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Utilisation of Instructional Resources and Achievement of Learning Outcomes: The Case of Teaching and Learning of Biology in Nairobi City County, Kenya

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ABSTRACT

Biology is widely recognized as a foundational scientific discipline, underpinning critical advancements in fields such as genetic engineering and medicine. However, national examination reports in Kenya from 2013 to 2023 consistently reveal sub-optimal student performance in Biology, suggesting persistent challenges in its pedagogy and learning processes. This study investigated the extent to which the utilization of teaching and learning resources influences students' academic performance and the attainment of intended learning outcomes in Biology. 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 revealed that the use of instructional 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.

KEYWORDS: Instructional resources, learning outcomes, teaching and learning, Biology instruction, student achievement

1. INTRODUCTION

Biology, as a core scientific discipline, plays a vital role in driving socio-economic development through its contributions to critical sectors such as health, biotechnology, agriculture and environmental sustainability. In industrializing countries, including Kenya, the importance of Biology education is underscored by national and international development frameworks that link scientific literacy to economic competitiveness and innovation (World Economic Forum, 2006; NGSS, 2013; Republic of Kenya, 2007, 2015, 2019; NESP, 2015). Despite this recognized significance, a body of research indicates that education systems are struggling to deliver effective Biology instruction, resulting in consistently low student achievement and weak learning outcomes in the subject (Morsel and Hand, 2018; OECD, 2017). These shortcomings are often attributed to a range of persistent challenges: inadequate use of teaching and learning resources, insufficient teacher training and limited engagement with practicals.

Given Biology's critical role in equipping learners with scientific skills essential for addressing real-world challenges, there is an urgent need to enhance the quality of its teaching. This requires deliberate investment in pedagogical strategies, resource allocation and curriculum implementation that support meaningful and outcomes-based Biology education. A significant number of students who report difficulty in mastering Biology concepts, often attribute their lack of understanding to instructional approaches that fail to connect new content with their existing knowledge base (Bustami, Syafruddin & Afriani, 2018).

Research indicates that in the absence of explicit instructional support, learners tend to retain their pre-existing misconceptions, which can hinder conceptual development (Bustami et al., 2018). As a result, it is imperative for Biology educators to actively elicit, recognize and address students' prior conceptions as a foundation for effective instructional planning and delivery. Meaningful learning in Biology occurs when students are supported in constructing understanding through sense-making processes (Ashoori, Kajbaf, Manshaee, & Talebi, 2014; Bustami et al., 2018). To this end, teachers must create opportunities that enable learners to engage cognitively with content such as through visualization of abstract concepts, hypothesis formulation, critical analysis and argumentation.

Strategic use of teaching and learning resources, thus, becomes essential in facilitating deeper comprehension, enabling students to bridge gaps between theoretical knowledge and practical understanding in Biology. The effective utilization of teaching and learning resources is also a critical component in the teaching of Biology, particularly given the heavy nature depicted in the subject's abstract and concept. Arya and Christ (2016), in a study conducted in China, demonstrated that successful Biology instruction requires the deliberate integration of instructional resources in a coherent and sequential manner to facilitate conceptual understanding.

Careful planning and systematic deployment of both material and infrastructural resources enable educators to address diverse learner needs by supporting the visualization and internalization of complex biological phenomena. Supporting this view, Morsel and Hand (2018) argue that the strategic use of material learning resources significantly enhances students' conceptual grasp by making abstract ideas more accessible and concrete. However, despite the recognized importance of instructional resources in Biology education, national examination reports in Kenya from 2013 to 2023 reveal persistently low student achievement in the subject. This trend suggests a disconnect between pedagogical expectations and actual classroom practices, particularly in the use of resources that support effective teaching and meaningful learning.

2. REVIEW OF LITERATURE

OECD (2017) highlights the need to embrace new ways of teaching using contemporary teaching and learning resources. Further, OECD states that teaching and learning resources provide for an organized delivery of content in a stable structure that may become the object of reflection and discussion. Utilization of teaching and learning resources is, therefore, vital in offering learners suitable experiences that promote learning, leading to achievement of the learning outcomes.

