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A Comparative Study of Virtual and Traditional Field Trips on Secondary School Students' Performance and Retention of Pollution Concepts in Zamfara State

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Abstract

This study compared the Effects of Virtual and Traditional Field Trips on Secondary School Students' performance and Retention of Pollution Concepts in Zamfara State. The study adopted quasi-experimental design involving experimental and control groups. The population of the study consists of 806 SS 1 Biology students from 8 Science Secondary Schools in Zamfara State, comprising 658 boys and 148 girls. A purposive sampling technique was used to select two schools with comparable characteristics. A total of 102 students were obtained from the two intact classes selected. The instruments used for data collection was pollution performance test (alternative A and B). Alternative A was used for pretest and posttest while alternative B was used for post-posttest. The instrument was validated by one experienced biology teacher and one test and measurement expert. A reliability coefficient of 0.76 and 0.80 were obtained for alternative A and B respectively after pilot study. The statistical tools used for data analyses include Mean, Standard Deviation and independent t-test. Findings revealed that secondary school students taught pollution concepts using virtual field trips performed better compared to those taught with physical field trips. Conversely, the result also indicated that students learned about pollution through physical field trips had better long-term retention than those experienced the concept using virtual field trip. It is recommended that, government should endeavour to equip all secondary schools within the state with resources need for virtual learning, as technology is seen to improved students' performance and retention of pollution concepts.

Keywords*:* Virtual Field Trips, Physical Field Trips, performance, Retention, Pollution Concept, Secondary School Students

Introduction

The world as a global community lays much emphasis on science and technology. The attainment of science and technology at all levels of education depends on the teaching effectiveness measured in terms of the knowledge of what to teach, how to teach and when to teach it (Oyegun, 2013). In today's era of science and technology, there is a great need to improve quality of education especially science education. This can be possible by bringing fundamental changes through ICT driven innovative teaching and learning strategies that can provide students centered learning environment which makes learning processes more interesting to the students (Tafa, Olanriwaju & Adamu, 2020). The rapid growth of technology in schools and its integration into teaching reshaped the interaction of teachers, students, curricula and technologies, and eventually transformed the learning environment (Uğur, Saria, Miraç Harun Talip 2019). The use of technology in science laboratories provides useful opportunities for students who can participate in high-budget, dangerous and complex experiments which are difficult to realize (Akçayır, Alçayır, Pektaş & Ocak, 2016).

In order to give students the tools they need to succeed in the modern world of science and technology, the Federal Government of Nigeria, emphasizes the importance of science education which is the cornerstone of any country's technological advancement and taught at all educational levels thereby making it mandatory at both primary and junior secondary schools. As a discipline, Science covers a wide range of areas such as biology, chemistry, and physics. In schools it can be taught as a combined subject as it is in elementary school or as a subject matter class as it is in later years, like biology. Bichi (2019) highlights that "At tertiary level, biology is one of the important subjects that formed part of the requirement for admission especially in pure and social sciences programs and it is part of general studies (science technology and society) for students in many fields of studies in Nigerian colleges of education, polytechnics and universities". However, within the realm of science education, particularly in biology, effectively teaching complex and often abstract concepts like pollution is crucial for fostering environmental literacy. While various pedagogical strategies are employed, physical field trips strategy stands out as a powerful tool for connecting theoretical knowledge with real-world phenomena. field trips allow students to engage directly with their environment, observing phenomena firsthand and fostering a deeper understanding of intricate concepts such as the causes, impacts, and mitigation of pollution (Sussan & Ebele, 2021). The authors emphasize that

such direct engagement can make abstract environmental concepts more meaningful for students.

