programs, and methods that suit the great developments in geographic technologies, such as global positioning systems (GPS), geographic information systems (GIS), remote sensing (R.S.), and aerial photography. The importance of these technologies lies in their ability to collect and process data and information accurately and effectively, in addition to their role in identifying issues and proposing appropriate solutions (Wadih, 2015).

Geographic Information Systems (GIS) are pivotal ICT applications that leverage advanced software and spatial data for thorough analysis. They provide speed, accuracy, and decision-making support, while also predicting future trends and integrating with other technologies. In educational settings, GIS significantly enhances students' map-related skills and geographical knowledge, thereby deepening their understanding of the curriculum (Shin, 2006). In addition, GIS technology is essential for automated map production, enabling efficient and accurate handling of mapping tasks through databases. It offers rapid map generation with precision in scale and projection, allows for easy modifications in a digital format, and facilitates quick analysis and updates without requiring paper prints (Wadih, 2015). Geographic Information Systems (GIS) enhance data presentation for effective analysis and interaction among teachers, students, and their surroundings. They foster understanding of the impact of location on historical events and aid in integrating data into maps to improve visualization skills (Cimbaljević, 2014).

The issue of the study stems from the researchers' practical experience: they noticed, through their attendance at supervisory classes for geography teachers, their discussions, and their ongoing interactions with students, that a large number of students lack many skills needed to read and understand maps. This may be due to the teachers' reliance on standard methods in teaching the skill of reading and understanding maps. Despite the importance of this skill in developing students' geographical understanding, standard methods do not keep pace with modern technological

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developments that can contribute to improving map teaching methods and increasing the effectiveness of the educational learning process, as well as the effectiveness of the educational learning process.

This study emphasizes the significance of Geographic Information Systems (GIS) in geography education, showcasing how technology enhances the educational process. It argues for integrating modern technology to improve students' map-reading skills and spatial understanding. For teachers, GIS serves as a tool to elevate teaching methods, boost student engagement, and facilitate innovative learning experiences. Curriculum developers benefit by crafting technology-aligned curricula that present geographical content more practically. Moreover, the study offers insights for teacher development on incorporating technology to enhance teaching effectiveness and adapt to technological advances in education. This agrees with Tawalbeh (2025) and AlZeinati & Tawalbeh (2025).

Researchers believe that relying on standard methods may weaken students' ability to understand and interpret maps accurately and analyze the spatial information they contain, which may limit the development of their geographical abilities and their effective interaction with the study materials. Therefore, there is an urgent need to introduce modern technologies, such as GIS, into the teaching process. The study can be formulated with the following main question: What is the impact of using GIS in geography teaching on the development of the skill of reading and understanding a map?

The following sub-questions emerge from the main question:

RQ1: Are there statistically significant differences ($\alpha = 0.05$) between the mean scores of the experimental group and the mean scores of the control group on the map reading and comprehension skill test due to the teaching method (using GIS and regular)?

2. Literature Review

Several previous studies related to the topic of the study have been conducted, including:

Artvinli's study (2010) in Turkey aimed to examine the impact of using aerial photos, data, maps, and graphics from geographic information systems (GIS) on students' achievement in geography and their attitudes towards studying geography at the lower secondary level. The study sample consisted of (665) male and female students from 15 schools distributed in several Turkish cities, to achieve the aim of the study, a GIS scale consisting of 24 paragraphs was applied to measure the role of GIS components in academic achievement and attitude towards geography, the results showed a statistically significant positive effect of using GIS components, such as aerial images, data, maps and graphics, in improving student achievement and building positive attitudes towards studying geography practically.

Kerski's study (2011) in the United States of America aimed to examine the impact of using GIS (such as maps, aerial photographs, and satellite images) on the achievement of secondary school students. To achieve this goal, the descriptive survey method was used, where the study tool included a questionnaire consisting of 33 paragraphs. The study sample included 1520 male and female teachers from public secondary schools across the United States of America. The results showed that although the use of GIS in teaching is not widespread, teachers recognize its importance in improving academic achievement and providing students with spatial thinking skills and a sense of place during learning. The results also indicated that the software currently available in schools needs to be modernized and developed to ensure that it is used more effectively in geography lessons.

Baroaidah (2015) conducted a study to identify the impact of a Geographic Information Systems (GIS)- based training program on the acquisition of related knowledge and the development of map

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production skills among female students in the Department of Geography at the College of Arts and Humanities in Jeddah. A quasi-experimental approach was used to achieve this goal, and a training program was developed to equip female students with the knowledge and skills needed to produce maps using GIS. The sample consisted of 34 randomly selected students, the results of the statistical analysis showed that there were statistically significant differences at the level of (0.01≥ a) between the mean scores of the students in the pre and post measurement in favor of the post measurement, in the acquisition of knowledge related to GIS, cognitive performance of the skill of map production, and practical performance of the skill of map production using the note card, which indicates the effectiveness of the training program.

