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Original Article

Correlation Between Teachers' Frequency of Virtual Field Trips Use and Student Achievement in Geomorphology in Secondary Schools in Murang'a East Sub-County

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ABSTRACT

Persistent underperformance in geomorphology among secondary school students in Kenya has raised concerns regarding the effectiveness of traditional instructional approaches. Virtual Field Trips (VFTs) have emerged as a promising pedagogical innovation for enhancing visualisation and experiential learning. However, linking teacher VFT use frequency to individual student academic performance in Kenyan geography lessons remains limited despite the growing adoption of VFTs in secondary schools globally. This study examined the correlation between teachers' frequency of VFTs use and student achievement in geomorphology in Murang'a East Sub-county, Kenya. A descriptive correlation was designed. Data were collected through teacher questionnaires and student geomorphology performance records. A two-level analytical framework was employed; a student-level analysis using individual scores in geomorphology of 314 form three geography students, each paired with their own teacher's VFTs frequency score and a confirmatory teacher-level analysis using weighted class mean scores in geomorphology alongside respective teacher frequency of VFTs usage. At the student level, a strong positive correlation was realised between teacher VFT frequency and individual student scores ($r = .658$, $p < .001$, $n = 314$). Further, linear regression analysis revealed that a one-unit increase in teacher VFTs usage frequency predicted a 13.745 percentage point increase in individual student score ($R^2 = .433$, Adjusted $R^2 = .431$, $p < .001$). The finding was corroborated at the teacher level analysis ($r = .784$, $p = .004$, $n = 11$). The null hypothesis, "there is no significant relationship between teachers' VFTs usage frequency and academic achievement in geomorphology", was rejected. This study provided contextual empirical evidence that increasing teacher VFT use frequency in geomorphology instructions had a quantifiable positive impact on student academic performance.

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INTRODUCTION

The persistence under performance of Kenyan secondary school students in geomorphological processes topics has been documented over multiple years of the Kenya Certificate of Secondary Education (KCSE) examination. These topics, including internal land forming processes and external land forming processes such as glaciation and ocean seas and their coasts, consistently appear among the poorly performed questions in the geography paper one (KNEC 2017-2022). This poor performance is an indication of existing challenges in how these visualisation-dependent concepts are taught and understood.

Virtual Field Trips (VFTs), which are digitally delivered educational experiences that enable learners to explore geographical sites and geomorphological features through videos, images, simulations or interactive platforms (Wolf et al., 2021), have emerged as a promising response to this challenge. VFTs offer a cost-effective alternative to physical field trips, which are majorly constrained by terrains, school budget, time constraints and safety concerns (Pugsley et al., 2024). VFTs help overcome these challenges by enabling students to virtually experience river valleys, coastal erosion features, glacial landscapes and volcanic formations without leaving the classroom (Pugsley et al., 2024). Studies from Greece, Nigeria, south and Kenya have established significant associations between VFT exposure and improved academic outcomes in science, geography and history education (Vandelli et al., 2024; Hope et al., 202; Mutabari et al., 2024)

Nevertheless, the empirical literature is largely characterised by two limitations that this study addresses. First, most of the existing studies have employed quasi-experimental or group comparison designs. Only a few have employed the correlational designs that quantify the relationship between the degree of VFTs use and the magnitude of performance. Second, most of the studies have examined the effects of VFTs at the group level, using class means or experiential group averages as the unit of analysis rather than at the individual student level, where the most direct evidence of teacher impact on learner outcomes can be obtained. This study, therefore, fills both gaps by adopting the correlational design and implementing a two-level analysis framework that pairs each individual student's geomorphology score with their own teacher's VFTs frequency score. As a result of adopting this research design, the study provided a direct examination of the teacher-student performance link in VFT research to date in the Kenyan geography education context.

Statement of the Problem

Geomorphology is a sub-branch of geography that exposes learners to landforms and land-forming

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processes. Geomorphology content requires the learners to visualise and interpret abstract landforms, processes and spatial relationships. According to the Kenya Certificate of Secondary Education (KCSE) geography reports, persistent low performances in geomorphology have been noted among students in Kenyan secondary schools, particularly in Murang'a East Sub-county.