Lawal (2023) assert that, field trip method can indirectly improve students' cognitive processes and thinking skills leading to a better understanding of concrete biology concepts. Also the implementation of teaching learning using this method is also seen to be fundamental to the success of educational development goals." Students truly need to interact with their surroundings to see, for example, the effects of pollution in real habitats and examine them, enabling them to grasp these abstract environmental issues more comprehensively (Behrendt & Franklin, 2014). However, despite their clear pedagogical value, physical field trips are often troubled with significant restrictions. As noted by Whitesell (2016), "teachers admit that there are many obstacles that disallow them from taking their classes on field trips including geographic, financial, logistical, time constraints and safety". Given these multifaceted constraints, finding suitable alternatives is unavoidable, thus using a virtual field trip to assist field trip approaches can be a logical one.

Captivating the 21st-century learner is a challenge, one that can be approached with the integration of various technologies to grasp the learner's interest. Virtual Field Trips (VFT) are one of such technology that has been integrated into the classroom. It is a guided exploration through the World Wide Web that organizes a collection of pre-screened, thematically based web pages into a structured online learning experience. (Foley,2017). According to Khotima, Krisnawati and Budi (2021), Virtual field trip (VFT) is a collection of technology-based resources used together to give students the learning experiences gained from an actual field trip. Newsome (2013), defined Virtual Field Trip as alive interactive program taught by a content provider to a classroom through the use of video conferencing technology. However, Lawal (2023), believe that VTFs are used both as a supplement to field trips as well as to provide an alternative when an actual field trip experience is not possible. Similarly, Zentis (2010), reported that VFTs can be an alternative or complementary to field activities because they are able to simulate the realities of the "outside" world in the classroom.

Also Opalewski and O'Leary, 2019 found that, "many cultural institutions utilize technology to provide distance learning opportunities or virtual field trips for students". "When used effectively, technology can open students to new experiences and places and many of the obstacles that teachers face with

a traditional field trip no longer apply". Teachers do not need to worry about money, getting permission, scheduling chaperones, taking medical risks, or skipping out on important classroom instruction time. Thus, when tradition field trips are not possible, virtual field trips offer a viable alternative. Technology empowers educators to offer novel learning experiences, facilitating connections with diverse individuals and locations through tools like videoconferencing and internet resources (Zanetis, 2010). The potential advantages of virtual environments, particularly in Biology education, are substantial in today's digital age. As technological tools such as educational games, online simulations, and virtual learning environments become increasingly prevalent, there's a growing need for educational researchers to deeply investigate their impact on learning outcomes (Mahya, 2017).

Another variable of concern in this study is the retention of students towards virtual field trip strategy. Retention is a key construct that most classroom teachers strive to maximize among their students. Student retention in biology hinges on a complex interplay of factors influencing how effectively students remember and apply biological concepts. Andrew and Sanjay (2012) defined retention as the ability of a learner to communicate to others repeatedly and overtime what he /she have learnt and how he/she has come about the results. the authors believe that, the most important thing about learning is retaining the acquired knowledge for future use. This is particularly true in science education, especially biology, where the primary goal is to equip students with a lasting understanding of the natural world. This understanding goes beyond simply being able to recall fact on exams. However, to be able to measure retention, a test has to be conducted on the learner to know if the material learnt are retained and can be remembered and reproduced. Biology is not a subject which can be learnt by mere memorization through rote learning. It is a known fact that the ability to remember takes place more effectively when experiences are passed across to the learner via an appropriate instructional or teaching method.

Statement of the problem

Environmental education is a vital component of sustainable development, enabling individuals to understand the intricate relationships between human systems and the natural environment, and to make informed decisions about environmental issues (UNESCO, 2021). However, the insecurity challenges in Zamfara State, Nigeria, have severely disrupted the education sector, making

it impossible to organize physical field trip, which are essential for hands-on learning experiences in environmental education (Balarabe, 2025), As a result, teachers are forced to rely on traditional teaching methods, which have been found to be ineffective in teaching abstract concepts like pollution. Traditional teaching methods often prioritize rote memorization and lectures, neglecting the development of critical thinking and problem-solving skills (Ugwu, Akpanke, 2024). Given the limitations of traditional teaching methods and the inaccessibility of physical field trip, there is a need to explore alternative approaches to teaching environmental concepts. This study aims to investigate the effectiveness of virtual field trip compared to traditional field trip (where possible) and traditional teaching methods on secondary school student performance and retention of pollution concepts, with a view to identifying a viable solution to improve environmental education in Zamfara State.

