

WHY UTILIZATION OF INFRASTRUCTURAL RESOURCES IS KEY IN TEACHING AND ACHIEVEMENT OF LEARNING OUTCOMES IN BIOLOGY: THE KENYAN EXPERIENCE

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ABSTRACT

This article examines the extent to which both teachers and learners utilize infrastructural resources to support the development of scientific understanding in Biology, particularly through visualization of abstract concepts, hypothesis generation, critical analysis, and reflective critic aimed at deepening comprehension. Further, the article assesses the extent to which utilization of infrastructural resources in Biology teaching and learning influences the achievement of learning outcomes in public secondary schools in Nairobi County, Kenya. Adopting a mixed-methods approach within an explanatory sequential design, the research commenced with a quantitative survey followed by in-depth qualitative inquiry in selected secondary schools, informed by the survey results. The study was conducted in Nairobi City County, encompassing 114 public secondary schools. Data collection tools included structured questionnaires, in-depth interview schedules, focus group discussion (FGD) guides, and classroom observation protocols. Participants comprised Biology teachers, students and subject matter experts from the Kenya Institute of Curriculum Development (KICD), the Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA), and Biology education lecturers from Kenyatta University. The findings reveal that the use of infrastructural resources in Biology was limited and primarily facilitated the development of lower-order cognitive abilities, basic scientific process skills, and a generally negative attitude towards the subject. Thus, there is need to expand and diversify the use of infrastructural resources so as to enhance the quality and depth of Biology education.

Keywords: infrastructure, infrastructural resources, teaching, achievement, learning outcomes, Biology and Kenya

1.0 INTRODUCTION

Science has long served as a catalyst for socio-economic advancement across industrializing nations (The World Economic Forum's Global Competitiveness Report, 2006; NGSS, 2013; Republic of Kenya, 2007, 2015, 2019; NESP, 2015). Through scientific inquiry and innovation, significant gains have been made in sectors such as healthcare, technology, education and energy. However, empirical evidence indicates that many education systems are ill-equipped to meet the demands of effective science instruction, resulting in diminishing learning outcomes in scientific disciplines (Morsel & Hand, 2018; OECD, 2017). Moreover, persistent

concerns such as inadequate utilization of infrastructure remain insufficiently addressed (Morsel & Hand, 2018; OECD, 2017).

In light of science's pivotal role in national development, it is imperative that countries prioritize the delivery of high-quality science education. Bustami et al. (2018) emphasize the critical role of teachers in facilitating meaningful learning by employing effective pedagogical strategies, alongside the appropriate use of instructional resources and infrastructure. Accordingly, Biology educators are tasked with creating learning experiences that promote conceptual clarity and cognitive engagement.

2.0 LITERATURE REVIEW

The use of infrastructure in Biology instruction constitutes a critical component of effective science education. Empirical studies call attention to the significance of appropriate facilities such as laboratories, computer rooms and libraries in enriching the teaching and learning experience. For example, Widodo and Agustin (2016) report that conducting Biology lessons within a laboratory setting, as opposed to a conventional classroom, increases student motivation. However, findings by Mwamba and Kabungu (2018), in a study exploring the impact of laboratory availability on secondary school learners' academic performance in Zambia, revealed no statistically significant effect on examination outcomes. This suggests that while Biology, as a science discipline, benefits from laboratory-based instruction, academic success is influenced by the broader learning environment rather than merely the physical space. All the same, the value of laboratory experiences should not be understated.

Scholars such as Namasaka et al. (2017) and Rosenthal (2018) contend that constructivist pedagogies are more effectively implemented in specialized learning environments such as laboratories, computer rooms, or aquariums where students can engage in experiential learning. These settings facilitate active experimentation and direct observation, thereby enhancing conceptual understanding and supporting the achievement of intended learning outcomes.

Alade and Iwu-James (2018), in a study examining the relationship between library utilization and academic performance among Biology students in Nigeria, found that access to and engagement with library resources significantly predicted improved academic outcomes. This emphasizes the necessity for teachers to actively encourage learners to make use of library facilities to supplement classroom instruction. In a related investigation, Sugimoto, Tsukagoshi, and Nishida (2017) explored the use of television as a teaching aid in Biology education in Japan. Although the televised content effectively stimulated student interest in the subject, the study revealed no statistically significant impact on measurable learning outcomes. These findings suggest that while the television room may not directly influence academic achievement, its capacity to captivate and motivate learners plays a valuable role in sustaining engagement, an essential precursor to meaningful learning. Collectively, these studies highlight the multifaceted nature of instructional infrastructure, illustrating that its educational value lies not only in enhancing cognitive outcomes but also in fostering the motivational and affective conditions necessary for effective science learning.