Elbanna (2017) conducted a study to assess the effectiveness of using GIS in developing achievement and geographical sense among first-grade secondary students in geography. Descriptive and quasi-experimental methods were used to achieve this goal. The sample consisted of first-grade secondary students at Umm Al-Momineen Secondary School for Girls and the New Secondary School in Mansoura, the study focused on teaching the unit of location and surface of the earth from the geography book for the first grade secondary using applications such as Google Earth, ArcMap and space visuals, the study tools included an achievement test in geography and a test to measure geographical sense, the results showed the effectiveness of using GIS in developing academic achievement and geographical sense among first-grade secondary students.

Degirmenci's study (2018) aimed to investigate teachers' opinions about the use of GIS technology in teaching geography in Turkey. The descriptive method was adopted, and an interview tool was prepared to collect data. The tool was applied to a sample of 15 teachers, and the results showed that the vast majority did not use GIS in their lessons, and the reasons were insufficient knowledge of how to use it. Teachers also referred to insufficient capabilities, infrastructure, programs, and hardware. However, it was noted that all teachers agreed on the necessity of using GIS in geography lessons.

Atiya and Mohammed (2019) aimed to evaluate the effectiveness of a proposed Google Earth-based program in geography to develop spatial thinking skills among secondary school students. The study used a descriptive and quasi-experimental approach. The study tool consisted of a test of visual-spatial thinking skills for first-grade secondary students. It was administered to 80 female first-grade secondary students at Nasr Abdel Ghafour Secondary School for Girls in Menouf, Menoufia Governorate, and they were divided into two groups: an experimental group and a control group. The results of the study revealed a difference between the mean scores of the experimental and control groups on the visuospatial thinking skills test as a whole, in favor of the experimental group. There was a difference between the mean scores of the experimental group in the post- and pre-application in favor of the post-application.

Abu Khashba (2020) conducted a study to identify the impact of using GIS in teaching geography on the development of map-reading skills among first-grade secondary students. The sample consisted of female students from two classes in the first grade of secondary school, with one class representing the experimental group and the other the control group. A unit from the first-semester geography curriculum was taught to the experimental group, using ArcGIS as one of the GIS programs. In contrast, the control group was taught in the usual way. The results showed that there were statistically significant differences at the level of 0.05 between the mean scores of the students of the experimental group and the control group in the map understanding skill test in favor of the experimental group. This result was interpreted as indicating that the ArcGIS program contributed to the development of map-reading skills among the students in the experimental group.

Baroaidah and Al-Jahdali (2021) conducted a study to identify the impact of teaching the skill of producing a digital map using GIS technology on the performance of female secondary education

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students in the curriculum system (joint program) in the city of Jeddah. A quasi-experimental one-group design was used. To achieve the objective, a list of skills needed to produce a digital map using GIS technology was prepared, in addition to preparing an observation card consisting of (26) phrases, after checking the reliability and stability of the observation card, it was applied beforehand on a sample of (30) female students, and then the independent variable (GIS technology) was introduced and the card was applied afterwards. The results showed statistically significant differences between the averages of students' scores before and after measurement, in favor of the post-measurement, indicating a positive effect of using GIS technology on students' performance in digital map production.

Omran, Zayed, and Tahtawi (2023) conducted a study to identify the impact of using GIS in teaching the principles of the maps course on the development of map-reading skills and spatial thinking among students in the geography department at the College of Education. To achieve this goal, a list of map-reading and spatial-thinking skills was prepared, along with an instructional guide for the teacher and a booklet for the student to develop these skills. A test was also prepared to measure map-reading and spatial thinking skills, using a quasi-experimental approach, as it relied on pre- and post-measurement of the experimental and control groups. The sample included an experimental group consisting of (20) students from the second division of the Department of Geography, who studied the principles of maps course using GIS, and a control group consisting of (20) students from the same division who studied the same course in the usual way, the results showed that the use of GIS contributed significantly to the development of map reading skills and spatial thinking in the experimental group students. The results also showed a statistically significant difference at the 0.05 level between the average scores of the experimental and control group students on the test of map-reading skills and spatial thinking, in favor of the experimental group in the dimensional application.

Modern geographic technologies and diverse learning resources, such as maps and GIS, are essential tools to enhance geography education in light of rapid technological changes, as integrating these technologies into the educational process helps develop students' skills in analyzing geographic data and understanding phenomena more deeply. Therefore, based on the above, this study revealed the impact of using GIS in teaching geography on the development of the skill of reading and understanding maps.