A study conducted by Ong'amo, Ondigi and Omariba (2017) in Kenya revealed that students who were taught using instructional resources demonstrated significantly better academic performance compared to those who received instruction with minimal or no resource support. These findings suggest a positive correlation between the use of teaching and learning resources and improved student achievement in Biology. However, the study did not explicitly identify the specific learning outcomes most influenced by the utilization of these resources, leaving a gap in understanding how various resource types contribute to distinct cognitive or skill-based gains.

Among the material resources examined, textbooks were reported as the most commonly used, primarily due to their accessibility and ease of use (Ong'amo et al., 2017). Textbooks offer structured content delivery, visual aids such as diagrams and illustrations, as well as embedded review activities and assessments that support content retention (Arya, 2016). On the other hand, their widespread use has been critiqued for reinforcing rote memorization and passive learning strategies, which are increasingly discouraged in contemporary pedagogical research in favor of approaches that foster critical thinking and conceptual understanding.

Morselli and Hand (2018) emphasize the value of visual aids such as charts and graphs in enhancing students' comprehension of complex biological concepts. These visualization tools enable learners to process abstract information more effectively by providing concrete, interpretable representations of data and relationships. In addition to visual materials, worksheets serve as important instructional resources that facilitate active engagement with content as found by Fu et al. (2013) that the use of worksheets significantly improved students' understanding of genetic concepts by encouraging the application of knowledge in novel contexts.

Similarly, Wang et al. (2017) noted that incorporating worksheets into Biology instruction can foster the development of critical thinking skills by prompting learners to analyze, evaluate and synthesize information. Collectively, these findings call attention to the pedagogical value of integrating material resources particularly graphs, charts and worksheets into Biology teaching, as they promote deeper conceptual understanding and cognitive engagement.

3. METHODOLOGY

This study adopted a mixed methods research approach, specifically utilizing an *explanatory sequential design* that entails the systematic collection, analysis and integration of both quantitative and qualitative data to comprehensively address the research questions. This methodological orientation was selected for its capacity to harness the complementary strengths of both quantitative and qualitative paradigms, thereby mitigating the inherent limitations associated with each when employed independently. As Creswell (2011) asserts, mixed methods research offers a robust framework for attaining a more holistic and nuanced understanding of complex research problems.

The explanatory sequential design characterized by a two-phase investigative process, beginning with the collection and analysis of quantitative data, followed by a subsequent qualitative phase designed to elaborate on and provide deeper insight into the initial findings was employed to guide the study's structure. In the first phase, quantitative data were gathered to capture measurable aspects of the phenomenon under investigation, including but not limited to learning outcomes, types of teaching and learning resources and pedagogical processes.

The insights derived from the quantitative analysis informed the design and implementation of the qualitative phase. Specifically, the quantitative results guided the purposive selection of participants for in-depth qualitative inquiry and shaped the development of interview protocols and other data collection instruments. The over-arching objective of this sequential integration was to elucidate and contextualize the quantitative findings by eliciting explanatory narratives and experiential perspectives from participants, thereby enriching the overall interpretation and validity of the study's conclusions.

The intent of the qualitative phase, in this study, was to deepen the understanding of both the instructional processes involved in teaching Biology and the resultant learning outcomes interpreted as the 'product' of the pedagogical process. Building upon the quantitative findings, the researcher purposively selected a subset of schools that were identified through statistical analysis as illustrative cases for further qualitative exploration. Within these selected sites, Biology lessons were systematically observed, and data were gathered from key informants to capture their perspectives, interpretations and lived experiences related to the teaching and learning of Biology.

In alignment with Gough and Deatrick (2015), the qualitative component emphasized not only the exploration of outcomes but also a rigorous investigation of the underlying processes shaping those outcomes. This phase sought to uncover how pedagogical practices are enacted in real classroom settings and how various contextual factors interact to influence the efficacy of instruction and student comprehension. As Doldor, Silvester and Atewologun (2017) note, qualitative methodologies facilitate an intensive, context-sensitive inquiry that yields a rich, holistic understanding of complex educational phenomena.

