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ENHANCING MAP READING AND INTERPRETATION SKILLS IN GEOGRAPHY EDUCATION THROUGH DIGITAL TECHNOLOGIES: A CASE OF KISARAWE DISTRICT IN TANZANIA SECONDARY SCHOOLS

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Abstract.
Background. The integration of digital technologies into education has significantly transformed learning worldwide, including the teaching and learning of geography. Traditional methods of map reading and interpretation have evolved with advancements in digital maps and geospatial tools, enabling interactive spatial analyses and enhancing spatial thinking and geographic literacy. The study asses the role of digital technologies on improving map reading skills among Form Three students in Kisarawe District, Tanzania.
Method. A quasi-experimental design was used, comparing digital and traditional teaching methods. The experimental group utilized Google Maps and Google Earth, while the control group relied on printed maps and textbooks. Data collection involved pre-test and post-test scores, observations, and questionnaires over six (month), with 147 students selected through stratified sampling.
Results. Findings revealed low pre-test performance, with a high failure rate among male and female students. However, self-made achievement test results showed significant improvement after digital interventions, with failure rates dropping sharply and more students scoring A, B, or C. These findings confirm the effectiveness of digital tools in enhancing geography learning.
Conclusion. The study concludes that digital technologies enhance students' map reading skills and recommends integrating them into the curriculum, aligning with SDG 4 to improve geography education, especially in resource-limited settings.
Keywords: Digital technologies, Map reading; Geography education; Secondary school students; Tanzania; Education for Sustainable Development Goals (SDGs)

Introduction

The integration of digital technologies into education has significantly transformed learning worldwide, including the teaching and learning of geography. Traditional methods of map reading and interpretation have evolved with advancements in digital maps and geospatial tools, enabling interactive spatial analyses and enhancing spatial thinking and geographic literacy (Goodchild & Janelle, 2022; Core, 2023; Demirci et al., 2020). Digital technologies such as Geographic Information Systems (GIS), Google Maps, and Google Earth

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facilitate interactive learning experiences that promote deeper engagement and understanding among students (Bednarz & Lee, 2020).

The United Nations (UN) has emphasized the importance of digital technology in education through its Sustainable Development Goals (SDGs), particularly Goal 4 (quality education) and Goal 9 (industry, innovation, and infrastructure), which advocate for digital literacy as a means of promoting sustainable development (United Nations, 2023). UNESCO and other UN agencies support the integration of digital technologies into education to improve learning outcomes and prepare students for modern economies. Initiatives such as UNESCO's *Education 2030 Framework for Action* and the International Telecommunication Union (ITU)-led partnerships aim to bridge the digital divide by improving infrastructure, providing technical support, and training educators, particularly in under-resourced areas (UNESCO, 2023).

In developed countries, remote sensing, and digital mapping tools have become integral to geography curricula, fostering students' spatial and analytical skills (Demirci, Karaburun, & Ünlü, 2020). However, African nations face challenges in integrating these digital tools due to limited resources and inadequate infrastructure. Despite these constraints, research from South Africa and Kenya has demonstrated the positive impact of mobile devices and digital maps on geography education (Chigona, 2021; Kafyulilo et., 2015).

Tanzania has introduced digital technology into its curriculum, yet limited access to technology and insufficient teacher training have hindered effective implementation (Mkwizu & Ndalichako, 2019). Nonetheless, digital tools have shown potential in improving students' spatial reasoning, engagement, and motivation in geography, particularly in map reading and interpretation (Mtebe & Raisamo, 2015). These technologies also offer an opportunity to counter the declining interest in geography by making the subject more relevant to contemporary careers (Nyika, 2019). This study asses how digital technologies can enhance map reading skills among Form Three secondary school students in the Kisarawe District, Tanzania, offering insights for curriculum development and policy interventions to revitalize geography education.

Students' map reading and interpretation skills in geography have been consistently evaluated by the National Examinations Council of Tanzania (NECTA) through Candidate Item Response Analysis (CIRA) reports. These reports from 2018 to 2022 reveal persistent challenges in students' ability to analyze topographic maps, interpret symbols, and apply mathematical calculations. For example, the NECTA (2022) report showed that 59.07% of candidates scored between 0–3 marks in Question 3, demonstrating weak skills in drainage analysis, vegetation distribution, and economic activity identification. Similarly, in 2021, 34.7% of students scored very low, while only 20.41% achieved high marks. The 2020 results were even more concerning, with 96.4% of students failing Question 3 on Sikonge sheet number 137/2. A similar trend was observed in 2019 and 2018, where over 85% of students failed to demonstrate sufficient map reading skills. Despite some improvements in national geography pass rates from 51.24% in 2017 to 66.10% in 2022, a significant percentage of students still struggle with this topic. Kisarawe District has recorded notably poor performance, with most schools ranking low at both regional and national levels. In 2022, no school in the district achieved high grades in geography, with less than 50% of students passing. This consistent underperformance highlights the urgent need for improved teaching strategies, better resource allocation, and integration of digital tools to enhance map reading and interpretation skills.