3. Methodology

The researchers used a quasi-experimental design with control and experimental groups to assess the impact of using GIS in geography teaching on the development of map-reading and understanding skills.

3.1. Samples of the study

The study population consisted of all eighth-grade students from Bushra Comprehensive Secondary School for Boys, affiliated with the Directorate of Education of the Qasbah Irbid District, for the second semester (2024/2025). The study sample was selected from the study population by the purposive method, as the two study groups were randomly assigned to be one of them: The experimental group consisted of 20 students, who were taught using GIS, and the control group consisted of 20 students, who were taught using the usual method.

3.2. Study variables

The study included the following variables:

3.2.1. The independent variables are:

The teaching strategy has two levels:

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- Teaching using GIS.
- Teaching using the standard method.

3.2.2. The dependent variables are

- The skill of reading and understanding the map.

3.3. Statistical treatment

To answer the study questions, arithmetic means, standard deviations, and multiple contrasts were calculated using the statistical package program (SPSS), through the use of the following statistical methods:

Frequency, percentages, arithmetic mean, standard deviation, analysis of covariance (ANCOVA), and multivariate analysis of variance (MANOVA) were used to answer the study questions.

3.4. study tools

The study tools consisted of the following:

3.4.1. Map Reading and Comprehension Skills Test

The researchers cited educational literature on map reading and comprehension skills, such as Hamida (2008).

Referring to previous studies related to map reading and comprehension skills, such as Baroaidah (2015) and Omran et al. (2023).

Reaching the skill of reading and understanding a map, which is represented by (interpreting map symbols and keys, understanding the scale and spatial relationships between geographical elements). The test included multiple-choice questions.

Refer to the study unit "Journey in My Homeland" in the geography textbook, analyze it, and propose related learning outcomes.

Formulating the questions of the map reading and comprehension test from the unit (interpreting map symbols and keys, understanding scale, and spatial relationships between geographical elements), in its initial form.

- *Validity of the Map Reading Comprehension Test:*

The validity of the map reading and comprehension test was verified in two different ways:

I: Content validity: The content validity of the map reading and comprehension test was verified by presenting it to a group of arbitrators specialized in social studies curricula and teaching methods, in addition to university professors from the Department of Geography in a number of Jordanian universities (10). The arbitrators were asked to express their opinions about the extent to which the test paragraphs cover the skills of reading, analyzing, interpreting, and inferring from the map, and the extent to which they represent the content of the study unit. They were also asked to evaluate the soundness of the language used in formulating the questions, the accuracy of the alternatives, and the appropriateness of the paragraphs for the target age group. The test consisted of four main dimensions: Reading the map, Analyzing the map, Interpreting the map, and Inferring from the map, with each dimension comprising five multiple-choice items, for a total of twenty items. Based on the judges' feedback, the wording of some paragraphs was modified to be clearer and more accurate, some alternatives were replaced to be more relevant to the targeted content, and some paragraphs were rearranged to achieve a logical sequence and enhance the clarity of the skill measured in each dimension of the test. All substantive comments were taken into consideration before the final version of the test was approved.

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II: Construct validity: The construct validity of the test was extracted by distributing it to a survey sample from Al-Hussein bin Talal Secondary School for Boys, consisting of 20 students from outside the study sample and from within its community, and then the value of the Pearson correlation coefficient was calculated for each paragraph of the test with the total score of the test.

To extract the indicators of the construct validity of the test, the correlation coefficients of the test skills with the test as a whole were extracted in an exploratory sample from outside the study sample from Al-Hussein Bin Talal Secondary School for Boys, consisting of 20 students, where the test paragraphs were analyzed, as the correlation coefficient here represents an indication of validity for all test paragraphs, as shown in Table 1.

Table 1. Correlation coefficients for reading and understanding the map

Paragraph number	Correlation coefficient with the instrument	Paragraph number	Correlation coefficient with the instrument
1	0.63	14	0.70
2	0.66	15	0.75
3	0.64	16	0.71
4	0.68	17	0.74
5	0.67	18	0.76
6	0.72	19	0.78
7	0.65	20	0.73
8	0.69		
9	0.61		
10	0.70		
11	0.62		
12	0.66		
13	0.60		

It is clear from Table 1 that the correlation coefficients between the paragraphs of the map reading and comprehension test and the instrument's total score range from 0.60 to 0.78, all within the statistically acceptable range, indicating a significant correlation between each paragraph and the total score.

Difficulty coefficients and discrimination coefficients were calculated for the vocabulary of the map reading and comprehension skill test on a sample size of 20 male and female students from outside the study sample and from Al-Hussein bin Talal Secondary School for Boys, as shown in Table 2.