Rapholo, Lelliott and Rauscher (2018) conducted a study to examine the impact of computer-based simulations on learning outcomes in Biology and found that such tools significantly enhanced students' comprehension of abstract biological concepts. This accentuates the

importance of integrating digital simulations into instruction, suggesting that Biology educators should actively utilize computer laboratories to enrich learners' experiences through interactive and visual representations.

Similarly, botanical gardens have emerged as valuable educational resources, offering unique opportunities for experiential learning in plant biology. Stregar, Schussler, Lee, and Martin (2019), in a study conducted in the United States, found that students who participated in guided visits to botanical gardens exhibited superior cognitive abilities including observation, analytical reasoning and interpretative skills compared to peers who did not engage in such experiences. This finding affirms the potential of botanical gardens to cultivate higher-order thinking skills in plant sciences, thereby contributing to deeper, more meaningful learning.

Solheim, Berg, Nerland and Manger (2017) investigated the educational impact of aquarium visits and found that students who participated in aquarium-based programs exhibited an enhanced understanding of aquatic ecosystems and the complex interrelationships among living organisms. This finding supports the integration of out-of-classroom learning environments in Biology instruction to foster deeper ecological literacy. Similarly, Jensen, Blackwell and Bialeschki (2019), in a study conducted in the United States, explored the effects of zoo-based learning experiences and concluded that such environments significantly promoted students' critical thinking abilities and engagement in scientific practices, including hypothesis formulation and data analysis.

Consequently, school administrations and parents should support and facilitate educational visits to zoological institutions as a means of enriching Biology education. However, the use of zoos and aquariums in teaching also raises important ethical and animal welfare considerations. Educators must, therefore, critically evaluate these concerns and ensure that such instructional strategies align with responsible and humane educational practices.

3.0 METHODOLOGY

This study adopted a mixed methods approach, specifically utilizing an explanatory sequential design, to comprehensively investigate the relationship between infrastructure utilization and learning outcomes in Biology education. The mixed methods approach was selected for its ability to harness the complementary strengths of both quantitative and qualitative methodologies while mitigating their respective limitations. As Creswell (2014) asserts, mixed methods research enables a more nuanced and complete understanding of complex research problems.

The explanatory sequential design involved two distinct but interconnected phases. In the initial phase, quantitative data were collected from 100 Biology teachers through structured questionnaires. This phase aimed to quantify key variables such as student learning outcomes and the types of educational infrastructure in use namely: laboratories, libraries, computer rooms, botanical gardens and aquariums.

The quantitative findings subsequently informed the second phase of the study by guiding the purposeful selection of participants and shaping the qualitative interview questions. In the follow-up qualitative phase, schools identified through quantitative analysis were revisited. The researcher conducted classroom observations of Biology lessons and engaged teachers in

in-depth discussions to elicit their perspectives and interpretations. As noted by Gough and Deatrick (2015), qualitative inquiry emphasizes the understanding of underlying processes as well as outcomes, thereby enabling the researcher to explore not only what is occurring, but also how and why it occurs.

This research design facilitated an in-depth, holistic exploration of how educational infrastructure was leveraged in the teaching of Biology and how such usage correlated with the achievement of learning outcomes. By integrating empirical measurement with contextual understanding, the study achieved both breadth and depth in its investigation.

4.0 FINDINGS, INTERPRETATION AND DISCUSSION

The response rate of the questionnaire used in the survey for the quantitative study was 100 out of the expected 114 teachers. This was a return rate of 88%. Tobias et al (2018) note that a return rate of 55% and above is acceptable. The respondents in this study were Biology teachers, Form 3 Biology students from selected schools and Biology specialists from Kenya Institute of Curriculum Development (KICD), Centre for Mathematics, Science and Technology Education Africa (CEMASTEA) and Kenyatta University (KU). The Biology teachers responded to the study questionnaire; the Biology students participated in focused group discussions (FGDs) while the Biology specialists participated in interviews as key informants.

The teachers were asked to state the extent to which they used infrastructure resources. Figure 1 shows the responses on the use of infrastructure resources in the teaching of Biology.