Table 1: List of most failed topics/subtopics in geomorphology in K.C.S.E between 2017 and 2022, retrieved from K.C.S.E geography reports (KNEC, 2017-2022)

Year	Poorly Performed Topics Under the Geomorphology Sub-Discipline
2017	Glaciation
	Internal land forming processes (folding)
2018	Internal land forming processes (folding)
2019	Seas, oceans and their coasts/coastal geomorphology
2021	Glaciation
	Action of water in limestone areas (karst sceneries)
2022	Internal land forming processes (faulting)
	Glaciation
	Ocean seas and their coasts

Source: *(KNEC, 2017-2022)*

The low performance has been attributed to the abstract nature of the topics under geomorphology as well as the limited opportunities for experiential learning. Conventional learning strategies that rely on textbooks and teacher explanation may not adequately develop students' conceptualisation of the geomorphological concepts. Therefore, there is a need to explore innovative pedagogical approaches to bridge the gap between theory and real-world application.

Virtual Field Trips have emerged as a promising instructional strategy that allows simulation of real-world environments. In addition, VFTs can enhance student engagement and understanding of geomorphological concepts. Moreover, VFTs may be used to overcome the challenges associated with the physical field trips and revive the performance in geomorphological topics. According to Pugsley et al (2024), as compared to actual field trips, virtual excursions are cost-effective. Yet, very little is known about the extent to which VFTs are actually used in Kenyan geography classrooms, especially in teaching geomorphology, and whether the frequency of use by geography teachers has any real link to how students perform academically.

Specific Research Objective

To establish the correlation between form three geography teachers' frequency of VFTs use and student academic achievement in geomorphology in secondary schools within Murang'a East sub-county, Kenya.

Research Hypothesis

There is no statistically significant relationship between teachers' frequency of VFTs use and students' academic achievement in geomorphology in secondary schools within Murang'a East sub-county, Kenya.

The TPACK Framework and Frequency of VFT Use

The frequency of VFTs use by teachers is not simply a function of willingness. Instead, it is shaped by the teacher's Technological Pedagogical Content Knowledge (TPACK) as conceptualised by Mishra and Koehler (2006). Teachers with strong TPACK possessing integrated knowledge of geomorphology content, effective pedagogy and digital tools operation are better positioned to use VFTs regularly. Indeed, teachers with strong TPACK can select relevant platforms, design structured activities around

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VFT content and manage the technology demands of VFTs delivery.

REVIEW OF RELATED LITERATURE

Several studies have established an association between VFT use, academic performance and knowledge acquisition. For instance, Vandelli et al. (2024) demonstrated that 90% of the students regularly exposed to structured virtual tours of European geomorphological sites improved students' conceptualization of geomorphological concepts. A study by Petersen and his team in 2020 found that Virtual Field Trips or VFT-based education on climate change gave results. The Virtual Field Trips education did not just help students learn more about the subject. It also made them more engaged, confident and motivated. All these gains in knowledge and other areas add up to grades over time. This is similar to what Makransky and Mayer found in 2022. They discovered that students who used Field Trips did better on tests both right after learning and after some time had passed.

Another study by Khotimah et al. (2024) showed that using Virtual Field Trips in secondary schools helped students become more digitally literate and learn more about their subjects. This means that Virtual Field Trips have benefits beyond the subject they are studying. These results suggest that Virtual Field Trips can have an effect on how well students learn in general, which can help them do better in school.

In Nigeria, Lawal conducted a study in 2023 with school students. Lawal compared how well Virtual Field Trips worked compared to field trips. The students who used Field Trips did significantly better on tests both right after the study and after some time had passed, than the students who went on traditional field trips. Virtual Field Trips helped the students learn more. The results were better for the Virtual Field Trips group.