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Table 2. Difficulty coefficient and discrimination coefficient for the paragraphs of the map reading and comprehension skill test

Paragraph number	Difficulty coefficient	Discrimination coefficient	Paragraph number	Difficulty coefficient	Discrimination coefficient
1	0.65	0.45	14	0.62	0.42
2	0.70	0.50	15	0.68	0.48
3	0.6	0.40	16	0.63	0.43
4	0.75	0.55	17	0.66	0.44
5	0.58	0.38	18	0.64	0.46
6	0.67	0.49	19	0.69	0.50
7	0.62	0.41	20	0.61	0.40
8	0.66	0.43			
9	0.59	0.39			
10	0.71	0.52			
11	0.63	0.44			
12	0.60	0.40			
13	0.65	0.45			

It can be seen from Table 2, that the values of the difficulty coefficient in the table are commensurate with the level of difficulty of the test paragraphs with the level of the target students, where the values range between (0.58 and 0.75), which indicates that most of the questions are of medium to appropriate difficulty, which contributes to distinguish the level of students without the questions being too easy or too difficult, and based on what Odeh (2014) indicated that the paragraph is considered good and acceptable within the test, if the paragraph difficulty coefficient ranges between (0.20) and (0.80), so no paragraphs were deleted from the test paragraphs.

The discrimination coefficients range between 0.38 and 0.55, and based on what Odeh (2014) pointed out, a paragraph is considered good and acceptable within the test if its discrimination coefficient is higher than 0.25, so none of the test paragraphs were deleted. All test paragraphs were retained, so that the test in its final form consists of 20 paragraphs. The researchers found that the referees' estimate was appropriate, so all test paragraphs were considered appropriate.

- *Stability of the map reading and comprehension test*

To ensure the stability of the test, the test-retest method was used, where the test was applied to an exploratory sample from outside the study sample and from within its community, consisting of 20 eighth-grade students, and the test was applied to the exploratory sample after two weeks. The Pearson correlation coefficient was calculated between the scores of the exploratory sample students at the two times, and Table 3 shows this:

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Table 3. Repeatability of the map reading and comprehension test

The test	Repeatability stability	Number of paragraphs
Map-reading skill	0.82	5
Analyzing the map	0.80	5
Map Interpretation Skill	0.85	5
Deducing from the map	0.81	5

The results showed that the repeatability values of the map reading and understanding skills test ranged between 0.80 and 0.85, where the map interpretation skill recorded the highest value (0.85), followed by the map reading skill with 0.82, then the map inference skill with 0.81, and finally the map analysis skill with 0.80. These values reflect high stability and good reliability of the test, which indicates the validity and effectiveness of the instrument in measuring the targeted geographical skills.

- *Equivalence of the two study groups in the map reading and comprehension test*

To verify equivalence between the two study groups in the pre-test, the arithmetic means and standard deviations of the experimental and control groups' pre-test performance on the geographical thinking skills test were extracted, and Table 4 shows these.

Table 4. Results of the t-test for two independent groups to compare the arithmetic means of the performance of the tribal study sample on the map reading and comprehension skill test according to the study group (experimental and control)

Skill	Group	Arithmetic mean	Standard deviation	T-value	Degrees of freedom	Statistical significance
Map-reading skill	Control	2.40	.9400	-0.370	38	0.714
	Experimental	2.50	.7600			
Map analysis skill	Control	2.25	.8500	-0.191	38	0.849
	Experimental	2.30	.8010			
Map Interpretation Skill	Control	2.25	.5500	0.224	38	0.824
	Experimental	2.20	.8330			
Inference skill from the map	Control	2.05	.7550	-1.013	38	0.318
	Experimental	2.30	.8010			

Table 4 shows no statistically significant difference in the mean performance of the two study groups on the map reading and comprehension skill test, indicating that the two groups are statistically equivalent prior to the treatment procedure.

3.4.2. A teacher's guide on the impact of using Geographic Information Systems (GIS) in teaching geography

This guide aims to show how to use Geographic Information Systems (GIS) as an effective educational tool to develop students' skills in reading and understanding maps, and to provide simplified study material on GIS and the steps to program maps accurately.

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Digital technologies used:

- *Virtual tours:*

The "Journey in My Homeland" unit will be adapted from the eighth-grade book, incorporating virtual tours into the educational content to enhance students' understanding of maps and geographical locations in innovative, interactive ways.

- *Using Google Earth:*

The Google Earth application was used to display real-life geographical locations, helping link the geographical concepts taught to the practical and real-world reality.

- *Use of GPS:*

GPS technology was used to determine travel routes between archaeological sites, providing students with practical experience in tracking and analyzing geographical paths in an applied scientific manner.