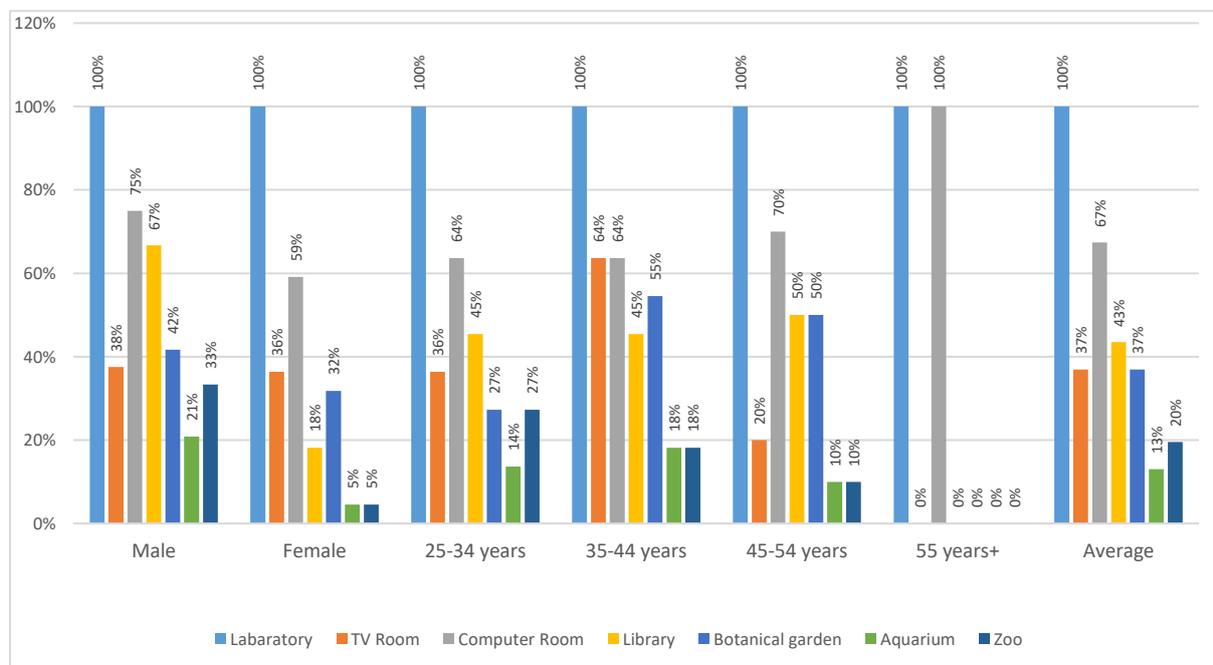


Figure 1: Use of Infrastructure Resources

All the 100 teachers, regardless of gender, age or teaching experience, reported utilizing laboratories in the instruction of Biology. This unanimous response underscores a widespread

recognition of the pedagogical value of laboratory-based teaching in the subject. The finding aligns with the work of Rapholo, Lelliott and Rauscher (2018) as well as that of Rosenthal (2018) who emphasizes the critical role of laboratory experiences in enhancing Biology education. It is evident that the respondents acknowledged the laboratory as an essential component of effective Biology instruction.

In relation to the use of computer rooms, a substantial proportion of the participants (67%) indicated incorporating this resource into their teaching practices. This suggests a growing inclination among Biology educators towards integrating digital technologies into their instructional methodologies. The result corroborates Rapholo, Lelliott and Rauscher's (2018) findings, which highlight a preference among Biology teachers for utilizing computer rooms to facilitate learning. This trend reflects a positive shift towards embracing technologically enriched teaching environments within the discipline.

The findings of the present study reveal a concerning trend that a majority of the teachers (57%) reported that they did not refer learners to the library for further research. This outcome stands in contrast to the assertions of Arya (2016), who underscores the significance of library use in Biology education and advocates for its integration into pedagogical practices.

Similarly, the data indicates that 63% of the respondents did not incorporate the use of television rooms in their Biology instruction. This finding aligns with the observations of Timms (2018), who notes that although television rooms have the potential to enrich the learning experience, they are frequently perceived by educators as spaces designated primarily for entertainment. The present finding suggests that many teachers may have internalized this perception, thereby overlooking the educational potential of audiovisual resources. Additionally, the under-utilization of television rooms could be attributed to infrastructural limitations, as some schools may lack such facilities altogether, further discouraging teachers from considering them as viable instructional resources.