Moreover, Hope et al. (2021) demonstrated in a quasi-experiment that chemistry students exposed to VFT-integrated instruction achieved a higher post-test mean (77.30) compared to a control group mean of 59.67. The difference in performance achievement was attributed to VFTs' use. Similarly, Lawal (2023) found that biology students taught using VFTs achieved a mean score of 25.13 compared to 23.08 for students taught using traditional field trips. This evidence confirms the advantages of VFTs on students' academic achievement. These findings are supported by a study in the Kenyan context by Mutabari et al. (2024), which established that VFT integrated history instructions in Murang'a county produced significantly higher students' scores compared to control groups. This local evidence directly confirms the relevance of VFTs in teaching practices.

Existing literature generally shows that VFTs positively influence learning across different subjects. However, the majority of these studies focused on the cause-and-effect experimental design, leaving a gap in understanding the statistical relationship between VFTs usage and student performance. Moreover, few studies have focused on the extent of VFTs use by geography teachers and their relationship to student academic achievement. Further, a few studies focused on geomorphology as a sub-branch of geography. Therefore, by investigating the relationship between the frequency of VFT use by geography teachers and student academic performance in geomorphology in secondary schools within Murang'a East sub-county, Kenya, this study will fill these gaps existing in the literature.

RESEARCH METHODOLOGY AND DESIGN

The study adopted a descriptive correlational design. Correlational design was selected because the study's primary objective was to measure the direction and strength of the relationship between teacher VFTs frequency of use and student achievement in an organic classroom setting without experimental manipulation. The design is appropriate for studies that aim to identify relationships (Ishtiaq, 2019).

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The study was conducted in Murang'a East sub-county, Murang'a county, central Kenya. The subcounty has both rural and peri-urban characteristics with a rugged, dissected landscape providing rich case material for geomorphology instruction. Ten secondary schools were purposively selected from 33 schools to ensure representation across school categories and levels.

Participants comprised 314 form three geography students and their 11 respective form three geography teachers in the ten selected secondary Schools. The target student sample was 364 students, calculated using Yamane's (1967) formula at 95% confidence level and 5% margin of error (N=3,982, n=364). The actual response rate for student performance records was 86.3% (n=314), with a shortfall attributed to absenteeism and incomplete test records on geomorphological processes. A response rate of 86.3% exceeds the 70% adequacy threshold established by Mugenda and Mugenda (2019).

Two data collection tools were used: a teacher questionnaire (TQ) collected the teachers' VFTs frequency of use. Teachers self-reported their frequency of VFT use on a five-point Likert scale (1=Never, 2=Rarely, 3=Sometimes, 4= Often, 5=Very often). Secondly, a student performance record sheet collected individual geomorphology test scores for each of the 314 students, specifically on "External land forming processes". Each student's score was paired with their own form three geography teacher's VFTs frequency of use score. The questionnaire was piloted in two secondary schools outside the study area, with Cronbach's values exceeding 0.70 across all Likert scale sections, confirming acceptable internal consistency.

RESULTS AND FINDINGS

Table 2 presents the distribution of teachers and students by VFT frequency group. No single teacher reported using VFTs 'very often", indicating that the maximum frequency observed was 'often'.

Table 2: Distribution of Geography Teachers and Students by VFT Frequency Group

Frequency Score	Frequency Label	N (Teachers)	N (Students)	% of Students
1	Never	3	51	16.2%
2	Rarely	1	26	8.3%
3	Sometimes	5	161	51.3%
4	Often	2	76	24.2%
Total		**11**	**314**	**100%**

The data presented in the table revealed that 51.3% of all the students were taught by teachers who sometimes incorporated VFTs into their lessons, while 24.2% had teachers who used them more regularly. On the other hand, 24.5% of geography learners were taught by teachers who rarely or never used VFTs.

To examine the relationship more precisely, a student-level analysis was undertaken using the individual scores of all 314 Form Three geography students. Each student's score was directly linked to the respective teacher's frequency of VFTs use. Descriptive statistics for individual student geomorphological scores against teacher VFTs frequency group were first conducted, and the results are presented in Table 3.