Research objectives

The aim of this study is to compare the effectiveness of virtual and physical field trips on secondary school student's performance and retention of pollution concept in Zamfara state, Nigeria. Specifically, the study was set to:

1. Compare the mean performance scores of secondary school students taught pollution concept using virtual field trip and those taught with physical field trips in Zamfara State.

2. Compare the mean retention scores of secondary school students taught pollution concept using virtual field trip and those taught with physical field trips in Zamfara State.

Research Questions

The following research questions were stated to guide the study:

1. What is the difference in the mean performance scores of secondary school students taught pollution concept using traditional field trip and those taught with virtual field trip in Zamfara State?

2. What is the difference in the mean retention scores of secondary school students taught pollution concept using virtual field trips and those taught with physical field trip in Zamfara State?

Research Hypotheses

Based on the research questions raised for this study, the following hypothesis would be tested at 0.05 level significance.

Ho_1 There is no significance differences in the performance scores of secondary school students taught using virtual field trips and those taught with physical field trips strategy in Zamfara State.

Ho_2 There is no significance difference in the retention scores of secondary school students taught pollution concepts using virtual field trips and those taught with physical field trips strategy in Zamfara State.

Methodology

The study adopted quasi experimental design, involving experimental and control groups. The population of the study consists of 806 SS 1 biology students from 8 science secondary schools in Zamfara State, comprising 658 boys and 148 girls. A purposive sampling technique was used to obtain two schools with comparable characteristics. A total of 102 students were obtained from the 2 intact classes selected. The instruments used for data collection are: Pollution Performance Test (PPT) and Pollution Retention Test (PRT). Pollution Retention Test (PRT) was the reshuffled PPT and was used as post-posttest. The instruments was validated by one experienced biology teacher and one test and measurement expert.A reliability coefficient of 0.76 and 0.80 were obtained for alternative A and B respectively after pilot study. The statistical tools used for data analyses include Mean and Standard Deviations, independent t-test.

Results

Research Question One

What is the difference in the mean performance of students taught pollution using virtual and those taught using physical field trips? The result of the analysis is presented in Table1.

Table 1: Means and Standard Deviation on achievement Scores of Students taught Pollution using Virtual and those taught using Physical Field Trips

Treatment	N	Mean	Std. Deviation	Mean Difference
Virtual Field Trip	52	54.0192	17.88470	

							11.37923
Physical Field Trip	50	42.6400	18.42554				
Total	102						

Source: field work, 2025

Table 1 shows the average scores (mean) and how spread out the scores were (standard deviation) for students who learned about pollution in two different ways through virtual field trips and through physical field trips. The results show that, students who used virtual field trips had an average score of 54.02, while those who went on physical field trips had an average score of 42.64. This means that, on average, students who learned through virtual field trips scored about 11.38 points higher than those who learned through physical field trips. The standard deviation values (17.88 for virtual and 18.43 for physical) show that in both groups, students' scores varied widely, meaning some students scored much higher or much lower than the average. In simple terms, the data suggests that virtual field trips helped students understand pollution better and performed better in the test compared to physical field trips.

Null Hypothesis One

There is no significant difference in the mean performance score of students taught pollution using virtual and those taught using physical field trips. This null hypothesis was tested using inferential statistics of independent sample T-test for post-test scores of the experimental and control groups. The result of the analysis is presented in Table 2.

Table 2: Summary of Independent Sample T-test on performance Scores of Students taught Pollution using Virtual and those taught using Physical Field Trips.