With regard to the use of botanical gardens, only a minority of teachers reported integrating them into their Biology instruction. A substantial proportion (63%) did not utilize botanical gardens as a teaching resource. This finding is consistent with the observations of Stregar, et al. (2019), who acknowledge the pedagogical value of botanical gardens in plant studies, while also noting their limited use due to their general unavailability in schools. It may thus be inferred that the under-utilization of botanical gardens stems primarily from infrastructural constraints. Even among schools possessing such facilities, full utilization appears to be lacking, despite many educators recognizing their potential educational benefits.

Concerning the use of zoos and aquariums, only 20% of teachers indicated that they had used a zoo as a teaching aid, whereas a significant majority (80%) had not. The use of aquariums was even more limited, with only 13% of the respondents incorporating them into their teaching, and 87% reported no usage. These findings are in agreement with Solheim et al. (2017), who attribute the infrequent use of these resources to their limited availability, as well as to ethical considerations and concerns about animal welfare. It can, therefore, be concluded that the low utilization of zoos and aquariums in Biology instruction is primarily due to logistical and ethical constraints, rather than a lack of pedagogical value.

In the qualitative component of the study, the researcher engaged key informants to explore optimal strategies for leveraging infrastructure in the teaching and learning of Biology. When prompted on the effective utilization of available resources, the key informants offered a range of insightful perspectives. Their reflections illuminated both the opportunities and constraints associated with infrastructure use in Biology education, highlighting practical recommendations for enhancing pedagogical outcomes through improved access to, and integration of facilities such as laboratories, botanical gardens and digital learning environments.

The excerpts from key informants encapsulate their views on effective utilization of infrastructure such as the classroom, laboratory, computer room, library and television room in the teaching and learning of Biology. Key Informant Y pointed out that:

Biology is a practical subject. You cannot split Biology and laboratory because for improvement of learning outcomes, you must do research which is field-based or laboratory-based.

Key Informant Y underscored the inherently practical nature of Biology, asserting that the subject should remain inextricably linked to laboratory instruction. The informant emphasized that laboratories are not merely supplementary facilities but essential spaces for conducting scientific inquiry and facilitating experiential learning. Consequently, Key Informant Y advocated for consistent integration of laboratory sessions into Biology teaching, positioning the laboratory as the ideal and preferred environment for effective instruction in the subject.

Key Informant X shared the same sentiments about laboratory use as follows as follows:

From my own experience, teachers of Biology should be stationed in the laboratories. Before teaching anything, they should have a prior experience in the laboratory to observe what happens. For example, if they want to demonstrate how catalase enzyme reacts with hydrogen peroxide, they should test.

Key Informant X has similarly highlighted the critical role of laboratory use in the effective teaching and learning of Biology. The informant emphasized that teachers should engage with experiments in advance of presenting them to students, underscoring the importance of teacher preparedness in facilitating practical sessions. This perspective reflects the belief that educators must possess a thorough understanding of experimental procedures in order to guide learners effectively and ensure meaningful engagement with the content.

Furthermore, Key Informant X advocated for the integration of practical experiments within the laboratory setting to reinforce theoretical knowledge acquired in the classroom. This approach emphasizes the necessity of bridging abstract concepts with empirical experience, thereby fostering a deeper comprehension of biological principles. These views are consistent with the findings of Namasaka et al. (2017) and Rosenthal (2018), who argue that laboratory engagement, following theoretical instruction, is essential in Biology education. The laboratory environment enables learners to undertake hands-on experimentation and direct observation, thereby enhancing conceptual understanding.

Regrettably, findings from the present study reveal that laboratories were frequently repurposed as conventional teaching spaces, rather than being utilized for their intended function, that is to facilitate experimental inquiry and reinforcing classroom learning. This disconnect signals a missed opportunity to fully exploit the pedagogical advantages of laboratory-based instruction in Biology.

Regarding the use of the computer room, Key Informant X recommended that both students and teachers utilize this facility for research purposes. This suggestion reflects an understanding that, beyond classroom instruction, learners should be encouraged to explore additional sources of knowledge, with the computer room offering valuable opportunities for independent inquiry and digital literacy development. In relation to the television room, the key informant proposed its use for viewing real-life phenomena relevant to Biology. This perspective gives emphasis to the importance of contextualizing biological concepts within observable realities, thereby enhancing learners' ability to connect theoretical knowledge with practical, lived experiences.