Literature Review

Map reading and interpretation remain critical skills in geography subject, yet student performance in these

areas has been consistently low, as highlighted by multiple Candidate's Item Response Analysis (CIRA) reports from the National Examinations Council of Tanzania (NECTA). These reports provide insights into students' challenges in understanding and applying map-related concepts over recent years.

NECTA (2022) analyzed students' performance in question three of the Certificate of Secondary Education Examination (CSEE), which assessed various aspects of map reading and interpretation using Ilonga sheet number 225/2. Out of 520,841 candidates who attempted the question, 59.07% scored between 0-3 marks, indicating limited knowledge and skills in map reading. Only 40.93% of students performed at an average level or above (scoring 3.5-11 marks). The analysis attributed poor performance to students' insufficient familiarity with map-related concepts such as economic activity identification, vegetation distribution, drainage patterns, and area calculations.

Similarly, NECTA (2021) reported students' performance in a similar map reading question based on Mbeya sheet number 244/4. In this case, 34.7% of the 486,361 candidates scored between 0-3 marks, while 65.3% managed an average or above score (3.5-11 marks). The report indicated that students who performed poorly struggled with calculating the area using the square method and interpreting transport networks. However, compared to 2022, this year recorded relatively better performance, suggesting minor improvements in students' understanding of map interpretation.

The 2020 CIRA report revealed a significant decline in performance, with 96.4% of the 386,765 candidates scoring between 0-3 marks on map reading and interpretation using Sikonge sheet number 137/2. The questions required students to calculate distances, determine the highest elevation points, and analyze relief features. Only 3.5% of candidates scored 3.5-7 marks, while 0.1% achieved between 7.5-11 marks. The report noted that students' inability to apply mathematical concepts to map calculations and their lack of familiarity with grid references contributed to the poor performance.

NECTA (2019) further supported this trend, showing that 86.9% of 359,450 candidates scored below 5.5 marks when tested on Ilonga sheet number 265/2. Only 13.1% scored above 5 marks out of 18, indicating widespread difficulties in map reading, particularly in determining areas, settlement patterns, and economic activities from the map. These findings suggested that students were either not adequately exposed to practical map reading exercises or struggled with the technical aspects of cartographic interpretation.

The review of NECTA's annual reports indicates a persistent challenge in students' ability to read and interpret maps in geography examinations. Although there have been minor fluctuations in performance, the overall trend suggests that a significant proportion of students struggle with fundamental mapping concepts, including distance measurement, elevation analysis, area calculation, and economic activity identification. This consistent underperformance raises concerns about the effectiveness of teaching strategies and the availability of instructional resources for map reading.

While NECTA reports highlight the performance trends, they do not extensively explore the underlying causes of poor student performance. The reports suggest insufficient knowledge and practice, but they lack empirical analysis of factors such as teacher preparedness, availability of digital resources, and students' engagement with modern technology in learning map skills. This gap underscores the necessity of research focusing on how digital tools can address the deficiencies observed in students' performance. Studies examining the role of digital mapping technologies in enhancing spatial literacy and problem-solving skills provide promising

insights, but their applicability in resource-limited settings like Tanzania remains underexplored. Therefore, this study seeks to bridge the gap by evaluating the influence of digital technologies on improving map reading and interpretation skills among secondary school students in Tanzania.

Methodology

Research Design. A non-equivalent comparison group pre-test and post-test quasi-experimental design was used to compare groups exposed to digital tools (experimental) with those exposed to traditional methods (control). This design was chosen because of the impracticality of random assignment and allowed meaningful comparisons despite limitations, such as potential bias and external influences. (Beyhatin and Ozdemir, 2022; Tekin, 2016). The intervention lasted for six (month) with each group receiving three (3) months of instruction. Google Maps and Google Earth were used as the experimental groups. Self-made achievement tests served as assessment tools with scores as the dependent variable. The study targeted Form Three students, as map reading and interpretation are part of their syllabi (TIE, 2019). A total of 147 students were selected through stratified sampling

Research Tools. The tools employed were computers, projectors, internet access, lesson plans, course outline, self-made achievement tests, lesson notes, marked class attendance, class timetable, students' pre-test results, class journals, log book and paper map (traditional class method) and Geography syllabus.

Data collection procedure. This study investigates the use of digital technology in map reading and interpretation within the Geography subject in Tanzanian secondary schools. To achieve this, a non-equivalent quasi-experimental design with a pretest-posttest approach was employed over a period of six (6) months, involving two schools with distinct instructional methods.