- *Validity of the guide*

The validity of this guide was confirmed by presenting it to (10) specialized arbitrators from Jordanian university professors, supervisors, and teachers of the Ministry of Education in the specialization of social studies curricula and teaching methods. The arbitrators evaluated the appropriateness of the scientific content for the target age group, the accuracy and clarity of the scientific material, the compatibility of activities and educational methods with the lesson objectives, and the appropriateness of evaluation methods and time allocation for each lesson. Based on their feedback, which included simplifying some technical terms, adding practical examples and exercises, promoting the use of open-source GIS software such as QGIS, and rearranging some topics, the researchers made the necessary adjustments to the guide. The amendments also included simplifying the language, including clear practical examples, improving the explanation of symbols and colors in digital maps, and guiding the use of appropriate programs, which contributed to raising the level of reliability of the guide and increasing its suitability for the target group with the intention of everything possible in the guide to contribute to the development of students' skills in GIS.

3.5. Study Procedures

This study undertook a detailed procedure to address a specific research question concerning map reading and comprehension skills among eighth-grade students at Bushra Comprehensive Secondary School for Boys. This involved identifying the research gap and formulating appropriate research questions. A comprehensive review of theoretical literature and previous studies was conducted to gather relevant information. The research project, approved by the Research Ethics Committee at Yarmouk University, included securing the necessary facilities to carry out the tasks and communicating with the academic administration to obtain official approval.

The study sample consisted of eighth-grade students, and basic instruments, such as a map reading and comprehension test, were developed. These instruments were presented to experts for feedback to ensure their suitability and objectivity, and modifications were made based on their recommendations. The research also focused on collecting educational materials and setting clear objectives for the skills test to ensure its alignment with the educational content.

A preliminary test was designed that incorporated various question types, and a pilot study was conducted with a small sample to evaluate the effectiveness of the instruments. After making adjustments, the test was administered to both the experimental and control groups to ensure educational equivalence. The collected data were entered into SPSS software for analysis using appropriate statistical methods. The results are presented in an easily interpretable format, including

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graphs and tables, and analyzed according to the study's objectives. Finally, the study concludes with key findings and recommendations for practitioners and the academic community based on these results.

4. Results

RQ1: Are there statistically significant differences (α = 0.05) between the mean scores of the experimental group and the mean scores of the control group on the map reading and comprehension skill test due to the teaching method (using GIS and regular)?

To answer this question, it is necessary to check the significance of the difference between the arithmetic means of the study sample's performance on the map reading and comprehension skill test, so the arithmetic means and standard deviations of the study sample's pre and post-performance on the map reading and comprehension skill test, according to the teaching method (using GIS and regular), were calculated, as shown in Table (5).

Table 5. Arithmetic means, standard deviations, and adjusted arithmetic mean of the map reading and comprehension skill test in the pre- and post-measurements according to the teaching method (using GIS and regular)

Teaching method	Tribal performance		Dimensional performance	
	Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation
Experimental group (Using GIS)	9.30	1.031	16.10	2.489
Control group (Standard Method)	8.95	1.791	11.10	2.149

Table 5 shows significant differences in the arithmetic means of the two study groups' scores on the map-reading and understanding skill test between pre- and post-measurements, by teaching strategy (GIS versus the usual method). The results showed that the arithmetic mean of the dimension score in the experimental group (16.10) with a standard deviation of 2.489 was higher than that in the control group (11.10) with a standard deviation of 2.149.

To determine whether these apparent differences were statistically significant at the significance level (α = 0.05), a one-way analysis of covariance (ANCOVA) was used for the dimensional measure, controlling for the effect of the pretest score as a covariate, in order to neutralize any initial effect of the pretest scores on the final results. This statistical method enabled us to attribute the differences in dimensional performance to the teaching strategy variable alone, after removing the effect of potential tribal variance.

The results of the accompanying univariate analysis of variance, as shown in Table 6, are presented below.

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Table 6. One-way ANCOVA results for the scores of the experimental and control groups on the dimensional map reading and comprehension test, according to the teaching strategy variable

Source of variance	Sum of squares	Degrees of freedom	Mean sum of squares	P-value	Significance level	Eta square η^2
Premeasurement (concomitant)	9.319	1	9.319	1.757	0.193	0.049
Teaching strategy	234.736	1	234.736	44.249	0.000	0.516
Error	196.281	37	5.305			
Total	7854.000	40				

It is clear from Table (6) that there is a statistically significant difference at the level of ($\alpha = 0.05$) between the arithmetic means of the scores of the students of the two groups (experimental and control) in the post-measurement of the map reading and understanding test attributed to the variable of teaching strategy, where the value of (F) 44.249 with a statistical significance of 0.000, which indicates a statistically significant effect of the teaching strategy. Thus, the first null hypothesis is rejected, and the alternative hypothesis is accepted, stating that there is a statistically significant difference in the performance of students in the experimental group taught using GIS and that of the control group taught in the usual way.

