Geographic Information System Software and Discovery-Based Learning Strategy for Enhancement of Geography Students' Performance and Retention in Rivers State

By

Elvis-Njoku, Nkechi Theresa
Department of Curriculum Studies and Educational Technology
Faculty of Education
University of Port Harcourt
nkechi_elvis-njoku@uniport.edu.ng

Abstract

The study investigated the use of Geographic Information System software and the Discovery-Based Learning Strategy for enhancing the performance and retention of geography students in the Port Harcourt Local Government Area, Rivers State. Four objectives, four research questions, and four hypotheses guided the study. Quasi-experimental design was adopted in the study. One hundred and fifty-two (152) senior secondary school two (SSS2) students, which consisted of sixty (83) males and forty-eight (69) females in three (3) intact classes, formed the sample size of the study. One instrument entitled: Geography Performance Test, which also tested students' retention, was developed, validated, and considered reliable with a reliability coefficient of 0.64 using Pearson's Product-Moment Correlation Statistics. The research questions were answered with Mean and Standard Deviation, while the hypotheses were tested at a 0.05 level of significance using analysis of covariance. Results showed that Geographic Information System Software (GISS) and a Discovery-based learning strategy proved to be more effective than the lecture method in the understanding of Geography at the senior secondary school level. It was also established that gender did not significantly influence the academic performance of SS1 students in GISS, DBLS, and lecture method groups in Geography. Furthermore, the study established that GISS and DBLS enhanced students' retention in Geography. It was recommended among others that teachers should use Geographic Information System Software and a Discovery-based learning strategy to teach Geography in senior secondary schools to enhance the academic performance of students both in internal and external examinations.

Keywords: Geographic Information System Software, Discovery-Based Learning Strategy, Geography Education, Academic Performance, Retention

Introduction

There is no doubt that educators play pivotal roles in the achievement of any nation's educational goals, and that classroom instruction is the single most critical component of quality education. The success of these programs relies not only on the policies themselves, but also on the instructors' degree of passion and devotion to their jobs. According to Al-Kamali (2019), it is the quality of the teaching staff that determines the success of any educational system. Without good teachers, schools could barely meet its goals.The recruitment of qualified educators was a central tenet of Nigeria's national strategy on education. Students need to develop spatial competency in order to be successful in life, and one of the best ways to do so is by studying geography in secondary school (Kerski, 2020). In recent times, a lot of high school students don't see geography as a topic that will help them in the real world. Consequently, a lot of people have preconceived notions and biases about the study of Geography.

Many different fields of study within geography have the potential to yield substantial monetary gains for society at large, including people, schools, and companies. There is a growing need for geography instructors in secondary schools, since most educators in our culture acknowledge the importance and relevance of the subject. Several scientific disciplines have contributed to the field of geography, which studies the planet's surface. These include biology, anthropology, meteorology, geology, and astronomy. The field of study known as "geography" examines the ways in which physical features and events interact with one another as a result of their placement on Earth's surface. Some of the many benefits of studying geography include the opportunity to get marketable skills and a wide range of job paths to choose from. Unfortunately, student views regarding geography are never addressed, despite the subject's importance in both everyday life and education (as indicated earlier). This perspective of pupils in this class may be important to how geography is taught. Using computers in the classroom was formerly considered a fleeting trend that would be replaced by something else entirely. The potential of computers to enhance classroom instruction and student motivation has long baffled many school administrators, instructors, and educators. The challenge of incorporating technology into course material is an additional hurdle to the difficulty of integrating technology into the curriculum (Shin, 2020). It is challenging to resolve the aforementioned issue of "utilisation of technology according to educational content" because of infrastructural and economic concerns. Restricting the use of this