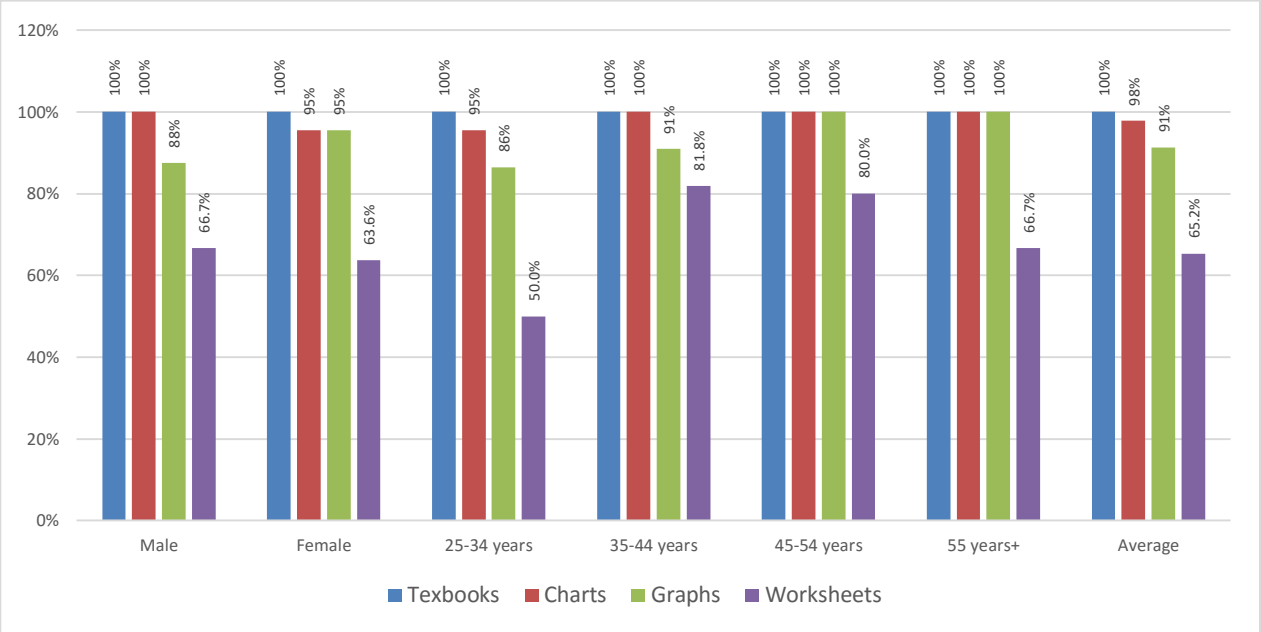
Through direct classroom observation and in-depth engagement with educators and learners, the study was able to elicit nuanced insights that illuminated the patterns, meanings and contextual dynamics underlying the quantitative trends. Together, the sequential integration of quantitative breadth and qualitative depth enabled a more comprehensive and multi-faceted understanding of the research problem, enhancing the validity, interpretive power,and practical relevance of the study's findings.

The adoption of a mixed methods research design, while methodologically robust, also presented several practical challenges. Chief among these were the demands of extensive data collection and the time-intensive processes required for analyzing both quantitative and qualitative datasets. In anticipation of these complexities, the researcher developed a structured and coherent sequence of research activities to ensure methodological rigor. Adequate time was allocated for each phase of the study, data collection, analysis and integration to uphold the integrity of the research process and enhance the credibility and trustworthiness of the findings.

4. FINDINGS AND DISCUSSION

In the quantitative phase, Biology teachers were surveyed on their utilization of various material resources in instruction. Figure 1 presents their responses regarding the extent to which these resources were employed in the teaching of Biology.