The value of the eta square ($\eta^2 = 0.516$) indicates that the teaching strategy explained 51.6% of the variance in the dimensional score of the map reading and comprehension test, which is considered significant, indicating a high effect size, according to Al-Kilani and Al-Sharifin (2016), that the effect size is large if it exceeds 16%.

To determine to whom the difference is attributable, the adjusted arithmetic means and standard errors were extracted on the dimensional measurement according to the teaching strategy, as shown in Table 7.

Table 7. Adjusted arithmetic means and standard errors of the sample students' scores on the map reading and comprehension test according to the teaching strategy variable

Teaching strategy	Adjusted arithmetic mean	Standard error
Experimental group (Using GIS)	16.041	0.517
Control group (Normal Method)	11.159	0.517

** The total score is 20*

The results in Table 7 indicate that the difference was in favor of the experimental group, whose members studied using GIS, whose adjusted arithmetic mean was 16.041, compared to the control group (normal method), whose adjusted arithmetic mean was 11.159.

The significance of the differences between the arithmetic means of the study sample's performance on each skill of the map-reading and comprehension skills test was also checked. The Multivariate Analysis of Variance (MANOVA) was tested on the dimensional arithmetic means of the

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study sample's scores on the map reading and comprehension skills test, according to the teaching method (using GIS versus the usual method). This is shown in Table 8.

Table 8. The arithmetic means and standard deviations for each skill of the map reading and comprehension skills test in the pre- and post-measurements according to the teaching method (using GIS versus the usual method)

Domain	Group	Tribal performance		Dimensional performance		Adjusted arithmetic mean	Standard error
		Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation		
Map-reading skills	Using Geographic Information Systems (GIS)	2.50	0.760	4.4500	82558.	4.462	.2120
	Regular	2.40	0.940	3.0500	1.09904	3.038	.2120
Map analysis skill	Use of geographic information systems	2.30	0.801	3.9500	99868.	3.891	.2250
	Normal	2.25	0.850	3.0000	1.12390	3.059	.2250
Map interpretation skill	Use of geographic information systems	2.20	0.833	3.7500	1.20852	3.718	.1960
	Normal	2.25	0.550	2.4500	60481.	2.482	.1960
Skill in inferring from a map	Use of geographic information systems	2.30	0.801	3.9500	94451.	3.891	.2350
	Normal	2.05	0.755	2.6000	1.27321	2.659	.2350

It is clear from the data in Table 8 that there are significant differences between the pre- and post-arithmetic means of the experimental group students who learned using GIS, compared with the performance of the control group students who learned in the usual way, across all skills on the map reading and comprehension test.

The results also show differences in the adjusted arithmetic averages of dimensional performance between the two groups, all of which favored the experimental group, indicating the positive impact of using GIS in developing geographical thinking skills. The adjusted arithmetic mean in map reading skill for the experimental group was 4.462 compared to 3.038 for the control group, in map analysis skill 3.891 compared to 3.059, in map interpretation skill 3.718 compared to 2.482, and finally in map inference skill 3.891 compared to 2.659.

These results indicate a clear superiority of the group that used GIS in acquiring the skills of reading, analyzing, interpreting, and inferring from maps, compared to the usual method.

To statistically verify the significance of these differences, a multiple analysis of variance (MANOVA) was used to assess dimensional performance between the two groups in the targeted skills, as shown in Table 9.

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Table 9. Results of the multiple analysis of variance (MANOVA) for the dimensional measurement in the map reading and comprehension skills test according to the teaching method (using GIS versus the standard method)

Source of variance	Domain	Sum of squares	Degrees of freedom	Mean sum of squares	P value	Significance level	Eta squared η2
Measurement	Map-reading skill	562.500	1	562.500	595.404	.0000	.9400
	Map analysis skill	483.025	1	483.025	427.356	.0000	.9180
	Map interpretation skill	384.400	1	384.400	420.957	.0000	.9170
	The skill of inferring from a map	429.025	1	429.025	341.423	0.000	0.900
Group Hotelling= 1.309	Map-reading skill	19.600	1	19.600	20.747	.0000	.3530
	Map analysis skill	9.025	1	9.025	7.985	.0070	.1740
	Map interpretation skill	16.900	1	16.900	18.507	.0000	.3280
	The skill of inferring from a map	18.225	1	18.225	14.504	0.000	0.276
Error	Map-reading skill	35.900	38	945.			
	Analyzing the map	42.950	38	1.130			
	Interpreting the map	34.700	38	913.			
	Deducing from the map	47.750	38	1.257			
Total	Map-reading skill	618.000	40				
	Map Analysis Skill	535.000	40				
	Map Interpretation Skill	436.000	40				
	Map Inference Skill	495.000	40				
Modified total	Map-reading skill	55.500	39				
	Map Analysis Skill	51.975	39				
	Map Interpretation Skill	51.600	39				
	Deducing from the map	65.975	39				

The results of the multiple analysis of variance (MANOVA) for the dimensional measurement in the map reading and comprehension skills test showed that there were statistically significant differences between the experimental and control groups, which differed in the teaching method, where GIS was used in the experimental group and the usual method in the control group.