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Table 3: Descriptive Statistics of Individual Student Scores by Teacher VFT Frequency Group (n = 314)

Frequency Score	Frequency Label	N (Students)	Mean Score (%)	SD	Min	Max
1	Never	51	24.61	10.54	12	59
2	Rarely	26	19.31	4.51	13	30
3	Sometimes	161	52.61	15.76	16	98
4	Often	76	61.03	15.75	31	98
Total		**314**	**47.34**	**20.37**	**12**	**98**

A consistently upward trend in students' academic scores in geomorphology scores as the teacher frequency of VFTs use increased. A performance gap was realised between the "never" group (M=24.61%) and the "often" group (M=61.03%), indicating the direct implications for geomorphology instruction. Notably, the 'rarely' group recorded a lower mean (19.31%) than the "never" group (24.61%). This revealed that infrequent and irregular VFT use may be less effective than no VFT use at all. This might be possibly due to cognitive disruption when VFTs are used inconsistently without adequate pedagogical scaffolding. In addition, the study realised an overall mean of 47.34% that was way below the 50% mark. This was a confirmation of the consistent underperformance as documented in the geography KCSE report (KNEC, 2017-2022). Further, a one-way ANOVA confirmed that differences across groups were statistically significant ($F(3,310) = 105.067$, $p < .001$).

Pearson correlation was subsequently carried out at the student level, with results presented in Table 4.

Table 4: Pearson Correlation between Teachers' Frequency of VFTs Use and Individual Student Scores (n = 314)

		Frequency of VFTs Use	Individual Student Score
Frequency of VFTs Use	Pearson Correlation	1	.658**
	Sig. (2-tailed)		<.001
	N	314	314
Individual Student Score	Pearson Correlation	.658**	1
	Sig. (2-tailed)	<.001	
	N	314	314

A strong positive relationship was established between student geomorphological scores and teachers' frequency of VFTs use ($r = .658$, $p < .001$, $n = 314$). This finding revealed that increased frequency of VFTs use by geography teachers was associated with improved student academic performance in geomorphology. The finding concurred with the finding of a study by Salma (2023), who similarly observed that learners taught through VFT-based instructions outperformed those only exposed to conventional teaching methods.

Further, linear regression at the student level was conducted to assess the predictive power of teacher VFT frequency on student performance. The results were indicated in Table 5.

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Table 5: Linear Regression Model Results: Frequency of VFTs Use Predicting Individual Student Score (n = 314)

Model		B	Std. Error	Beta	T	Sig.
1	(Constant)	8.381	2.432		3.446	<.001
	Frequency of VFTs Use	13.745	0.891	.658	15.421	<.001

Model Summary: R = .658, R^2 = .433, Adjusted R^2 = .431, Std. Error of the Estimate = 15.371, F(1, 312) = 237.819, p < .001.

The regression model accounted 43.3% of the variance in geomorphology scores of individual students (R 2 =.433; Adjusted R 2 =.431). The overall model was statistically significant (F(1,312) = 237.819, p < .001). Each unit of the teacher VFT frequency score was found to predict an increase in the geomorphology score of an individual student by 13.745 percentage points.

To validate and complement these student-level results, a parallel analysis was conducted at the teacher-level using each teacher's frequency of VFTs use alongside their own students' weighted mean performance. Given that census sampling was applied to include all the available form three geography teachers across the ten secondary schools, the full teacher population of 11 was captured, making correlation analysis appropriate at this level (Creswell & Creswell, 2023). Table 6 presents the teacher-level Pearson correlation results.

Table 6: Pearson correlation between teachers' frequency of VFTs use and weighted student mean score (n=11)

		Frequency of VFTs Use	Weighted Student Mean Score
Frequency of VFTs Use	Pearson Correlation	1	.784**
	Sig. (2-tailed)		.004
	N	11	11
Weighted Student Mean Score	Pearson Correlation	.784**	1
	Sig. (2-tailed)	.004	
	N	11	11

***. Correlation is significant at the 0.01 level (2-tailed).*

The student-level results were validated by the teacher-level results. A high positive correlation (r =. 784, p =.004, n=11) was observed between teacher VFT frequency and the weighted average student scores. The coherence between these two levels of analysis adds considerable weight to the conclusion that teacher frequency of VFTs use genuinely matters for student achievement. The teacher level regression results, detailed in Table 7 further support this.