Treatment	N	Mean	SD	df	F	P-value	Decision
Virtual Field Trip	52	54.0192	17.88470				
				1	.424	0.002	Reject HO
Physical Field Trip	50	42.6400	18.42554				
Total	102						

Source: Field work, 2025

Table 2 presents the results of an Independent Sample T-test, which was used to check if the difference in scores between students taught pollution through virtual field trips and those taught through physical field trips was significant. The average score for the virtual field trip group was 54.02, while the average score for the physical field trip group was 42.64. The statistical test shows a p-value of 0.002, which is less than 0.05. This means the difference between the two groups is statistically significant. In simple terms, this result confirms that students who learned through virtual field trips performed significantly better

in their performance test on pollution than students who learned through physical field trips.

Research Question Two

What is the difference in the Retention ability of students taught pollution using virtual and those taught using physical field trips? The result of the analysis is presented in Table 3.

Table 3: Means and Standard Deviation on Retention ability of Students taught Pollution using Virtual and those taught using Physical Field Trips

Treatment	N	Mean	Std. Deviation	Mean Difference
Virtual Field Trip	52	84.1346	14.44127	6.94538
Physical Field Trip	50	91.0800	14.07827	
Total	102			

Source: Field work, 2025

Table 3 shows the average retention scores of students who learned about pollution through virtual field trips and those who learned through physical field trips. Retention here means how much the students were able to remember after the lesson. Students in the virtual field trip group had an average score of 84.13, while those in the physical field trip group had an average score of 91.08. This means the physical field trip group remembered slightly more of what they learned, with a difference of about 6.95 points in their favor. However, both groups had relatively high retention scores, showing that both teaching methods were effective in helping students remember what they were taught. The standard deviations (14.44 for virtual and 14.08 for physical) show that the spread of scores within each group was similar. In simple terms: While virtual field trips helped students learn well, physical field trips gave them a slight advantage in remembering the content over time.

Null Hypothesis Two

There is no significant difference in the Retention ability of students taught pollution using virtual and those taught using physical field trips. This null hypothesis was tested using inferential statistics of independent sample T-test for post-test scores of the experimental and control groups. The result of the analysis is presented in Table 4.

Table 4: Summary of Independent Sample T-test on Retention ability of Students taught Pollution using Virtual and those taught using Physical Field Trips

Treatment	N	Mean	SD	df	F	P-value	Decision
Virtual Field Trip	52	84.1346	14.44127				
				1	2.615	0.016	Reject HO
Physical Field Trip	50	91.0800	14.07827				
Total	102						

Source: Field work, 2025

Table 4 presents the results of the Independent Samples t-test comparing the retention ability of students taught pollution using virtual field trips and those taught using physical field trips. The mean retention score for the virtual field trip group was 84.13, while the physical field trip group had a higher mean score of 91.08. The p-value obtained was 0.016, which is less than the 0.05 significance level. This means that the difference in retention between the two groups is statistically significant. In other words, students who went on physical field trips were able to remember more of what they learned compared to those who participated in virtual field trips. In simple terms: Both groups remembered a lot, but physical field trips clearly gave students a stronger memory of the lesson, and this difference was not just by chance it is real and meaningful.

Discussion

The discussion of results of this study is based on the findings of this study. The finding from research question one revealed that students taught pollution concepts using Virtual field trip performed better than their counterparts taught using a physical teaching approach. This superior performance can be attributed to several factors. For example, virtual trips provide a highly controlled and focused learning environment, free from the logistical challenges of physical trips, such as travel time, weather, or on-site distractions. This allows students to concentrate fully on the specific learning objectives. Virtual trips can also be manipulated to highlight key concepts or be replayed as needed, ensuring all students grasp complex ideas at their own pace. These findings align with Babson (2025), who reported a similar increase in students' performance using virtual field trips. This also conforms with the findings of Suleiman (2024); Thelma *et al.,* (2024) and Sanyoy (2018) who reported that application of virtual reality technology in biology is more effective than the use of conventional teaching method, the authors added that VRTs increases knowledge of the topic promote active experience, rather than just passive information as it is done in conventional learning.