technology to teacher-student "preparation for presentations" lessens its potential beneficial effects on learning and instruction and raises the risk of unintended consequences. The adoption process can be accelerated in the education sector by adapting and requiring GIS under these conditions. In industrialised nations, this method is utilised in the classroom somewhat more frequently. Nonetheless, in underdeveloped nations, this approach is seen as a foundation of knowledge for future generations. The study literature indicates that academics and educators alike are interested in incorporating GIS into the classroom and the learning process. Jenner (2019) adds that a major reason for using GIS in educational programs is that it fosters an environment that values active learning and research. This, in turn, inspires educators to think of innovative methods to include GIS into their lessons. Nevertheless, the question of whether GIS is a means to an end or an end in and of itself is a matter of contention. We should consider Geographic Information Systems (GIS) one of the twenty-five most consequential innovations of the twenty-first century. Since its inception, GIS has expanded the scope and methodology of spatial analysis, radically altering the field of geography and solidifying its place as an integral part of fields such as sociology, biology, urban planning, geology, politics, and politics. Additionally, it resulted in significant changes to the way geography was taught. At the university level, GIS was initially implemented for the purpose of teaching geography. Many schools in Nigeria now include GIS coursework in their geography majors, and some even provide degrees in geospatial information science (GIS) at the bachelor's, master's, and doctoral levels. Nigerian universities have seen the effects of both miniaturisation and the increasing usage of geographic information systems (GIS). The importance of geographic information systems (GIS) in introducing middle school children to technology and inspiring them to major in STEM fields began to grow in the early 1990s. Since several additional studies have demonstrated that GIS may assist in the creation of inquiry-based learning environments, interest in the area has grown at the secondary level, despite the fact that GIS is more of a teaching tool than a technology. Due to these educational advantages, several secondary school programs in the US, Canada, and Africa use GIS within their science, chemistry, biology, mathematics, environmental science, social science, and geography curricula. The geographic information system (GIS) is a suite of applications that work together to collect, organise, query, analyse, and display geographical data. With its flexible analysis capabilities, geographic information systems (GIS) provide several benefits, particularly in the realm of geography

education and other related subjects. Using GIS, pupils have been able to hone their spatial reasoning abilities.

According to Prensky (2020), there are three main reasons a geography teacher uses GIS:

- GIS supports geography teaching and learning.
- GIS is a tool for studying geographic problems at various scales.
- GIS is the tool needed for 21st-century business.

There is a lot of evidence in the literature on the possible benefits of GIS for both students and instructors, but implementing it in secondary schools is still difficult. Several studies have looked at this and offered advice on how to get the most out of geographic information systems. Moreover, several studies have shown that students' understanding could suffer if the wrong approach is used. There are three main problems with using GIS in secondary schools, says Lloyd (2021). (1) technological considerations, including data, software, and hardware availability; (2) insufficient professional development opportunities for educators; and (3) structural challenges that either support or impede educational innovation. Lack of time for instructors to learn GIS and incorporate it into lesson plans is one of several other obstacles highlighted in previous research. In discovery-based learning, the instructor takes on more of a facilitative role, allowing students to learn by doing, with the goal of constructing their own knowledge (Mohammed, 2012). Similarly, Abubakar and Dodboo (2011) outlined how it helped students comprehend problem-solving through hands-on experimentation. Compared to the explanatory one, it demonstrated better performance among students. Rather of being spoon-fed information, students are given the chance to independently uncover scientific facts, concepts, and principles. It encourages students to actively participate in the scientific process, which leads to their own discoveries and knowledge. In a discovery-based learning technique, students are encouraged to independently observe, think, ask questions, and uncover the content. Facilitator and informant is the best way to describe a teacher's job. When a person uses their brain to uncover some of the ideas and notions, that's when discovery happens. Observation, categorisation, measurement, prediction, determination, and inference are the processes that lead to discovery. According to Mendikbud

(2013), this is known as the cognitive process, while the discovery process is the mental assimilation of ideas and principles.

Statement of the Problem

The current biggest problem in Nigeria is the students' attitude towards the study of Geography in senior secondary school. According to the 2022 and 2023 national Geography results reported by the Chief Examiners of the West African Examination Council (WAEC), students' performance in 2023 was somewhat worse, with a raw mean score of 31.0 and a standard deviation of 11.92. We compared this to the WASSCE 2022 raw mean score of 31 with a standard deviation of 10.91. Additionally, research has shown that students from various regions of the nation do poorly in Geography classes (Nwagbo, 2022). Poor applicants' performance in Geography and other courses in the WAEC and UTME has resulted in higher education institutions in Nigeria failing to maintain the 60%:40% provision for Science/Technology and Arts/Humanities admission ratio. In order to achieve the nation's educational goals and raise student achievement on standardised tests, we must keep looking for new and improved methods of teaching geography. Table 1.1 of the WAEC results shows that most Port Harcourt schools have been performing poorly in Geography.

Table 1.0: WAEC Results of selected schools in Port Harcourt L.G.A from 2019-2023

Grades	2019	2020	2021	2022	2023
A1	-	-	-	-	07
	-	-	-	-	-
B3	-	-	-	-	11
C4	21	-	-	1	2
C5	11	-	6	-	-
C6	50	25	76	7	4
D7	53	57	49	23	56
E8	32	136	46	42	33
F9	170	58	23	110	75
Pending	-	9	10	-	
Withheld	-	2	-	-	-
Total	337	287	212	183	188
% Pass	24%	8.7%	38%	14%	
				16.7%	

Source: WAEC Results of selected schools in Port Harcourt LGA from 2019-2023.