Table 7: Linear Regression Model Results: Frequency of VFTs Use Predicting Weighted Student Mean Score at Teacher Level (n = 11)

Model		B	Std. Error	Beta	T	Sig.
1	(Constant)	15.106	7.872		1.919	.087
	Frequency of VFTs Use	10.793	2.849	.784	3.789	.004

Model Summary: R = .784, R^2 = .615, Adjusted R^2 = .572, Std. Error of the Estimate = 10.163, F(1, 9) = 18.88, p = .004

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The teacher-level regression model predicted 61.5 percent of the variation in teacher-level weighted mean scores (R 2 =.615, Adjusted R 2 =.572, F(1,9) =18.88, p=.004), and every frequency unit increased the weighted mean scores by 10.793 percentage points.

The study also explored what factors might explain the variation in how frequently geography teachers used VFTs. Findings from the additional correlation analyses, summarised in Table 8, offer useful insights.

Table 8: Correlation between Teachers' Frequency of Use of VFTs and Teachers' Knowledge of Where to Find VFTs

		Frequency of VFTs use	I know where to find VFTs
Frequency in VFTs use	Pearson Correlation	1	.740**
	Sig. (2-tailed)		.009
	N	11	11
I know where to find VFTs	Pearson Correlation	.740**	1
	Sig. (2-tailed)	.009	
	N	11	11

**. Correlation is significant at the 0.01 level (2-tailed).

The results obtained demonstrated a positive and statistically significant relationship between the frequency of VFT use and knowledge of where to find VFT resources (r =.740, p =.009). This showed that the teachers who were knowledgeable about where to find VFT materials were more likely to use them regularly in their teaching.

Table 9: Correlation between Teacher Awareness of VFTs and Frequency of VFTs use

		Frequency in VFTs use	Teacher awareness of VFTs
frequency in VFTs use	Pearson Correlation	1	.454
	Sig. (2-tailed)		.160
	N	11	11
Teacher awareness of VFTs	Pearson Correlation	.454	1
	Sig. (2-tailed)	.160	
	N	11	11

In addition, as indicated in Table 9, there was a moderate relationship between teacher awareness of VFTs and frequency of use (r =.454, p =.160). This finding revealed that teacher awareness can lead to increased usage, but not significant because the p-value exceeded the recommended 0.05. VFT use frequency was also moderately positively correlated with the knowledge of teachers about the benefits of VFTs (r =.492, p =.124), showing that those teachers who were aware of the instructional usefulness of VFTs tended to use them more frequently. The results showing a positive correlation between virtual field trips use by teachers and their knowledge about the benefits of VFTs in classroom teaching and learning was indicated in Table 10 below.

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Table 10: Correlation between Teacher Awareness of VFTs and Teacher Knowledge of the Benefits of VFTs

		Frequency in VFTs use	Teachers' knowledge of the benefits of VFTs
frequency in VFTs use	Pearson Correlation	1	.492
	Sig. (2-tailed)		.124
	N	11	11
Teachers' knowledge of the benefits of VFTs	Pearson Correlation	.492	1
	Sig. (2-tailed)	.124	
	N	11	11

Conclusively, the study found that the frequency of use of VFTs among teachers was affected by knowledge of VFTs location, knowledge of VFTs and knowledge of VFTs benefits to teaching and learning.

DISCUSSION

The findings of this study provide compelling empirical evidence that the frequency with which secondary school geography teachers integrate VFTs into geomorphology instruction is a significant positive predictor of student academic achievement. At the student level, a strong positive correlation was established between teacher VFT frequency and individual geomorphology score ($r = .658$, $p < .001$, $n = 314$). The regression model accounted for 43.3% of the variance in student performance ($R^2 = .433$, $B = 13.745$, $p < .001$). These student-level findings were corroborated at the teacher level ($r = .784$, $p = .004$; $R^2 = .615$, $B = 10.793$), lending cross-level analytical thoroughness that strengthens the credibility of the conclusions.