Additionally, as some researchers have pointed out, the ability to safely visit hazardous or distant locations virtually allows for a wider range of educational experiences, which can also contribute to improved student outcomes (Harris and Osman, 2015). This superior performance is likely attributable to the unique opportunities VFTs afford, such as enabling students to explore geographically distant environments like mangrove ecosystems. The author added that, the use of VFT could provide an opportunity for students to explore the mangrove ecosystem not in their area, sees a graphical display and video clearly which help to improve their achievement in the topic of Colonization and Succession in Mangrove Ecosystems. Harris and Osman findings gains further support from the work of Karl (2014) who found that, while VFT appears to be a successful and innovative use of technology in the classroom, it also has direct cause of students' academic improvement. The positive impact of virtual learning environments on student achievement in biology is also consistently demonstrated by Gambari', Obilodan and Kawu, work (2017) who reveals that "students exposed to physics practical's using a virtual laboratory package performed better than those with conventional laboratory methods. However, beyond academic gains, the convenience and flexibility offered by virtual learning platforms are significant advantages. These aspects of VFTs not only facilitate access to otherwise inaccessible content but also empower students with greater autonomy in their learning journey, further reinforcing their pedagogical value.

The finding from research question two revealed that students taught pollution concepts using traditional field trips strategy retained retained the pollution concept better. This aligns with the principles of experiential learning and multisensory engagement. The tangible, real-world experience of a physical field trip allows for a deeper and more durable memory formation. The higher retention score observed in the traditional field trip aligns with a substantial body of literature on experiential learning. Researchers such as Ahmad (2014); Emmanuel, Josiah, and Samuel (2014); found that students taught with field trips instruction retained knowledge better than their counterparts in the control groups. This also supported by the work of Babson (2025); Yaki, Babagana, and Abubakar (2021); Mahmud, Ismail, and Ibrahim (2022); and Ejeh et al, (2021) whose findings revealed that field trip teaching strategies aid in knowledge retention.

Implication: The findings suggest that while virtual field trips can improve immediate understanding and access, physical, hands-on experiences are crucial for deep, long-term learning. This implies that virtual field trips should not fully replace traditional methods. Instead, educators should consider a blended approach, using virtual trips for initial engagement or to access hard-to-reach places, but following up with real-world, physical activities to reinforce and solidify learning whenever conditions, like security, allow for traditional field trips.

Limitations: Despite these results, this study is limited by the study's short duration. The research only assessed learning over a limited period, so it is unknown if the retention benefits of traditional field trips would last for a longer time. Also, this study was confined to a single topic, the pollution concept, which means the results may not be applicable to other, more hands-on STEM subjects.

Future research: Future research should conduct longitudinal studies to see if the retention benefits of traditional field trips last over time. Researchers could also investigate a blended approach, examining whether a combination of virtual trips for initial engagement and traditional trips for hands-on experience could yield even better learning outcomes. Furthermore, future studies should explore the effectiveness of virtual trips across a wider range of STEM subjects and with a larger, more diverse student population to increase the generalizability of the findings.

Conclusion

The results of this research highlight that neither virtual nor traditional field trips are a standalone solution. Virtual field trips are a powerful tool for promoting equity and ensuring educational access, especially when physical travel is unsafe due to insecurity. At the same time, the superior long-term retention from traditional trips confirms the value of hands-on, real-world experiences. This suggests that the most effective strategy is a blended approach, especially when teaching subjects that require environmental education such as pollution, whenever it is safe and possible to do so.

Recommendations

Based on the foregoing conclusion, the following recommendations were made:

1. State government and stakeholders should endeavour to equip all secondary schools within the state with resources needed for virtual learning environment.

2. Teachers should try to incorporate virtual learning instruction alongside the physical field trips strategy in teaching of pollution concepts.

3. Workshops should be organizes for secondary school teachers to be enlightened on the relevance of entering into virtual learning.

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