In School A, students were taught map reading and interpretation using the traditional method. Lessons were delivered over a period of, relying on printed maps, textbooks, and teacher-led explanations. During this period, data collection focused on three key tools: pre-test and post-test scores to measure learning outcomes, observation checklists to track student engagement, and weekly questionnaires to capture students' perceptions and learning experiences.

In contrast, School B employed a digital technology method for the same duration of three (3) months. Here, students utilized tools such as Google Maps, Google Earth, and other interactive digital platforms to learn the same content. Data collection methods mirrored those of School A, with an emphasis on understanding how digital tools influenced students' skills, engagement, and collaborative learning during map interpretation exercises.

For both schools, a pre-test was administered prior to the intervention to establish baseline skills in map reading and interpretation, while a post-test was conducted afterward to measure improvements. Data analysis focused on comparing the learning outcomes and levels of student engagement between the two groups. This approach aimed to determine the effectiveness of digital technology in enhancing Geography education and fostering improved map interpretation skills.

Results

Table 1

The performance grade of stream B both pre-test and self-made achievement test

Pretest	A	B	C	D	F	Total
Male	1	00	2	6	8	17

%	5.88	00	11.76	35.29	47.05	100
Female	00	00	06	08	03	17
%	00	00	35.29	47.64	17.64	100
Total	1 (2.94%)	00 (00%)	8 (23.52%)	14(41.17%)	11(32.35%)	34 (100)
Self-made Achievement test	A	B	C	D	F	Total
Male	02	04	15	00	01	22
%	9.09	18.18	68.18	00	4.45	100
Female	03	01	07	03	05	19
%	15.78	5.26	36.84	15.78	26.31	100
Total	**5(12.19%)**	**5(12.19%)**	**22(53.65%)**	**03(7.31%)**	**6(14.63%)**	**41(100%)**

Data obtained from Research Field (2024)

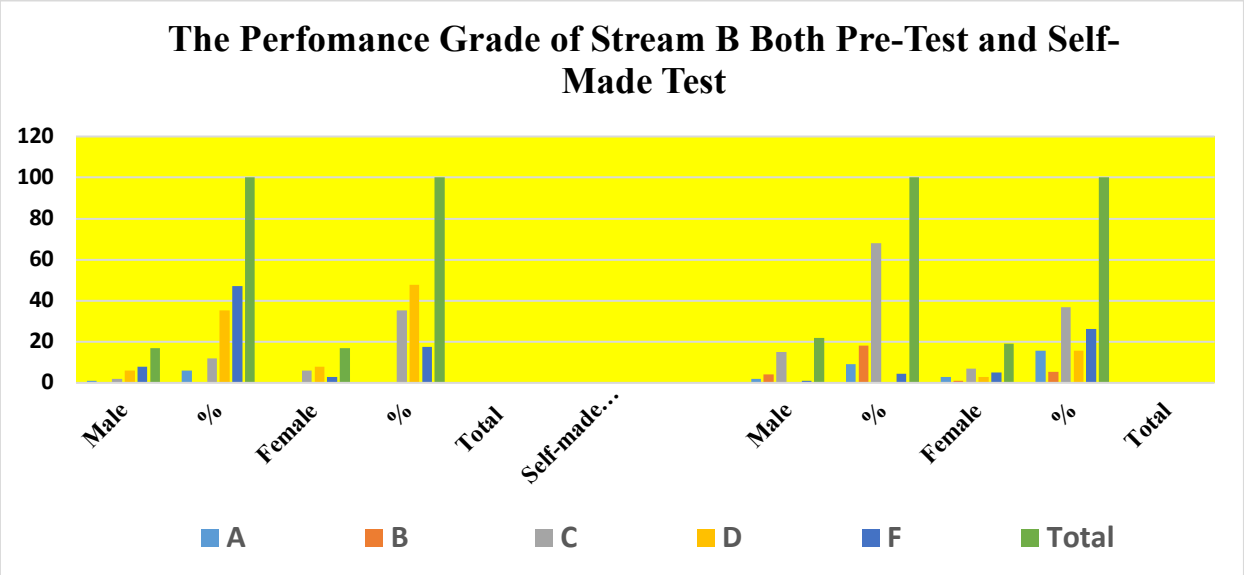

Figure 1 *The performance grade of stream B both pre-test and self-made achievement test*

Table 2

The performance grade of stream A both pre-test and self-made achievement test

Pretest	A	B	C	D	F	Total
Male	00	01	04	05	07	17
%	00	5.88	32.52	29.41	41.17	100
Female	01	01	00	12	04	18
%	5.26	5.26	00	63.15	12.05	100
Total	**01 (2.85%)**	**02 (5.71%)**	**04(11.42%)**	**17(48.57%)**	**11 (31.42)**	**35 (100%)**