Figure 1: Use of Material Resources in Teaching Biology



All 100 teachers (100%) reported using textbooks in teaching Biology, regardless of age or gender. A majority (98%) used charts while 91% employed graphs. Worksheets were the least utilized, with only 65% of teachers indicating their use. These results suggest a high level of reliance on material resources (65% – 100%), particularly those that are readily available and easy to use. This aligns with findings by Ong'amo, Ondigi and Omariba (2017), which highlighted the accessibility and usability of textbooks. The data imply that teachers prioritize convenience and availability in resource selection, with textbooks being most accessible, followed by charts and graphs, and worksheets being the least favored.

As Arya (2016) notes, visual aids such as charts and graphs enhance conceptual understanding and memory retention, a claim supported by the widespread use of these tools among the respondents. The researcher, through the qualitative study approach, sought to find out from the experts how teachers and students should use material resources especially the text books. The response from Key Informant W was as follows:
When it comes to books, we tell teachers how to study the books they use because there is also a case where teachers teach the text book and not the curriculum… some teachers have never looked at the syllabus. Some teacher wakes up and looks at the topic in the textbook and makes notes.

On the same concern of how teachers should utilize text books, Key Informant Y added:

KICD has prepared the 'orange book' which has specified a list of books you are to select from. Like we have the long horn, the comprehensive, we have the oxford. So a teacher is not supposed just to use one particular book.

Key informants emphasized that textbooks should be used in alignment with the syllabus and selected from the list of KICD-approved resources outlined in the 'Orange Book.' This emphasis is consistent with findings by Arya and Christ (2016) and Timms (2018), who stress that textbooks, as essential teaching tools, must be used in accordance with curriculum standards.

The researcher conducted focus group discussions with students in six schools to explore how both teachers and learners utilized textbooks in Biology instruction.

The students' responses in School Q were as follows:
R1: We refer to different types of text books. Highflier, test it and fix it, get it right, KCSE made familiar...
R2: The teacher comes with his own notes from the website, from the media and research and us students have the government course book certificate and other revision books so we check different points from every section.
R3: Sometimes the text book can help for revision. We have more revision books compared to course books.

R3: Some text books however have computer errors which may mislead the learner.
R4: Some text books have too many notes that can make a student not to read all of them.
R5: Our teacher also uses charts to show diagrams though not often
R1: Once in a while he also uses worksheets and asks us to work in pairs or groups.

In School Q, students reported using textbooks primarily for reference and revision. They often consulted multiple texts to compare content, a practice also observed in Schools R, S, and T. This access to a variety of textbooks suggests an enriched learning environment that promotes deeper engagement with content. These findings align with those of Arya (2016), who emphasized the central role of textbooks in Biology instruction due to their structured content, illustrative diagrams and embedded review exercises.

Notably, students in School Q demonstrated critical engagement with the materials, identifying typographical errors and commenting on the excessive verbosity in some texts. Additionally, the teacher in School Q supplemented textbook content with notes drawn from diverse sources, including media and online platforms. These observations underscore that while textbooks remain indispensable to Biology education, their quality must be rigorously vetted. Texts containing errors or poorly structured content can undermine learning and should be excluded from instructional use.

In School Q, teachers occasionally used charts to illustrate diagrams and employed worksheets intermittently to encourage pair or group work among students. However, these resources were used less frequently than textbooks. This pattern aligns with Wang et al. (2017), who observed that while worksheets, charts and graphs are valuable instructional tools in Biology; their usage tends to be limited in comparison to textbooks. Given their potential to enhance student engagement and conceptual understanding, it is recommended that teachers intentionally integrate these supplementary resources more consistently to support more effective and interactive learning experiences.

Unlike learners in schools Q, R, S and T, learners in school V and U expressed challenges in utilization of text books and other material resources. Learners in School V had this to say:
R1: We use 2 text books. KLB and Certificate. Our school has few books because of lack of money to replace the lost ones by former students. The teacher usually uses KLB and students share few copies of certificate. Sometimes the information in the books is not the same. When the teacher asks a question and use certificate sometimes you are not getting it.
R2: We write our own notes from certificate.
R3: Our teacher doesn't use charts and worksheets. We use only the text books.