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The results of the analysis showed that the effect of the teaching method was highly statistically significant on all measured geographical thinking skills, namely map reading, map analysis, map interpretation, and map inference, as the partial eta square values (η^2) ranged between 0.174 and 0.353, indicating a strong effect of the teaching method using GIS compared to the regular method.

The total Hotelling's Trace value was 1.309, with a significant level ($p < 0.001$), confirming a significant positive difference in favor of the group that used GIS to develop map reading and comprehension skills.

Thus, it can be concluded that relying on GIS in teaching effectively improves students' performance in geographical thinking skills compared to the usual method.

5. Discussion

This may be explained by the performative practices that were provided in the learning environment, which contributed to teaching geography as an educational content that focuses on skills and competencies, which is different from the common stereotype of some teachers and students from dealing with educational content, as content for memorization and recall, in addition to the learning environment provided by GIS that made geography a relevant subject for students, and this will agree with Tawalbeh (2025) who indicated that most social studies with his teaching practices can make their content useful to become useful life materials for students. This may be due to the GIS and its digital technical tools that attract students' interests and increase their interaction with the educational content, and this agrees with what was emphasized by Tawalbeh (2025), where he pointed out the importance of making social studies classes enjoyable and seeking to change the negative image prevailing among students towards social studies investigations. The researchers also attribute this result to the characteristics of the GIS-based learning environment, which enables the learner to interact with maps and contributes to the development of their ability to recognize spatial relationships, analyze geographical data, and interpret phenomena.

These results are consistent with previous studies highlighting the benefits of using geographic information systems (GIS) and visual aids in geography education. Artvinli (2010) found that aerial photographs and digital graphics enhance academic achievement and foster positive attitudes towards geography. Kerski (2011) confirmed that GIS improves student achievement and spatial thinking skills. Al-Banna (2017) further supported these notions, demonstrating GIS's effectiveness in enhancing students' geographical understanding. Abu Khashaba (2020) noted significant improvements in map comprehension through ArcGIS-based instruction. Moreover, Baraida and Al-Jahdali (2021) indicated that teaching digital map production using GIS significantly enhanced female students' performance. Collectively, the findings underscore GIS as a vital educational tool for developing key geographical thinking skills, including map reading, analysis, interpretation, and inference, compared with traditional teaching methods.

These results support contemporary trends in geography education that advocate incorporating Geographic Information Systems (GIS) into educational programs. This integration is backed by numerous studies and international educational bodies, including the UNESCO (2021) report on the future of digital education, which emphasizes the importance of using spatial technologies in teaching social and geographical topics. The implementation of these technologies is shown to enhance critical and analytical thinking skills among students.

The analysis of multiple variances revealed significant differences in performance between the experimental and control groups regarding map reading and comprehension skills, attributed to the instructional methods employed—specifically, GIS versus traditional approaches. The GIS-based teaching strategy demonstrated a strong statistical impact on all evaluated skills, including reading, analyzing, interpreting, and inferring from maps. The experimental group exhibited remarkable

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superiority in map-reading abilities, likely due to the interactive features of GIS that engaged multiple senses, particularly vision, thereby enhancing retention of learning material and proficiency in reading and understanding maps.

The experimental group's superiority in this study aligns with the theoretical framework emphasizing active and constructivist learning, positioning students at the center of the educational process. This approach fosters active involvement in knowledge construction through interaction with contemporary tools and technologies. The implementation of GIS systems transformed the educational environment into one that encourages discovery, allowing students to manipulate digital maps, modify their layers, and interrelate geographical information. This engagement deepened their comprehension of geographical concepts and enhanced their performance. Supporting Kerski's (2011) recommendations, Geographic Information Systems (GIS) technology facilitates a dynamic learning experience for students, allowing them to zoom in and out and view multiple layers. This interactive capability improves their understanding of geographical symbols and elements more effectively than traditional static maps. Kerski indicated that GIS tools enhance students' spatial thinking skills and their sense of place, thereby refining their ability to accurately interpret geographical elements. Further supporting this, Abu Khashaba's (2020) study demonstrated that ArcGIS enables practical map interaction, leading to improved map comprehension skills compared to conventional methods. Baroaidah's (2015) research corroborated these findings, showing that a GIS-based training program effectively enhances both cognitive and practical competencies in map production skills, specifically among female students.