Self-made Achievement test	A	B	C	D	F	Total
Male	00	01	09	07	04	21
%	00	4.76	42.85	33.33	19.04	100
Female	00	00	09	08	05	22
%	00	00	40.90	36.36	22.72	100
Total	**00 (00)**	**01 (2.32)**	**18(41.86%)**	**15(34.88%)**	**09(20.9)**	**43 (100%)**

Data obtained from Research Field (2024)

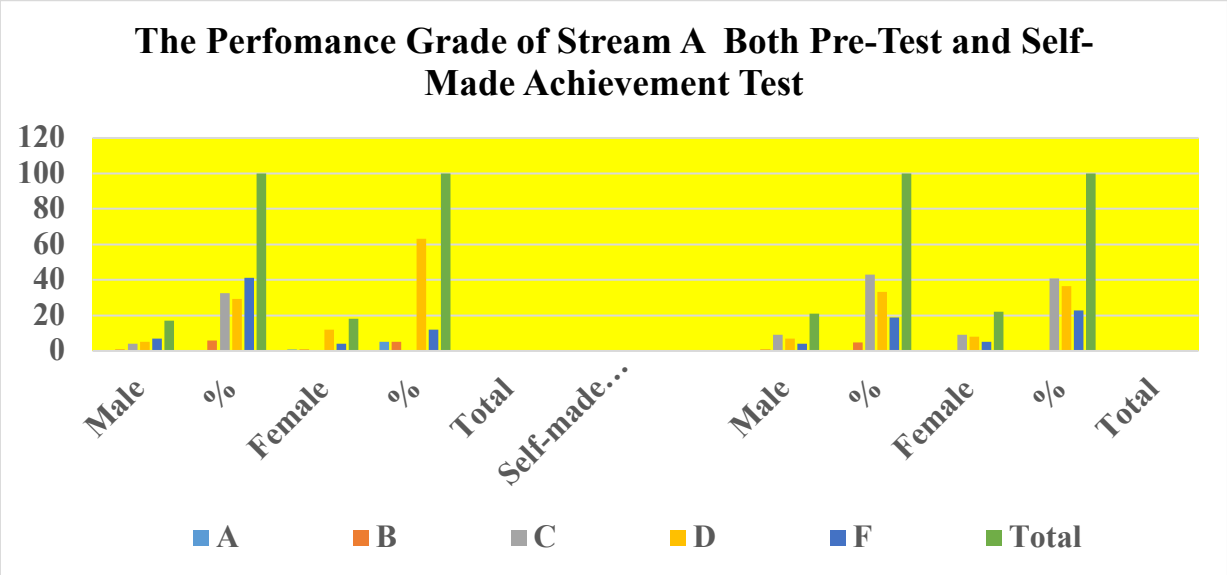

Figure 2 *The performance grade of stream A both pre-test and self-made achievement test*

Figure 3: *Students writing pre-test in school A- controlled group*

Source: Research Field (2024)

Table 3

The performance grade of yellow class both pre-test and self-made achievement test

Pretest	**A**	**B**	**C**	**D**	**F**	**Total**
Male	00	00	00	03	14	17
%	00	00	00	17.64	82.35	100
Female	00	00	04	09	08	21
%	00	00	19.04	42.85	38.09	100
Total	**00**	**00**	**04(10.52%)**	**12(31.57%)**	**22(57.89%)**	**38(100 %)**
SMAT	A	B	C	D	F	Total
Male	14	05	03	00	00	22
%	63.63	22.72	13.63	00	00	(100%)
Female	05	08	05	00	00	18
%	27.77	40.44	27.77	00	00	(100%)
Total	**19 (47.5%)**	**13 (32.5%)**	**08 (20%)**	**00 (00%)**	**00 (00%)**	**40 (100)**

Data obtained from Research Field (2024)