The recommendations provided by the key informants concerning the use of laboratories, classrooms, libraries, computer rooms and television rooms align with the findings of Alade and Iwu-James (2018), who emphasize the pivotal role of the library and advocate for its widespread adoption by both teachers and students in fostering research. Similarly, the informants' perspectives on the utility of the computer and television rooms resonate with Tsukagoshi and Nishida (2017), who argue that television rooms can stimulate student interest through visual engagement, while computer rooms serve as platforms for extended research and information access.

Collectively, these findings suggest that effective Biology instruction should leverage a diverse array of infrastructural resources. Each facility, whether a laboratory, library, computer room or television room should offer distinct pedagogical advantages. Thus, a multi-faceted approach to infrastructure use is essential for fostering comprehensive learning outcomes encompassing knowledge acquisition, skill development and attitudinal growth.

In the qualitative phase of the study, the researcher employed classroom observation guides to assess the utilization of educational infrastructure during both single and double Biology lessons across the six selected schools. These observations provided insights into how instructional spaces, particularly classrooms and laboratories, were employed in practice. The researcher systematically documented the extent to which various facilities supported teaching and learning activities, offering a grounded understanding of infrastructure usage within real instructional settings.

Table 1 presents a summary of the observational data, highlighting the use of classrooms, laboratories, ICT rooms and other relevant infrastructural resources during the observed Biology lessons.

Table 1 Class Observation: Use of Classroom, Laboratory, ICT room and other Infrastructure

School Q	School R	School S	School T	School	School V
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Single lesson	Single lesson	Single lesson	Single lesson	Single lesson	Single lesson
Learners were being taught from the laboratory. No experimentation was however observed. The laboratory had a white board and it was used more as a classroom. No reference was made on use of the library, computer room nor TV room.	Learners were being taught from a classroom. The classroom had a white board and was fitted with a projector. No reference was made on use of the library, computer room nor TV room.	Learners were being taught from an ICT room. There were no computers in the ICT room. The ICT room was fitted with a projector and had a white board. No reference was made on use of the library, computer room nor TV room.	Learners were being taught from the classroom. The classroom had a black board. No reference was made on use of the library, computer room nor TV room.	Learners were being taught from the classroom. The classroom had a black board. No reference was made on use of the library, computer room nor TV room.	Learners were being taught from the classroom. The classroom had a white board. No reference was made on use of the library, computer room nor TV room.
Double lesson	Double lesson	Double lesson	Double lesson	Double lesson	Double lesson
Learners were being taught from the laboratory. No experimentation was however observed. The laboratory had a white board and it was used more as a classroom. No reference was made on use of the library, computer room nor TV room.	Learners were being taught from a classroom. The classroom had a white board and was fitted with a projector. No reference was made on use of the library, computer room nor TV room.	Learners were being taught from an ICT room. There were no computers in the ICT room. The ICT room was fitted with a projector and had a white board. No reference was made on use of the library, computer room nor TV room.	Learners were being taught from the laboratory. No experimentation was however observed. The laboratory had a black board. No reference was made on use of the library, computer room nor TV room.	Learners were being taught from the classroom. The classroom had a black board. No reference was made on use of the library, computer room nor TV room.	Learners were being taught from the classroom. The classroom had a white board. No reference was made on use of the library, computer room nor TV room.

room nor TV
room.

In School Q, on the day of observation, both single and double Biology lessons were conducted in the laboratory. However, no experimental activities were observed during these sessions. In School R, instruction for both lesson types took place in the regular classroom. School S conducted both lessons in the ICT room which notably lacked computers and was instead equipped with a whiteboard and a projector. In School T, the single lesson was delivered in the classroom, while the double lesson took place in the laboratory, yet again without the inclusion of any practical experiments.

In schools U and V, both single and double lessons were held exclusively in classroom settings. Across all the schools observed, there was no instance in which learners were directed to utilize the library, computer room, or television room.

These observations reveal that while classrooms and laboratories were the most frequently used spaces, their pedagogical potential and particularly that of laboratories was not fully realized. Laboratories were treated merely as alternative teaching spaces rather than environments for hands-on experimentation. Similarly, the ICT room, where present, was used solely for projecting content, and not for interactive or research-oriented activities. Furthermore, none of the schools incorporated additional infrastructure such as libraries, television rooms, botanical gardens, zoos or aquariums during the observed lessons. This pattern suggests a constrained and superficial engagement with available infrastructure, with Biology instruction largely confined to traditional classroom teaching, even when conducted in specialized spaces.