Table 1.0's pass rate (score above D7) has been dismal for the majority of years. Getting into college, particularly to study geology and related fields, is difficult for students with consistently poor Geography scores. The result has been a shortage of workers and a slowdown in the economy. Therefore, it is critical that Geography discover a remedy to this problem immediately. In light of this, the research looked at how utilising a GIS and a Discovery Based Learning Strategy may help geography students in Rivers State perform better and remember more of what they learnt.

Aim and Objectives of the Study

The aim of this study is to investigate Geographic Information System Software and Discovery Based Learning Strategy for enhancement of Geography students' performance and retention in Rivers State. Specifically, the objectives of the study are to:

1. Find out the mean difference in performance scores of students taught Geography using Geographic Information System Software, Discovery Based Learning Strategy and lecture method

2. Investigate the mean difference in retention scores of students taught Geography using Geographic Information System Software, Discovery Based Learning Strategy and lecture method

3 Compare the mean differences in performance scores of male and female students taught Geography using Geographic Information System Software, Discovery Based Learning Strategy and lecture method

Research Questions

The following research questions guided the study

1. What is the mean difference in performance scores of students taught Geography using Geographic Information System Software, Discovery Based Learning Strategy and lecture method?

2. What is the mean difference in retention scores of students taught Geography using Geographic Information System Software, Discovery Based Learning Strategy and lecture method?

3 What is the mean difference in performance scores of male and female students taught Geography using Geographic Information System Software, Discovery Based Learning Strategy and lecture method?

Hypotheses

The following hypotheses were formulated and tested at 0.05 significance level

Ho_1 There is no significant difference between the mean performance scores of students taught Geography using Geographic Information System Software, Discovery Based Learning Strategy and lecture method

Ho_2 There is no significant difference between the mean retention scores of students taught Geography using Geographic Information System Software, Discovery Based Learning Strategy and lecture method

Ho_3 There is no significant difference between the mean performance scores of male and female of students taught Geography using Geographic Information System Software, Discovery Based Learning Strategy and lecture method

Methodology

The study used a quasi-experimental design due to the fact that participants were not randomly allocated to treatment and the independent variable was modified before the dependent variable was evaluated. This study's methodology allowed the researcher to examine the impact of a Geographic Information System (GIS) and a Discovery Based Learning Strategy (DBLS) on the performance and retention of geography students in Port Harcourt Local Government Area, Rivers State. The device was created for the purpose of gathering information. The Geography Performance Test (GPT) was an evaluation of students' knowledge and skills in the subject of geography. There were twenty-five multiple-choice questions about maps and plants on the Geography Performance Test (GPT). Based on the course goals, the researcher designed the GPT

questions.

Two geography instructors, the researcher's supervisor, and specialists from the University of Port Harcourt's Department of Curriculum Studies and Educational Technology checked the GPT for content and face validity. The instrument's dependability was confirmed through the use of the test-retest approach. What this means is that the students who were not part of the research took the GPT first, and then, after two weeks of receiving no therapy, they were given the same test again. We used Pearson's Product Moment Correlation Coefficient statistic to examine the differences in each person's scores between the first and second administrations. The Geography Performance Test achieved a reliability level of 0.64. Mean and standard deviation were used to analyse the data acquired for this study in order to answer the research objectives. Analysis of Covariance (ANCOVA) was used to test and analyse the hypotheses at the 0.05 level of significance.

Results

Research Question One: What is the mean difference in performance scores of students taught Geography using Geographic Information System Software, Discovery Based Learning Strategy and lecture method?

Table 2.0: Mean and Standard Deviation on the difference in performance scores of students taught Geography using Geographic Information System Software Discovery Based Learning Strategy and lecture method

Strategies	N	Pre-test	SD	Post-test	SD	Mean Gain
GISS	57	40.70	3.49	73.06	6.57	32.36
DBLS	44	42.60	3.50	65.40	5.44	22.80
LM	51	43.06	4.52	49.20	5.60	6.14

Table 2.0 shows that there was a mean increase of 32.36 points for students whose geography classes used Geographic Information System Software (GISS). Before the class, students' average score was 40.70, and after the class, their average score was 73.06. With a mean score of 42.60 before and a mean score of 43.06 after instruction utilising the Discovery-Based Learning Strategy

and lecture (LM), respectively, the students' performance improved to 65.40 and 49.20. Students taught using the Discovery Based Learning Strategy outperformed those taught using the lecture technique when looking at the mean increase between the pre-test and post-test mean scores. GISS had the greatest mean value. From what we can see, the impact of GISS and DBLS on students' performance in Geography is far greater than that of lecture-based lessons.