In School V, students relied on only two textbook types, with the teacher instructing them to write notes from a different text (***Certificate***) than the one used in class (*KLB*). This practice indicates textbook inadequacy, compelling students to manually copy content due to limited access. These findings align with those of Ong'amo, Ondigi, and Omariba (2017), who highlight that the high cost of teaching resources often hinders adequate use of materials like textbooks in some schools.

In School V, students were required to copy notes from a textbook (***Certificate***) that was not their preferred resource, due to the unavailability of the more favored KLB textbook, which was reserved for the teacher. This practice, while necessitated by resource constraints, is time-consuming and limits students' opportunity to engage meaningfully with content. These findings support those of Timms et al. (2018), who observed that in resource-poor schools, the limited materials available are often monopolized by teachers. The ***Certificate*** textbook used by students was reported to contain errors, suggesting a disparity in quality between the teacher's and learners' resources. Moreover, the teacher did not employ additional instructional aides such as charts or worksheets, resulting in an over-reliance on inadequate textbooks. This situation was also noted in School U, and this puts students in such contexts at a clear disadvantage, particularly given the central role of textbooks in Biology instruction.

Following the assessment of material resource utilization in Biology instruction, the researcher examined their influence on learning outcomes. Using a five-point Likert scale (**1 = lowest, 5 = highest**), Biology teachers indicated the extent to which various instructional resources contributed to students' achievement. The results are summarized in Table 1.

Table 1: Extent to which Material Resources Contribute to Learning Outcomes

Teacher Characteristics		Textbooks	Charts	Graphs	Worksheets
Gender	Male	4.21	3.83	4.04	3.17
	Female	3.91	3.50	3.41	3.32
Age	25-34 years	3.77	3.50	3.50	3.05
	35-44 years	4.27	4.18	3.82	2.91
	45-54 years	4.70	3.70	4.40	3.90
	55 years+	3.33	3.00	3.00	3.67
Experience	4 years or less	3.25	3.50	3.38	3.13
	5-10 years	4.22	3.78	3.70	3.17
	11-15 years	4.40	4.20	4.00	2.60
	16-20 years	4.00	2.00	4.00	4.00
	21-25 years	4.75	4.50	4.50	3.75
	30 years and above	3.80	2.60	3.60	3.80
Average		**4.07**	**3.67**	**3.74**	**3.24**

Across all age groups, gender and levels of teaching experience, teachers rated worksheets (3.24), charts (3.67) and graphs (3.74) as moderately useful in enhancing learning outcomes, while textbooks received a higher rating of 4.07, indicating they were considered significantly more effective. Most teachers, thus, viewed textbooks as the most impactful resource for promoting student achievement. However, this contrasts with the findings by Morselli et al. (2018), who argue that reliance on textbooks may foster rote memorization rather than deep understanding. The implication is that many Biology teachers in this study may not have employed instructional methods that support higher-order thinking, potentially limiting students' learning outcomes.

Kenya National Examinations Council (KNEC) reports from 2013 to 2022 indicate that many Biology students struggle with questions requiring higher-order cognitive skills such as analysis and evaluation. Interestingly, teachers with over 30 years of experience rated worksheets as the most effective resource in enhancing learning outcomes. This supports the findings by Fu et al. (2013) and Wang et al. (2017), which highlight the role of worksheets in fostering active learning and critical thinking. Such approaches enable deeper conceptual understanding and improved academic performance. However, the limited use of worksheets observed in this study suggests a missed opportunity to enhance learners' higher-order thinking and achievement.