The findings stand in contrast to the recommendations of several scholars, including Rapholo, Lelliott and Rauscher (2018), who emphasize that laboratories should be dedicated to practical experimentation rather than conventional instruction. Alade and Iwu-James (2018) advocate for the ICT room as a hub for student research while Tsukagoshi and Nishida (2017) highlight the educational value of television rooms in stimulating student interest, and the role of computer rooms in promoting inquiry-based learning.

Overall, the observations indicate a pattern of under-utilization or non-availability of critical educational infrastructure. This limited engagement restricts the richness of Biology instruction and undermines opportunities for experiential and inquiry-based learning, ultimately compromising the development of scientific knowledge, skills and attitudes among learners.

Having established the utilization patterns of infrastructural resources in the instruction of Biology, the researcher proceeded to investigate the extent to which these resources impact learning outcomes. Within the quantitative framework of the study, participating Biology teachers were surveyed to gauge their perceptions regarding the contribution of various infrastructural resources to the attainment of learning outcomes.

Respondents rated each resource on a Likert scale ranging from 1 (indicating minimal contribution) to 5 (indicating maximal contribution). The data reflecting these evaluations are summarized in Table 2, which delineates the perceived influence of infrastructural resources on learning outcomes.

Table 2 Extent to which Infrastructure Resources contribute to Learning Outcomes

Teacher Characteristics		Labarator y	TV Room	Comput er Room	Library	Botanic al garden	Aquarium	Zoo
Gender	Male	4.54	3.25	4.29	4.08	3.75	3.38	3.33
	Female	4.27	3.14	3.50	3.32	3.41	3.05	2.86
	Total	4.41	3.20	3.91	3.72	3.59	3.22	3.11
Age	25-34 years	4.27	3.18	3.82	3.86	3.59	3.23	3.09
	35-44 years	4.36	3.82	3.91	3.73	4.00	3.55	3.45
	45-54 years	4.90	2.80	4.20	3.60	3.30	3.00	2.90
	55 years+	4.00	2.33	3.67	3.00	3.00	2.67	2.67
	Total	4.41	3.20	3.91	3.72	3.59	3.22	3.11
	Experience	4 years -	3.75	2.38	3.50	3.38	3.38	3.00
	5-10 years	4.52	3.70	3.96	4.04	3.83	3.52	3.39
	11-15 years	4.40	3.80	4.00	4.00	4.00	3.60	3.60
	16-20 years	5.00	1.00	5.00	1.00	1.00	1.00	1.00
	21-25 years	5.00	2.50	3.75	3.50	3.25	2.25	2.50
	30 years and above	4.40	2.60	4.20	3.20	3.20	3.00	3.00
	Total	4.41	3.20	3.91	3.72	3.59	3.22	3.11
	Average	4.41	3.20	3.91	3.72	3.59	3.22	3.11

The use of the laboratory was rated highest among infrastructural resources, with a mean score of 4.41, underscoring its critical role in facilitating the attainment of learning outcomes. This finding corroborates the assertions of Namasaka et al. (2017) and Rosenthal (2018), who emphasize that the laboratory environment enables students to engage in experiential, hands-on experimentation, which is widely recognized as a catalyst for improved academic achievement. This evidence suggests that teachers possess a clear understanding of the indispensable role that laboratory-based instruction plays in enhancing Biology learning outcomes, notwithstanding the observation that, in practice, laboratories were under-utilized during classroom sessions.

Regarding the utilization of the computer room, teachers assigned it a mean rating of 3.91, identifying it as the second most significant infrastructural resource contributing to the

attainment of learning outcomes. This finding aligns with the observations of Rapholo, Lelliott and Rauscher (2018), who contend that the use of computer facilities can substantially enhance student achievement by facilitating comprehension of abstract biological concepts. Consequently, the finding of this study suggests that while teachers are endeavoring infrastructure resource remains under-exploited, most likely due to limitations in both technological resources and technical proficiency. to integrate computer room resources into Biology instruction, the full potential of this

The libraries were rated at 3.72. This finding indicates that some teachers valued library use to build on the achievement of learning outcomes in Biology teaching. This concurs with Alade & Iwu (2018) who state that some teachers understand that utilization of libraries significantly impacts on students' academic performance. The botanical garden was rated 3.59. A botanical garden is important in Biology teaching as it promotes achievement of higher levels of cognitive outcomes such as analysis and skills, such as observation (Stregar et al, 2019). The findings of the present study show that teachers appreciate that use of infrastructure such as library and botanical garden can promote high achievement of learning outcomes even though they were not using the resources sufficiently.