The overlap between student-level and teacher-level outcomes is very strong and consistent evidence to support the conclusion that teacher VFT frequency is a positive predictor of student geomorphology achievement. The results were similar to the findings by Egwu and Okigbo (2021), who showed that lessons which included VFTs had considerably more effective academic performance results for students than lessons not integrating VFTs.

These results were also in corroboration with the previous studies done on the use of VFT in teaching. For instance, Vandelli et al (2024) found that students who were accustomed to taking part in organised virtual geomorphology tours had a significant conceptual advantage. Similar results have been obtained in Nigerian secondary schools, as Hope et al. (2021) found a post-test advantage for VFT-integrated chemistry lessons. In addition to these, Lawal (2023) found that students taught biology with VFTs had better test results than those exposed to traditional field trips.

A noteworthy anomaly in the descriptive data is that students taught by teachers who used VFTs rarely performed below even the never-use group. This inverse pattern suggests that inconsistent VFT use may introduce cognitive disruption rather than learning benefit. This finding is consistent with Chen and Zhang's (2023) systematic review, which found that VFT effectiveness depends critically on a structured pedagogical approach. Where structure is absent, VFTs may be less effective.

In light of these findings, the null hypothesis "there is no statistically significant relationship between teachers' frequency of VFTs use and student academic achievement in geomorphology" was rejected. This conclusion is further supported by Evelpidou et al. (2021), who found that repeated exposure to Google Earth-based VFT activities meaningfully improved students' grasp of geomorphological concepts and their performance in assessments, suggesting that regular and sustained use amplifies learning outcomes.

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Limitations of the Study

The study was conducted in selected secondary schools within Murang'a East Sub-County and focused specifically on form three geography students. This may limit the generalisation of the findings to other regions or class levels. In addition, the study adopted a correlational design, meaning that the researchers could only establish a relationship and not causation. The study also relied on teachers' self-reported frequency of VFT use, which may have been influenced by personal bias or differences in interpretation. Nevertheless, the study provides valuable contextual evidence on the role of Virtual Field Trips in enhancing students' achievement in geomorphology in the Kenyan secondary school context.

CONCLUSION AND RECOMMENDATIONS

The study aimed at establishing the relationship between the frequency of VFTs use by geography teachers and student academic achievement in geomorphology. Based on the findings realized, the study concluded that the frequency of teachers' use of VFTs significantly influences students' academic achievement in geomorphology. Students taught by teachers who regularly integrated VFTs into the classroom instruction consistently demonstrated better performance compared to those exposed to limited or no VFTs use. The findings, therefore, suggest that frequent and well-structured use of VFT enhances learners' understanding of geomorphological concepts by promoting visualisation and experiential learning. The study further established that teachers' knowledge of where to find VFT resources plays a key role in determining the frequency of integration in teaching. Overall, the consistent findings across both student-level and teacher-level analysis provide strong empirical evidence that regular and pedagogically scaffolded integration of VFTs is an effective strategy for improving geomorphology learning outcomes in Kenyan secondary schools.

Recommendations for Action

Based on the findings, the researchers made the following recommendations.

- The teaching of the geomorphological concepts should incorporate frequent use of Virtual Field Trips (VFTs) by geography instructors.
- Secondary school administrators should ensure the provision of basic ICT infrastructure, including computers, projectors, and ready-made VFT material, which will empower teachers to use VFT more often without the hindrances posed by poor internet connection or a shortage of equipment.
- Teachers Service Commission (TSC), in partnership with KNEC and KICD, should provide professional development programmes that directly address the capacity of geography teachers to source, plan, and implement curriculum-based VFTs on a regular basis, as opposed to a once-only enrichment activity.

Recommendation for Further Research

Other variables like the attitude of students, their digital literacy, and school learning conditions that could also affect the success of Virtual Field Trips in geography learning should also be investigated.

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