Using a qualitative approach, the researcher explored expert perspectives on how material resources such as textbooks, charts, graphs and worksheets influence the achievement of learning outcomes based on Bloom's taxonomy. Originally structured in six hierarchical levels: Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation, the taxonomy was revised in 2001 to: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating. Key Informant X provided the following insight:

"You know Bloom's taxonomy starting from the lowest level of knowledge there are various things that are done. Using text books can help learners remember which is the lowest. It only requires a student to remember what they were taught. If the text book is good and has illustrations, it may help learners to comprehend. Illustrations, charts and graphs help learners visualize hence comprehend concepts. When you use worksheets, especially in groups, It helps learners work together. That is collaborative learning which encourages positive attitude. When one student is saying "si uangalie.. what are you seeing?" that one promotes achievement of higher outcomes like application and analysis."

Key Informant X observed that textbooks primarily support lower-order outcomes such as remembering, and may aid comprehension if well-illustrated. Over-reliance on textbooks, however, limits the development of higher-order thinking. Charts and graphs were noted to enhance visualization and comprehension, contributing to moderately higher cognitive outcomes. Worksheets were identified as being the most effective in fostering high-order skills such as application and analysis by promoting collaborative learning. This perspective aligns with Morselli and Hand (2018), who emphasize that visual aids like charts and graphs significantly enhance students' comprehension of Biology. Worksheets, in particular, facilitate deeper understanding and the application of concepts to novel contexts. Consequently, worksheets are ranked as highest material resources that best promote higher-order learning, followed by graphs and charts, with textbooks contributing least.

The researcher further sought from the learners' FGDs what learning outcomes teaching and learning resources such as text books, graphs and charts helped learners to attain. The following were the responses from School Q:
R1: Text book can help one to improve on what the teacher has not taught but other classes have been taught and your class have not been taught so you refer and are able to remember.
R3: charts and graphs help you apply theory.
R4: you can find the student has learnt the topic but has not understood it so through the worksheet when working with others it can help him to understand and analyze questions.

In School Q, a learner observed that textbooks aid in remembering and understanding concepts, indicating that their use primarily supports learning up to the second level of Bloom's taxonomy - understanding. However, as noted by a learner in School U, in the following quote, a well-crafted textbook incorporating questions, graphs and charts has the potential to facilitate higher-order cognitive skills.
R1: I use the textbook to revise. I like using KLB because at the end of each topic there are questions for revision and it helps me understand concepts. KLB also has diagrams, charts and graphs which can help one process and apply the knowledge gained. I refer to it myself so then I can understand better
For charts and graphs, from the FGD discussions, one can detect that they help in achievement of the learning outcomes up to the application level of the taxonomy. For worksheets, the learners in school R said the following:
R4: We rarely use worksheets in our lessons and I even think we do not know what that is as far as Biology is concerned.

A learner in School R reported that worksheets facilitate both understanding and analysis, indicating their role in supporting higher-order learning outcomes up to the analysis level of Bloom's taxonomy, thus surpassing textbooks, charts and graphs. Worksheets also encourage collaborative learning, further enhancing knowledge acquisition. These findings are in line with those of Arya (2016), who argues that textbooks primarily promote memorization and, if well illustrated, can improve learning, whereas worksheets foster higher cognitive skills such as analysis. Thus, based on learners' focus group discussions, it can be noted that worksheets most effectively support higher-order learning outcomes, while textbooks predominantly reinforce lower-order skills like remembering.

5. CONCLUSION

In view of this foregoing findings and discussion, the study concludes that the current use of instructional material resources in Nairobi City County largely limits achievement to low-order cognitive learning outcomes.

Recommendations

Based on the findings, it is recommended that:

1. Teachers should critically analyze the syllabus prior to instruction to ensure that textbook content aligns with curricular objectives.
2. Teachers should avoid relying solely on textbooks to guide lesson content and instruction, as this may lead to gaps if the texts are not fully aligned with the syllabus. Over-reliance on poorly aligned textbooks risks omission of essential knowledge and skills.
3. Teachers should consult multiple approved textbooks to cross-reference content and identify any inconsistencies or errors. Referring to a variety of vetted resources enhances instructional accuracy and supports the delivery of comprehensive and reliable subject matter.

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