Research Question Two: What is the mean difference in performance scores of male and female students taught Geography using Geographic Information System Software and Discovery Based Learning Strategy?

Table 3.0: Mean and standard deviation analysis on the mean performance scores of Geography male and female students taught with Geographic Information System Software (GISS) and DBLS

Group	Gender	N	Pre-test	SD	Post-test SD	Mean Gain
GISS	Male	33	38.16	3.03	74.96 6.01	36.80
	Female	24	44.16	3.88	70.53 7.33	26.37
DBLS	Male	23	36.I3	3.67	71.30 5.50	35.17
	Female	21	43.15	3.74	72.20 6.20	29.05

Table 3.0 shows that male students who were taught using the GISS and the DBLS had mean scores of 38.16 and 36.13 before and after the test, with 74.96 and 71.30 points, respectively, and a mean increase of 36.80 and 35.17 points. On average, female students gained 36.80 and 35.17 points when taught using the same method. The mean score before the exam was 44.16, and after the test it was 43.15, 70.53, and 72.20, for a mean score of 26.37. Examining the mean gain values showed that the impact on male students' academic performance was more than that on female

students' performance when using Geographic Information System software and a discovery-based learning technique.

Research Question Three: What is the mean difference in retention scores of students taught Geography using Geographic Information System Software, Discovery Based Learning Strategy and lecture method?

Table 4.0: Mean and standard deviation on mean retention scores of students taught Geography using Geographic Information System Software, Discovery Based Learning Strategy and lecture method

Strategies	N	Post-test	SD	Post-post	SD	Mean Gain
GISS	57	70.50	3.49	83.06	6.573	12.56
DBLS	44	65.04	4.52	69.20	7.60	5.14
LM	51	63.06	4.52	68.20	5.60	7.14

Students taught Geography using GISS had an average post-test score of 70.50 and an average retention score of 83.06, as shown in Table 4.0. The average post-test score for students in the control group who received instruction via lectures was 63.06, and their average retention score was 68.20. The results showed that compared to the control group, the experimental group's pupils made an average gain of 12.56. Based on these findings, it seems that using GISS and DBLS is more effective than using the lecture technique to improve students' performance in Geography.

Hypotheses

Ho_1: There is no significant difference between the mean performance scores of students taught Geography using Geographic Information System Software, Discovery based learning strategy and lecture method

Table 5.0 Analysis of covariance (ANCOVA) of performance of Geography students taught using GISS, DBLS, and LM

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1502.556[a]	2	751.278	20.382	.000
Intercept	2212.391	1	2212.391	60.023	.000
PreP	120.684	1	120.684	3.274	.073
Group	1444.244	1	1444.244	39.183	.000
Error	3870.212	149	36.859		
Total	42521.000	152			
Corrected Total	5372.769	151			

According to Table 5.0, the p-value of 39.183, which was obtained with 1 and 105 degrees of freedom, is less than the selected alpha of 0.05, and the F-value is 39.183 as well. Hence, the null hypothesis was declared incorrect. Students' average test results in Geography classes that used either the lecture technique, a discovery-based learning strategy, or geographic information system software were significantly lower than those classes that used the other two approaches.

Ho_2 There is no significant difference between the mean performance scores of male and female of students taught Geography using Geographic Information System Software and Discovery based learning strategy

Table 6.0 Analysis of covariance (ANCOVA) of performance scores of male and female students taught using Geographic Information System Software and lecture method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	99.649[a]	2	24.912	.518	.723
Intercept	2493.335	1	2493.335	51.861	.000
PretestP	38.718	1	38.718	.805	.372
Group	22.323	1	22.323	.464	.497
Gender	4.685	1	4.685	.097	.756
Group * Gender	39.220	1	39.220	.816	.368
Error	5144.270	93	48.077		
Total	57145.000	101			
Corrected Total	5243.920	100			

A group-based F-value of 0.464 at 1 and 107 degrees of freedom and a matching p-value of 0.497 are presented in Table 6.0. The gender-based one was 0.097 with 1–107 degrees of freedom and a p–value of 0.756 at the 0.05 chosen alpha level. What this means is that there was no statistically significant difference between the sexes when it came to the use of GISS in teaching geography. In addition, there was no statistically significant difference between the gender and learning approach interaction effects (F=0.816, p=0.368), which was higher than the 0.05 selected significance threshold.

