Journal of Turkish Science Education, 2025, 22(4), 801-821.
DOI no: 10.36681/tused.2025.039

Journal of Turkish Science Education
http://www.tused.org
© ISSN: 1304-6020

Integration of indigenous knowledge into grade 8 biology teaching and its effect on students' achievement

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ABSTRACT

This study examined the effect of integrating indigenous knowledge on eighth-grade students' ecology and biodiversity achievement in Injibara, Ethiopia. A nonequivalent pre-test-post-test quasi-experimental research design with a mixed-methods approach was employed. A total of 89 students participated in the study, with two intact classes randomly assigned: 46 students to the control group and 43 to the experimental group. Data were collected using a 25-item Ecology Achievement Test (EAT) and a focus group discussion. The face and content validity of the instruments were confirmed by advisors and subject experts. The internal consistency of the test items was assessed using the Kuder-Richardson formula (KR-20), yielding a coefficient of 0.83. Independent samples t-tests and analysis of covariance (ANCOVA) were used to test the null hypotheses, while means and standard deviations were used to address the research questions. The results showed that the experimental group outperformed the control group in integrating indigenous knowledge. Additionally, the achievement was not significantly influenced by gender, and there was no interaction between gender and the teaching method. These finding suggests that integrating indigenous knowledge into biology instruction enhances students' academic performance and fosters more effective teaching and learning outcomes.

RESEARCH ARTICLE

ARTICLE INFORMATION
Received:
18.12.2024
Accepted:
29.05.2025
Available Online:
23.21.2025

KEYWORDS:
Aacademic achievement, ecology and conservation, indigenous knowledge.

To cite this article: Yeruke, S. K., Ferede, M. W., & Merawi, T. M. (2025). Integration of indigenous knowledge into grade 8 biology teaching and its effect on students' achievement. *Journal of Turkish Science Education, 22*(4), 801-821. http://doi.org/10.36681/tused.2025.039

Introduction

Education is universally recognized as a cornerstone of sustainable development, fostering intellectual, social, moral, and practical growth across generations (Cimer, 2012; Mohanty, 2021). Beyond its role in personal development, education contributes to national progress by cultivating human capital, advancing innovation, and promoting social cohesion. In particular, science education plays a pivotal role in elevating societal standards and encouraging technological and cultural transformation (Gödek, 2004). Within this framework, biology education in Ethiopia is central to equipping learners with the scientific knowledge, attitudes, and practical skills necessary to address pressing challenges such as environmental conservation, public health, and sustainable agricultural development (Teferra et al., 2018). As a foundational science, biology supports industrialization and innovation through its applications in biotechnology, environmental management, and resource utilization (Jima, 2022).

Biology is also strategically aligned with Ethiopia's long-term development goals articulated in Vision 2030, which aims to transition the country into a middle-income economy. The national education policy emphasizes Science, Technology, Engineering, and Mathematics (STEM) by allocating 70% of higher education enrolments to these disciplines, reflecting the government's intent to build a skilled and innovative workforce (Chala, 2015; Teferra et al., 2018). Strengthening biology education, therefore, is integral to achieving Vision 2030 objectives, particularly in improving agricultural productivity, advancing healthcare, and promoting environmental stewardship. Enhancing biology learning at the foundational level, such as in Grade 8, is essential for nurturing students' scientific literacy, critical thinking, and problem-solving abilities. Integrating Indigenous Knowledge (IK) into biology instruction offers a culturally grounded and practical approach to achieve these competencies, laying the groundwork for future expertise in STEM fields. Through early exposure to locally relevant and experiential learning, students are better prepared to contribute to national development efforts and sustainable innovation.

Despite the recognized importance of biology education, student performance in the subject remains persistently low in Ethiopia. Studies reveal that many students entering secondary education exhibit weak foundational knowledge in science and mathematics (Tulu & Fantahun, 2021). Data from the National Educational Assessment and Evaluation Agency (NEAEA) further indicate that only 22.9% of Grade 10 students and 48.5% of Grade 12 students achieved scores of 50% or higher in biology (Yimam, 2023). These statistics fall short of national education standards, which require a minimum average of 50% across all subjects. Such outcomes raise critical concerns about the effectiveness of current teaching strategies and curriculum design in achieving desired learning outcomes.

Research across Africa identifies various factors influencing students' low achievement in science, including the use of teacher-centered pedagogies that disconnect learning from real-life experiences (Agboghoroma & Oyovwi, 2015; Naidoo, 2007). Additionally, cultural incongruence between classroom instruction and students' lived experiences often limits engagement and comprehension (Hodson, 2009). The inadequate incorporation of Indigenous Knowledge systems into the curriculum further compounds this issue (Nair & Abera, 2017; Ogunniyi, 2009). A recent analysis of Ethiopia's Grade 7 General Science curriculum revealed that nearly 79% of instructional activities fail to incorporate or encourage connections with IK (Yeseraw et al., 2023). Similarly, current textbooks seldom reflect indigenous contexts or pedagogical practices, underscoring an urgent need for curriculum reform that integrates local knowledge systems and values (Da Silva et al., 2024).