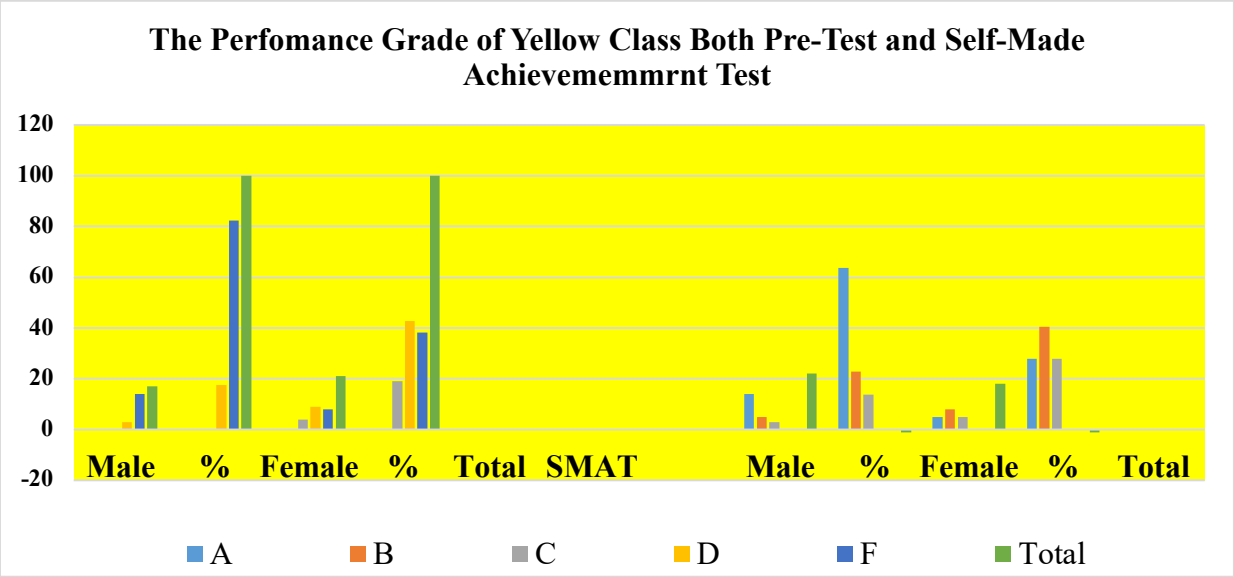

Figure 4: *The performance grade of yellow class both pre-test and self-made achievement Test*

Source: Research Field (2024)

Table 4

Performance grade of green class in both pre-test and self-made achievement tests.

Pretest	**A**	**B**	**C**	**D**	**F**	**Total**
Male	00	00	00	03	14	17
%	00	00	00	17.64	82.35	100

Female	00	00	04	09	08	21
%	00	00	19.04	42.85	38.09	100
Total	**00**	**00**	**04(10.52%)**	**12(31.57%)**	**22(57.89%)**	**38(100%)**
Self-made Achievement test	A	B	C	D	F	Total
Male	14	05	03	00	00	22
%	63.63	22.72	13.63	00	00	(100%)
Female	05	08	05	00	00	18
%	27.77	40.44	27.77	00	00	(100%)
Total	**19 (47.5%)**	**13 (32.5%)**	**08 (20%)**	**00 (00%)**	**00 (00%)**	**40 (100)**

Data obtained from Research Field (2024)

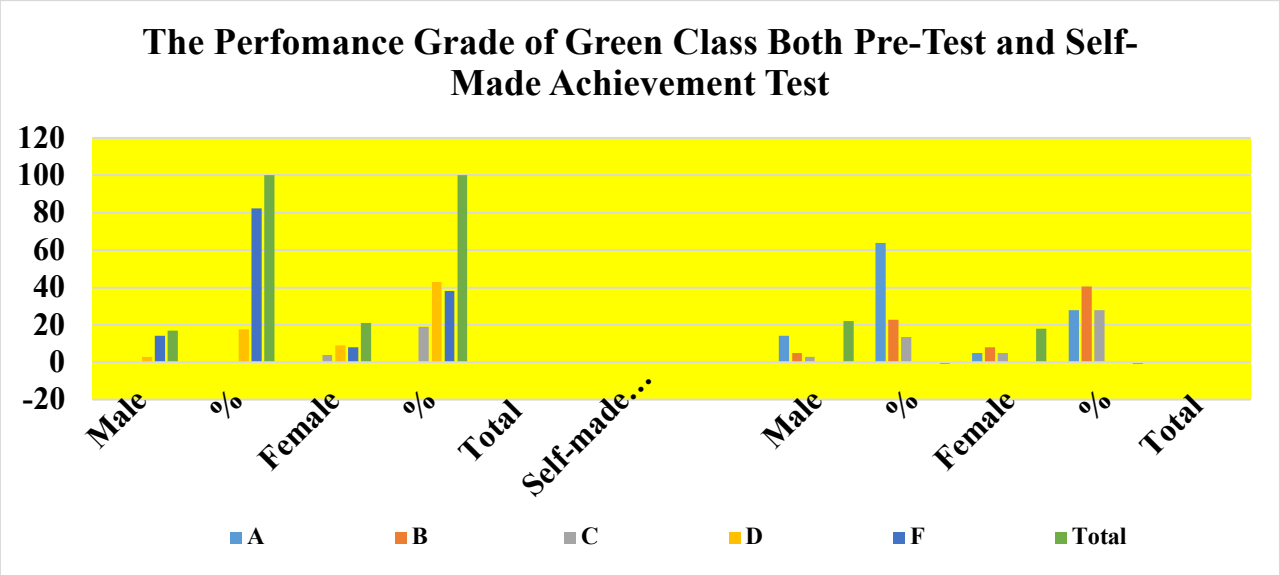

Figure 5 *Performance grade of green class both pre-test and self-made achievement test*
Source: Research Field (2024)