The skill of map analysis also showed a strong effect from using GIS, attributed to the ability to display multiple geographical layers simultaneously, allowing students to clearly compare and analyze the spatial relationships among geographical phenomena. This finding supports the study by Al-Banna (2017), which showed that the use of GIS applications such as Google Earth and ArcMap enhanced students' understanding of spatial relationships and interpretation of terrain and geographical locations. Omran, Zayed, and Tahtawi (2023) showed that the use of GIS in teaching the principles of the maps course led to remarkable improvements in map-reading skills and spatial thinking, including the ability to analyze geographical phenomena and relate them to location. Kirsky's (2011) study also indicated that GIS is an effective tool for developing students' abilities to perceive and analyze spatial patterns, which is directly reflected in improved map analysis skills.

Regarding map interpretation, GIS enables students to relate spatial data to reality, enhancing their ability to understand the causes and consequences of geographical phenomena. This interactive method helps to develop deeper deductive and causal thinking skills, which is confirmed by studies such as Kirsky's (2011) study, which showed that the use of GIS contributes to the development of spatial thinking and the ability to analyze and interpret geographical relationships, through students' interaction with spatial and visual data. The study of Rasha, Ahmed, Hamida, Ahmed, and Osman (2023) also supports this result, as it indicated that the use of GIS-based digital maps contributed to the development of spatial thinking skills among first-grade secondary students, including the interpretation and logical analysis of geographical phenomena. Similarly, Baroaidah's (2015) study showed that the GIS-based training program helped students to build realistic interpretations based on interactive map data and layers, which clearly supports the development of map interpretation skills.

As for the skill of inferring from a map, which represents a pinnacle of geographical reasoning, research indicates that Geographic Information Systems (GIS) have a significant positive impact on its development. The use of GIS facilitates virtual experiments and the simulation of various scenarios, fostering critical and investigative thinking among students and promoting the self-construction of knowledge. In contrast, traditional teaching methods tend to fall short in achieving similar educational benefits. This inadequacy is largely attributed to their dependence on static maps and

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descriptive explanations that lack interactivity and analytical depth. Such limitations hinder the effective development of geographic thinking skills, underscoring the benefits of integrating modern technologies such as GIS into geographic education.

This study highlights the importance of integrating Geographic Information Systems (GIS) into geography education, particularly for a digital generation adept at utilizing digital tools. It emphasizes that the harmony between the demands of virtual reasoning skills and digital simulations is significant in enhancing map reading and comprehension among students. The findings point to GIS as a critical factor in improving student performance, leading to a more interactive and profound learning experience. Consequently, educational institutions need to adopt modern technologies such as GIS and provide appropriate training for teachers to maximize benefits and improve learning outcomes in geography education.

6. Conclusion

The study explores the implementation of Geographic Information System (GIS) technology in geography education, highlighting its role as an engaging educational tool. GIS enhances student interest and engagement with geographical content, reinforcing the subject's relevance. The researchers emphasize the distinct features of GIS-based learning environments, which facilitate interactive engagement with maps. This interaction aids in the development of essential skills such as recognizing spatial relationships, analyzing geographical data, and interpreting various geographical phenomena.

The study demonstrated that participants in the experimental group, who received instruction through Geographic Information Systems (GIS), exhibited superior performance in map reading and comprehension skills compared to those taught using traditional methods. This skill enhancement is linked to the distinct teaching approaches employed in GIS education. Significantly, the GIS-based strategy had a robust, statistically significant impact on various facets of map reading and comprehension, including reading, analysis, interpretation, and inference from maps.

The experimental group demonstrated superiority due to the interactive features of Geographic Information Systems (GIS). These features enable students to zoom in and out and view multiple layers of data, facilitating a more accurate understanding of geographical symbols and elements. Additionally, GIS allows students to connect spatial data to real-world contexts, thereby enhancing their understanding of the causes and consequences of various geographical phenomena.

In conclusion, the study highlights the significance of Geographic Information Systems (GIS) as a powerful educational tool that enhances geographical thinking skills. These skills encompass the abilities to read, analyze, interpret, and infer information from maps. The integration of GIS into the educational curriculum allows students to gain a deeper understanding of their surroundings while also cultivating their critical and analytical thinking.

7. Suggestion

Based on the study's findings, the researchers recommend several strategies for enhancing students' geographic and analytical skills: diversifying classroom activities to develop map inference skills, integrating Geographic Information Systems (GIS) technology into curricula, and providing specialized training for teachers. They suggest preparing educational materials, like the "Journey in My Homeland" unit, and encouraging the use of interactive digital tools to motivate students and improve critical thinking. Ongoing applied research is essential to evaluate GIS's impact on education and develop tailored teaching strategies. Additionally, ensuring schools receive adequate technical and logistical support is crucial for effective learning.

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Declarations

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