H_{O3} There is no significant difference between the mean retention scores of students taught Geography using Geographic Information System Software and lecture method

Table 7.0 Analysis of covariance (ANCOVA) of the mean retention scores of students taught Geography using Geographic Information System Software and Discovery based learning strategy and Lecture Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1988.353[a]	2	994.176	35.711	.000
Intercept	3197.888	1	3197.888	114.88	.000
PostP	84.256	1	84.256	3.026	.085
Group	1085.890	1	1085.890	39.005	.000
Error	2923.166	149	27.840		
Total	48996.000	152			
Corrected Total	4911.519	151			

When the post-test mean score of students in both the GISS and LM groups were accounted for, the ANCOVA analysis produced an F-value of 39.005 at 1 and 105 degrees of freedom, as shown in Table 7.0. Similarly, a p-value of 0.000 was found. We may say that we rejected the null hypothesis since the p-value was smaller than the predetermined alpha level of 0.05. Students' ability to retain information about geography is significantly impacted by the use of geographic information system software and discovery-based learning strategies.

Discussion of Findings

The mean difference in performance scores of students taught Geography with Geographic Information System Software Discovery based learning strategy and lecture method (LM)

First, we wanted to know how much of a difference there was in the average test results of geography students who were taught using either the LM approach or the Geographic Information System (GIS). Table 2.0 shows that compared to students taught via the lecture approach, those

exposed to Geographic Information System software had much higher academic achievement. According to Table 5.0, the p-value of 39.183, which was obtained with 1 and 105 degrees of freedom, is less than the selected alpha of 0.05, and the F-value is 39.183 as well. Hence, the null hypothesis was declared incorrect. Students' average performance in geography classes that used GIS software differed significantly from those that used the traditional lecture style. This confirms the findings of Akinyemi (2020), who argues that using GIS software for education promotes students' curiosity, investigation, and evaluation of geographical concepts, ideas, and data. This goes above and beyond what students learn in a traditional classroom setting. In addition to encouraging pupils to study, it helps them develop the ability to think critically about what they've learnt. Teachers in Geographic Information System Software should use their imaginations to pique their students' interests and introduce them to new concepts.

The mean difference in performance scores of Geography of male and female students taught with Geographic Information System Software and Discovery based learning strategy

The results of both male and female students' work in geography classes that employed GIS software were the subject of the second research question. The results demonstrated that compared to female students, male students were more positively impacted by Geographic Information System Software in terms of their academic achievement. With 1 degree of freedom and 107 total degrees of freedom, the group-based F-value was 0.464 and the associated p-value was 0.497, as shown in table 6.0. The gender-based one was 0.097 with 1–107 degrees of freedom and a p–value of 0.756 at the 0.05 chosen alpha level. What this means is that there was no statistically significant difference between the sexes when it came to the use of GISS in teaching geography. In addition, there was no statistically significant difference between the gender and learning approach interaction effects (F=0.816, p=0.368), which was higher than the 0.05 selected significance threshold. The results are in line with those of Brooks, Bee, and Rogers (2019), who found no evidence of an interaction impact between gender and instructional approaches on student accomplishment. However, Artvinili's (2019) research proved that gender has no role in determining how well male and female Geography students do in school. Also, according to Angela Rikard (2022), when it comes to teaching geography using GIS software, there isn't a

discernible gender gap. Thus, researchers continue to disagree on how gender affects success dependent on instructional style.

The mean difference in retention scores of students taught Geography using Geographic Information System Software (GISS) Discovery based learning strategy and Lecture Method (LM)

Thirdly, we wanted to see how much of a difference there was in the average retention scores of geography students taught either using the LM or GIScience methods. The results showed that compared to pupils taught via the lecture technique, those exposed to GISS remembered far more information. According to these findings, GISS is more effective than the lecture technique in helping students retain information about geography. With 105 degrees of freedom and a p-value of.000, the ANCOVA analysis produced an F-value of 39.005 when controlling for the post-test mean score of students in both the GISS and LM groups (Table 7.0). The null hypothesis was rejected because the calculated p-value was lower than the predetermined alpha level of 0.05. This shown that GIS software significantly affects students' ability to retain information from geography classes. Gbenga and Effiong (2015) found that students exposed to Geographic Information System software had a better retention mean score than those exposed to the lecture technique. This conclusion is in line with their findings. The GISS approach outshines the lecture method. According to Joolingen (2019), GISS students build their own knowledge by conducting experiments in a domain and drawing rules from the outcomes. Learners essentially build their knowledge via designing their own experiments in the domain and inferring the laws of the domain themselves, according to the core premise of this sort of technique.
Last thoughts. The chronically poor results of Nigerian students in the subject of geography on the national senior secondary certificate test inspired this research. The inability to meet the objectives of senior secondary school education and geography education, on the one hand, and human and economic underdevelopment, on the other, are demonstrated by this. Students' academic achievement in Geography might have used some fresh, student-focused approaches to instruction.