Discussion

Table 1 and Figure 1 analysis of pre-test and self-made achievement test results revealed significant improvement in students' performance, indicating the effectiveness of traditional teaching methods. In the pre-test, male students had low scores: 5.88% earned Grade A, 11.76% Grade C, and 47.05% failed. Female students performed similarly, with no A or B grades, 35.29% achieving Grade C, and 17.64% failing. Overall, 67.64% of Stream A students scored A, B, C, or D, while 32.35% failed. In the achievement test, male students showed major improvement, with 95.45% scoring A, B, C, or D, and only 4.55% failing. Female students also improved, with 82.35% achieving these grades. Female Grade A increased from 0% to 15.78%, and Grade B from 0% to 5.26%. Overall, Grade F dropped from 32.35% to 14.63%. These results confirm that traditional teaching methods significantly improved students' map reading and interpretation skills.

The findings aligned with the NECTA results by highlighting both the challenges and the potential for

improvement in students' map reading and interpretation skills. The NECTA reports from 2018 to 2022 consistently show that a large percentage of students struggle with topographic map analysis, with failure rates reaching 96.4% in 2020 and over 85% in other years. This aligns with the pre-test results in Table 1, where both male and female students initially exhibited low performance, with 47.05% of males and 17.64% of females failing. However, the self-made achievement test results indicate a significant improvement after intervention, with the failure rate dropping from 32.35% to 14.63%. This suggests that targeted teaching methods can enhance students' spatial skills, which corresponds with the NECTA observation that students consistently underperform in Question 3 due to a lack of knowledge and skills. While national geography pass rates have improved slightly, as seen in the increase from 51.24% in 2017 to 66.10% in 2022, the persistent low performance in specific map-related questions underscores the need for improved instructional strategies. The literature review findings support the argument that structured teaching methods, including digital tools, could bridge the gap between theoretical knowledge and practical application. Therefore, while traditional methods have shown effectiveness in controlled settings, a broader, systematic integration of innovative teaching strategies could be key to addressing the persistent challenges identified by NECTA.

The analysis of Table 2 and Figure 2 on male and female students' scores on the pre-test and self-made achievement tests revealed notable differences. For male students, in the pre-test, one (5.88%) scored Grade B, four (32.52%) scored Grade C, five (29.41%) scored Grade D, and seven (41.17%) scored Grade F. In the self-made achievement test, performance improved, with one (4.76%) scoring Grade B, six (42.85%) scoring Grade C, seven (33.33%) scoring Grade D, and four (19.04%) scoring Grade F. The total number of male students increased from 17 to 21 between the two tests, and the pass rate (Grades A, B, C, and D) increased from 58.82% to 80.95%, whereas the failure rate (Grade F) decreased from 41.17% to 19.04%. For female students, in the pre-test, one (5.26%) scored Grade A majority scored grade C. After traditional teaching, Grade C increased significantly from 0% to 40.90%. However, the failure rate (Grade F) increased slightly from 12.05% to 22.72%, possibly because of truancy issues. Overall, these results indicated a positive shift in student performance after traditional teaching, with an increase in grades A, B, C, and D and a decrease in Grade F. The pass rate in the control group improved from 68.57% in the pre-test to 79.06% in the achievement test.

The results from Table 2 align with the NECTA reports by reinforcing the persistent challenges in students' map reading and interpretation skills while also demonstrating the potential for improvement through targeted teaching interventions. The NECTA reports from 2018 to 2022 indicate consistently high failure rates in topographic map-related questions, with over 85% of students scoring poorly in most years. Similarly, the pre-test results in Table 2 show a significant proportion of students struggling, with 41.17% of male students and 12.05% of female students failing. However, the self-made achievement test results reveal notable progress, as the pass rate among male students increased from 58.82% to 80.95%, and among the control group, it rose from 68.57% to 79.06%. This improvement supports the argument that structured teaching methods can enhance student performance. The NECTA results indicate that despite a rise in national geography pass rates from 51.24% in 2017 to 66.10% in 2022 students still face difficulties in interpreting drainage patterns, vegetation distribution, and economic activities. The increase in Grade C performance among female students from 0% to 40.90% mirrors the positive impact of effective teaching strategies, though the slight rise in failure rate suggests external factors like truancy may still hinder progress. These findings underscore the need for improved instructional methods, resource allocation, and possibly the integration of digital tools to further

strengthen students' map reading skills. The alignment between the self-made test improvements and the NECTA challenges suggests that with sustained efforts, students' performance on national examinations could see significant enhancements.