Television rooms were rated at 3.20 in enhancing the achievement of learning outcomes among the learners. This finding shows that the teachers were in agreement with Sugimoto et al (2017) who note that learning of Biology in the television room may enhance achievement of learning outcomes. Further, this shows that teachers found use of TV rooms somewhat useful in contributing to the achievement of learning outcomes. TV room use, therefore, should be encouraged as it has the potential to engage students, which in turn can promote learning.

The aquarium and the zoo were rated at 3.22 and 3.11. This finding is in line with that of Jensen, et al. (2019), who point out that use of zoos and aquariums in teaching Biology can promote high understanding of aquatic and biological ecosystems, enhancing students' critical thinking skills and scientific inquiry such as hypothesis testing and data analysis. Use of zoos and aquarium in teaching Biology may, therefore, contribute to a great extent in the achievement of learning outcomes.

Overall, teachers rated high the botanical garden, the aquarium and the zoo in teaching Biology (above 3 in a scale of 1-5). Teachers thus noted that these infrastructural resources were useful in contributing to achievement of learning outcomes. These findings show that teachers appreciated the use of different infrastructure in promoting the achievement of learning outcomes but unfortunately, they were not utilizing the most desired infrastructure.

In the qualitative phase, the researcher engaged key informants to explore more on the extent to which various infrastructural resources such as the laboratory, classroom, library, computer room, television room, botanical garden, aquarium and zoo contribute to the attainment of desired learning outcomes. Key Informants W offered the following insights:

The laboratories, if used for practicals, provide for hands-on working promoting not only cognitive skills such as application but also developing skills such as observation, measurement and experimentation. Exclusive classroom use may promote low cognitive order outcomes such as remembering. The computer room helps students to research and apply concepts. By comparing different researched concepts, they are

able to analyse and come up with conclusions. The library can also promote comprehension due to research as well as analysis. The TV room can bring practical applications and a deep understanding. The botanical garden, the aquarium and the zoo can help learners attain higher order cognitive skills such as application, analysis and synthesize as well as skills outcome such as hypothesis creation. The three also enhance positive attitudes to the subject which can promote learning.

Key Informant W observed that the use of a laboratory, by facilitating practical engagement, fosters not only cognitive outcomes such as the application of knowledge but also the development of essential scientific skills, including observation, measurement and experimentation. This insight stresses the laboratory's capacity to support higher-order learning outcomes and highlights its underutilization in the teaching and learning of Biology. According to the informant, the exclusive reliance on traditional classroom settings may primarily nurture lower-level cognitive skills such as recall and recognition. This observation may help explain the persistent gap in learners' attainment of advanced cognitive competencies such as synthesis and evaluation as documented in Kenya National Examinations Council (KNEC) reports from 2012 to 2023.

Regarding the library and computer room, the informant noted that their capacity to support independent research may facilitate cognitive outcomes such as comprehension and analysis, particularly through processes of comparison and critical engagement with information. However, this potential appears under-realized, as earlier findings in the study have revealed that these facilities were infrequently utilized. Consequently, the development of mid-level cognitive outcomes such as comprehension and analytical reasoning remains limited. Further, Key Informant W emphasized that resources such as the botanical garden, aquarium and zoo, by enabling learners to engage directly with living plants and animals, have the potential to foster higher-order cognitive outcomes, including analysis, synthesis and the formulation of hypotheses. In addition, these experiential learning environments may contribute to affective outcomes by cultivating a positive attitude towards the study of Biology.

Subsequently, the researcher sought to ascertain learners' perspectives on the extent to which the utilization of various infrastructural resources influenced the achievement of learning outcomes. In one of the FGDs, the learners offered the following reflections:

School Q

R1: The laboratory has a practical study area that helps in remembrance because anything that is taught and done by your hands is easier to remember

R2: Laboratory brings about understanding to the concept that you are covering.

R3: Laboratory also improves skills like observing and helps you to remember during exams.