Recommendations

Based on the study's findings, the following suggestions were made.

1. To improve academic achievement in senior secondary schools, teachers should employ Geographic Information System software and a discovery-based learning technique to teach Geography.
2. To improve students' retention in Geography, teachers should employ Geographic Information System software and a discovery-based learning technique in senior high schools.
3. Teacher training institutions should teach pre-service teachers about Geographic Information System software and discovery-based learning strategies.
4. Federal and state education ministries should provide workshops to help instructors grasp 21st century teaching practices.

References

Ackerman, & Lawrence, E. K. (2021). *Research methods, statistics, and applications*. Sage Publications.

Adedeji (2018). *The use of ICT in geographical teaching and learning at secondary and high school in Albania*. Retrieved from: www.academia.edu/.../THE_USE_OF_ICT_IN_GEOGRAPHICAL_TEACHING

Akinyemi, F. O. (2014). Perspectives on developing critical human gis capacity in a developing country context. *In Cartography from Pole to Pole* (pp. 451-460). Springer, Berlin, Heidelberg.

Akinyemi, F. O. (2020). An assessment of GIS use for teaching in Rwandan secondary schools. *The Geography Teacher*, 12(1), 27-40.

Akinyemi, F. O. (2016). Technology use in Rwandan secondary schools: an assessment of teachers attitudes towards geographic information systems (GIS). *International Research in Geographical and Environmental Education*, 25(1), 20-35.

Al-Kamali, A.A. (2019). An investigation of Northwest Arkans as High School Students 'attitudes towards using GIS in learning social studies, University of Arkansas. Pro Quest Digital Dissertations Document IDNo.1320949391.Baker, T. R. &White, S. H. (2003). The effects of G.I.S. on students attitudes, self-efficacy, and achievement in middle school science classrooms. *Journal of Geography*, 102(6),

Angela Rikard. (2022). Preparing pre-service teachers to incorporate geospatial technologies in geography teaching. *Journal of Geography*, 116, 226–236.

Artvinili (2019). Directed qualitative content analysis: The description and elaboration of its underpinning methods and data analysis process. *Journal of Research in Nursing*, 23(1), 42-55.

Hammend, (2020). *Learning ecology. A new approach in transformating ecological consciousness. In Learning toward an ecological consciousness: Selected transformative practices* (pp. 44-67). Palgrave Macmillan.

Hasan. (2020). *Understanding research. An introduction to reading research*. Van Schaik Publishers.

Healy, Walshe, & Lloyd, C. D. (2020). *Principles of geographical information systems*. Oxford university press.

Jenner (2019). Internet-Based GIS Mapping in Support of K-12 Education. *The Professional Geographer*, 57(1), 44-50.

Jenner, P. (2006). Engaging students through the use of GIS at Pimlico State High School. *International Research in Geographical and Environmental Education*, 15(3), 278-282.

Kerski, J. (2020). *The implementation and effectiveness of GIS, Technology and methods in secondary education*. Unpublished doctoral dissertation, University of Colorado, USA.

Lloyd, W. J. (2021): Integrating GIS into the undergraduate learning environment. *J. Geography* 100 158-163.

Lloyd, & Yidana, I. (2018). Teachers' ICT usage in second-cycle institutions in Ghana: A qualitative study. *International Journal of Education and Development using ICT*, 11(2).

Phoenix, M. (2000). *Learning with GIS, Arcuser Online, Haziran-Eylül 2000*, s. 6-24, http://www.esri.com/news/arcuser/0700/umbrella11.html.

Prensky, M. (2020). *Digital natives, digital immigrants. On the Horizon, MCB University*, 9(5), 1-6.

Shin, E. K. (2020). Using geographic information system (GIS) to improve fourth graders' geographic content knowledge and map skills. *Journal of Geography*, 105(3), 109–120.