Table 3 and Figure 4 indicate that; pre-test results for male students were as follows; grade A, B and C were 00 (00%), grade D were 3 (17.64%), F were 14 (82.35%) total male students sat for pre-test were 17 (100%). While Self-made achievement test results were as follows; grade A were 14 (63.63%), grade B were 05 (22.72%), grade C were 3 (13.63%), grade D and F were 00 (00). Nevertheless the data indicates changes in male performance rate. Despite both grade A and B male students were 00 (00%) in grade, in self-made achievement test significance changes occur where grade A were 14 (63.63%), B were 5 (22.72%), grade C decreased from 04 (19.04%) to 3 (13.63%). 1 (5.41%) male student was improved map reading and interpretation skills. Additionally 21 (100%) sat for pre-test and 22 (100) for self-made achievement test. The increase of 1 (4.55%) male student does not affect the results. As the table indicate great achievement occurred as far as the table showing both grade D and F were 00 (00%). On top of that grade A, B, C and D were 3 (17.64%) and F were 14 (82.35%) in pre-test meanwhile self-made achievement test both D and F were 00 (00%) while A, B and C were 21 (100%)

While female students in pre-test results were; both grade A and B were 00 (00%), grade C were 4 (19.04%), grade D were 9 (42.85%), grade F were 8 (38.09%) and total were 21(100%). furthermore self-made achievement test for female students were; both grade A and C were 5 (27.77%), grade B were 8 (40.44%), both grade F were 00 (00%) and total student sat for test were 18 (100%). The table analysed drastically significance differences after intervention. Before digital technology (google map, google Earth). The performance of students was poor. There was great improvement after intervention. According to the table pre-test showing 00 (00%) female students scored grade A while self-made achievement test were 5 (27.77%), grade B increased from 00 (00%) to 8 (40.44%), both grade D and F were 00 (00%). Beside the number of female students who sat for self-made achievement test was different with pre-test. Pre-test were 21 (100%) and sat for self-made achievement test were 18 (85.71%). 3 (14.29%) female students were absent. Therefore pre-test for female in grade A, B, C and D were 13 (61.90%) while grade F were 8 (38.09%). In self-made achievement test grade A, B and C were 18 (100%) and both grade F and D were 00 (00%).

Moreover the table 3 indicates the total of yellow class in pre-test both grade A and B were 00 (00%) while self-made achievement test A were 19 (47.5%), B were 13 (32.5%). Grade C increase almost half of it from 4 (10.52%) to 8 (20%), Grade D increased from 12 (31.57%) to 00 (00%) and F from 22 (57.89% to 00 (00%). in the line with NECTA (2019) which regarded grade F as failure it is clear after digital technology (google map and google Earth) no one student failed read and interpret map. All students were passed well. However the number of students sat for self-made achievement test increased until 40 (100) from 38 (100%). 2 (5%) students were absent in pre-test and 38 (95%) sat for pre-test. The study indicates remarkable changes because in self-made achievement test all students passed because both grade D and F were 00 (00%). All students scored grade A, B and C (100%) which was quite different before intervention where C & D were 16 (42.10%) and grade F were 22 (57.89%) more than half of the yellow class failed. The digital technology was usefully to enable these achievements.

The study's results contrast sharply with NECTA's Candidate Item Response Analysis (CIRA) reports from 2018 to 2022, which consistently highlight students' difficulties in map reading and interpretation. While

NECTA (2022) reported that 59.07% of candidates scored between 0–3 marks in drainage analysis and economic activity identification, and the 2020 results showed a 96.4% failure rate in interpreting the Sikonge sheet, the study's intervention using Google Maps and Google Earth led to remarkable improvements, with all students passing and a majority achieving grades A, B, and C. Despite a national geography pass rate increase from 51.24% (2017) to 66.10% (2022), specific topics like topographic maps remain a challenge, particularly in Kisarawe District, where no school achieved high grades in geography in 2022. The study demonstrates that digital interventions can effectively address these challenges, providing a strong case for integrating digital tools in geography education to enhance student performance at the national level.

Table 4 and Figure 5 show significant improvements in both male and female students in the experimental group after using digital technology. In the pre-test, 82.35% of male students failed, but after using Google Maps and Google Earth, all male students scored A, B, or C, with 63.63% achieving Grade A. Female students also improved, with 38.09% failing the pre-test, but all scored A, B, or C, with 27.77% achieving Grade A. The yellow class showed dramatic improvement, with no students failing the self-made achievement test, compared to over half failing the pre-test. All students in this class achieved Grades A, B, or C, demonstrating the effectiveness of digital technology. The response rate exceeded the 35% threshold (Saunders et al., 2007), confirming the validity of the findings. Male students' Grades A and B increased from 1 (5%) to 10 (50%) and 4 (20%) to 10 (50%), while Grade F dropped from 14 (70%) to 0%. Female students saw Grade A increase from 1 (7.14%) to 12 (52.17%) and Grade B rise from 4 (17.39%) to 8 (40.44%), with Grade F decreasing from 7 (50%) to 1 (4.34%). In the green class, Grades A and B rose from 2 (5.88%) to 22 (51.16%) and 8 (18.60%) to 8 (40.44%), while Grade F dropped from 21 (61.76%) to 1 (2.32%). Overall, digital technology significantly improved map-reading skills, with only one student failing.