R4: In the laboratory, the attitude is positive. In the classroom, it is different since people in the classroom can sleep and play but, in the lab, when you have the apparatus in front of you, you can't do anything playful there. Many of the students will be active.

R1: I think the learning outcomes we get from the classroom is different for me because in the classroom a teacher might come and teach something but when they come the next day the learner might have forgotten what had been taught.

R5: We have never visited the botanical garden and the aquarium in our school. I am sure it can help us in our exams.

R2: The challenge is that we use the laboratory like a classroom instead of doing experiments. In such a case learning outcomes will be same as those in the classroom.

R1: You see in the classroom the teacher mainly just dictates notes. So you forget what you learn.

R3: I guess the computer room and library may boost our learning outcomes but are not available for use in our school. Only computer students use the computer room.

R4: Madam I have never seen an aquarium or zoo.

R5: I think the botanical garden is the one Agriculture students' use for their KCSE project.

Learners in school Q attributed the use of the laboratory to achievement of learning outcomes such as remembrance, understanding and application. The learners also said that the laboratory enhanced their observation and experimentation skills and as well enhanced a positive attitude towards Biology. However, even in the laboratory, sometimes the learners did not conduct experiments and in this case same learning outcomes as those attained in the classroom may be achieved. The learners disregarded learning from the classroom and stated that it was difficult to attain even simple learning outcomes like remembering. The learners in school Q further said that the classroom may encourage them to play and sleep during the lesson. This shows that the learners did not like learning from the classroom all the time.

It is noteworthy that learners in School Q did not provide any substantive input regarding the influence of the library, computer room, television room, aquarium, or zoo on the achievement of learning outcomes. While some learners expressed the belief that the use of the computer room and library could potentially enhance learning outcomes, they were unable to specify the nature of these outcomes, as they had not been afforded the opportunity to access or utilize these facilities. This finding suggests a latent enthusiasm among learners to engage with diverse infrastructural resources, which remains unmet due to limited availability and access.

These findings are consistent with the observations of Widodo and Agustin (2016) as well as Etobro and Fabinu (2017), who report that teachers predominantly deliver instruction within conventional classroom settings. Even in cases where laboratories are present, they are frequently repurposed as standard teaching spaces, with limited emphasis on experimental or hands-on activities. In addition, infrastructural resources such as botanical gardens and aquaria are seldom available in most schools, thereby constraining opportunities for experiential learning and contributing to the underachievement of intended learning outcomes. These findings draw attention to the imperative of integrating a broader range of infrastructural resources into the teaching and learning process to facilitate more effective and holistic educational experiences.

5.0 CONCLUSION

In conclusion, the findings of this study reveal a marked under-utilization of diverse infrastructural resources in the teaching and learning of Biology. Instruction in the surveyed schools predominantly relied on conventional classroom settings, with occasional use of the laboratory. However, critical facilities such as the computer room, library, botanical garden, aquarium, and zoo; each of which has the potential to support higher-order cognitive outcomes such as analysis, synthesis and hypothesis formulation, were largely inaccessible or unused. As a result, the instructional approaches employed were limited to fostering lower-order cognitive

outcomes and basic scientific skills such as observation and measurement, while failing to cultivate more advanced competencies and affective engagement. Moreover, the minimal use of stimulating learning environments contributed to learner disengagement, suggesting a deficiency in promoting positive attitudes toward Biology.

This study, therefore, concludes that infrastructural resources utilization in Biology instruction were insufficient and primarily conducive to the attainment of low-level cognitive outcomes, rudimentary science process skills, and suboptimal affective responses.

5.1 Recommendations

The following are the findings of this study:

1. The infrastructural resources used by the teachers and learners should be expanded and diversified so as to enhance the quality and depth of Biology education.
2. Learners should be afforded opportunities to access and utilize infrastructural facilities, and conduct experiments during practical Biology lessons to promote active learning.
3. Learners should be helped to contextualize biological concepts within observable realities. This will enhance their ability to connect theoretical knowledge with practical, lived experiences.
4. Biology teachers should integrate a broader range of infrastructural resources such as libraries, television rooms, botanical gardens, zoos or aquariums into the teaching and learning process to facilitate more effective and holistic educational experiences.
5. The teachers should fully exploit the pedagogical advantages of laboratory-based instruction in Biology. This is because the laboratory environment can help learners to undertake hands-on experimentation and direct observation, thereby enhancing conceptual understanding.

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