The findings from Table 4 and Figure 5 strongly align with the persistent challenges outlined in NECTA reports while demonstrating the potential of digital technology to enhance students' map reading and interpretation skills. NECTA reports from 2018 to 2022 highlight significant struggles in topographic map analysis, with over 85% of students failing related questions in multiple years. Similarly, the pre-test results in Table 3 showed that 82.35% of male students and 38.09% of female students failed before digital interventions. However, after incorporating Google Maps and Google Earth, all male and female students scored A, B, or C, with male Grade A rising to 63.63% and female Grade A increasing to 27.77%. This improvement contrasts with the NECTA results, which consistently report low performance in skills such as vegetation distribution, economic activity identification, and drainage pattern analysis. Notably, the yellow class, which had over half of its students failing the pre-test, showed dramatic improvement, with no failures in the self-made achievement test. The decline in Grade F from 70% to 0% among male students and from 50% to 4.34% among female students indicates that digital technology provides a more effective learning approach compared to traditional methods. This contrasts with the national pass rate, which only saw incremental increases, from 51.24% in 2017 to 66.10% in 2022, despite persistent challenges in map-related questions. Furthermore, the significant performance improvements in the green class, where Grade A and B scores rose substantially, emphasize the role of interactive digital tools in fostering map-reading competencies. These results strongly suggest that integrating digital technologies into geography education can address long-standing difficulties identified by NECTA, potentially transforming students' performance in national examinations.

Implications of study

The findings of the study have significant implications for geography education, particularly in the integration of digital tools to enhance students' map reading and interpretation skills. The substantial improvement in student performance after using Google Maps and Google Earth suggests that traditional teaching methods alone may not be sufficient to address persistent challenges observed in national examinations, such as those highlighted in NECTA reports. The results demonstrate that digital technologies can bridge the gap between theoretical knowledge and practical application, ultimately fostering spatial thinking and analytical skills. This aligns with Sustainable Development Goal 4 (SDG 4), which emphasizes inclusive and equitable quality education by leveraging innovative learning strategies to improve student outcomes. The study highlights the necessity of incorporating digital resources into the geography curriculum to ensure students develop essential competencies, particularly in resource-constrained areas where access to traditional learning materials may be limited. Furthermore, the gender-disaggregated results indicate that digital interventions benefit both male and female students, promoting equal learning opportunities and reducing educational disparities. Thus, policymakers, educators, and curriculum developers should consider adopting and scaling up digital technology-based teaching approaches to enhance learning outcomes in geography and beyond.

Conclusion

Based on the findings, the study concludes that the integration of digital tools such as Google Maps and Google Earth significantly enhances students' map reading and interpretation skills in secondary schools. The pre-test results indicated low performance, with a considerable proportion of students failing, aligning with NECTA reports that highlight persistent challenges in topographic map analysis. However, the self-made achievement test results showed a remarkable improvement, with failure rates dropping to near zero and substantial increases in the number of students scoring Grades A, B, and C. These results confirm that traditional teaching methods, while somewhat effective, may not be sufficient in addressing students' difficulties in geography. Digital interventions provide an interactive and engaging learning experience, bridging the gap between theoretical knowledge and practical application. The findings also demonstrate that both male and female students benefit from digital learning tools, promoting equitable access to quality education. In line with Sustainable Development Goal 4 (SDG 4), the study underscores the need for education stakeholders to integrate digital technologies into the curriculum to enhance learning outcomes, particularly in resource-constrained environments. Therefore, policymakers and educators should consider adopting digital tools as a strategic approach to improving geography education and overall student performance in national examinations.

Recommendation

To enhance map reading and interpretation skills among Tanzanian secondary school students, key steps include investing in affordable digital devices and reliable Internet, especially in rural areas like Kisarawe; providing continuous teacher training on integrating tools such as Google Maps and Google Earth; revising the geography curriculum to include technology-driven assignments; and addressing gender gaps through mentorship and inclusive teaching practices. Partnerships with NGOs and private organizations can mobilize resources and support these efforts, ensuring the equitable and effective integration of digital technologies in geography education.

Data Access Statement: The research data supporting the findings of this study are available from the

Galgotias University, located in Greater Noida, Gautam Buddh Nagar, Uttar Pradesh, India. Access to data may be granted upon reasonable request from the university's research repository or relevant academic department.

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