Indigenous Knowledge, defined as the cumulative wisdom, skills, and practices developed by communities through generations of interaction with their environments (Mukuka, 2019) offers a culturally relevant and contextually meaningful framework for science education. Within this study, IK specifically refers to the traditional knowledge of the Awi community, encompassing ecological awareness, sustainable agricultural methods, soil and water conservation techniques, medicinal plant usage, and seasonal environmental patterns. This knowledge base, rooted in culture and practical experience, serves as a pedagogical bridge linking local environmental understanding to formal biological concepts. By contextualizing biology instruction within students' cultural realities, IK-based teaching can enhance engagement, comprehension, and retention, making scientific learning more accessible and meaningful (Kassa et al., 2024).

Despite these potential benefits, many developing countries continue to rely heavily on conventional, lecture-based teaching methods that limit student participation and conceptual understanding (Upu & Okwara, 2024). Empirical studies demonstrate that such traditional methods are less effective than innovative, context-based pedagogies that integrate IK and encourage active learning

(Adam, 2023; Ajayi et al., 2023; Fenetahun, 2018; Jima, 2022). Incorporating IK into biology education fosters a more holistic and experiential approach that links science with culture, thus improving conceptual understanding and student motivation (Khusniati et al., 2023). As Oluboyo (2021) asserts, education in indigenous settings must be both culturally and linguistically relevant to ensure equitable learning outcomes.

Ethiopia possesses a rich reservoir of Indigenous Knowledge across diverse domains, including traditional medicine, seed preservation, water management, and adaptive farming practices designed to address food insecurity (Tizita, 2016). Each ethnic community contributes distinct systems of knowledge that reflect local ecological conditions and cultural values. Given the diversity and contextual nature of IK, it is imperative to conduct region-specific studies that explore how these knowledge systems can be effectively integrated into formal education. For instance, research by Ali et al. (2022) has examined IK transfer in traditional medicine and agriculture, demonstrating that its integration into science teaching enhances learning relevance and outcomes. Similarly, Yeseraw et al. (2023) evaluated the inclusion of IK elements in Amhara Region trial textbooks, while Baye and Teshome (2020) documented the contributions of IK to agricultural productivity and community well-being in Gondar and Gojjam.

However, despite this growing body of research, there remains a significant gap regarding the integration of IK into biology instruction and its direct influence on students' academic achievement in the study area. While the use of IK in teaching has been reported to improve student achievement internationally, it remains uncertain whether similar results will be observed in this region (study area). Moreover, it is unclear whether such pedagogical approaches benefit male and female students equally, as findings from previous studies on gender differences in science performance have been inconsistent. Some researchers report that females perform better under IK-based teaching (Nbina & Wagbara, 2012), whereas others, including Audu (2017), Chibuye and Singh (2024), and Uduaka et al. (2020), found that male students outperform females. In contrast, studies by Agboghoroma & Oyovwi (2015) and Ugwu & Diovou (2016) indicate no significant gender-based differences in achievement. This unresolved issue highlights the need for further investigation into gender interactions in the context of IK-based biology instruction.

Additionally, a practical gap persists among teachers regarding how to effectively integrate IK into classroom practice. Many educators lack the pedagogical training, resources, and frameworks necessary to blend traditional and scientific knowledge meaningfully. Methodologically, existing literature provides limited insight into evaluating the outcomes of IK integration and understanding the mechanisms through which it enhances student achievement (Bohensky & Maru, 2011). Addressing these empirical, practical, and methodological gaps is essential for advancing educational equity and effectiveness in Ethiopia.

This quasi-experimental study is therefore designed to examine the effects of integrating Indigenous Knowledge into biology teaching on students' academic performance, particularly in ecology and biodiversity conservation. It seeks to determine the extent to which IK-based teaching strategies improve student achievement compared to conventional methods and whether gender differences influence these outcomes. By aligning science education with local knowledge systems, this study aims to contribute to national goals of improving science literacy, promoting inclusive education, and supporting Ethiopia's broader vision for sustainable development.

Research Questions

The following research questions have been formulated to achieve the research objectives:

1. Does the integration of IK significantly enhance students' academic achievement in biology compared to traditional teaching strategies?

2. Is there a statistically significant difference in the average achievement scores between male and female students taught biology using IK?

3. How do students perceive the effects of integrating IK in the teaching and learning of biology?

Theoretical Framework

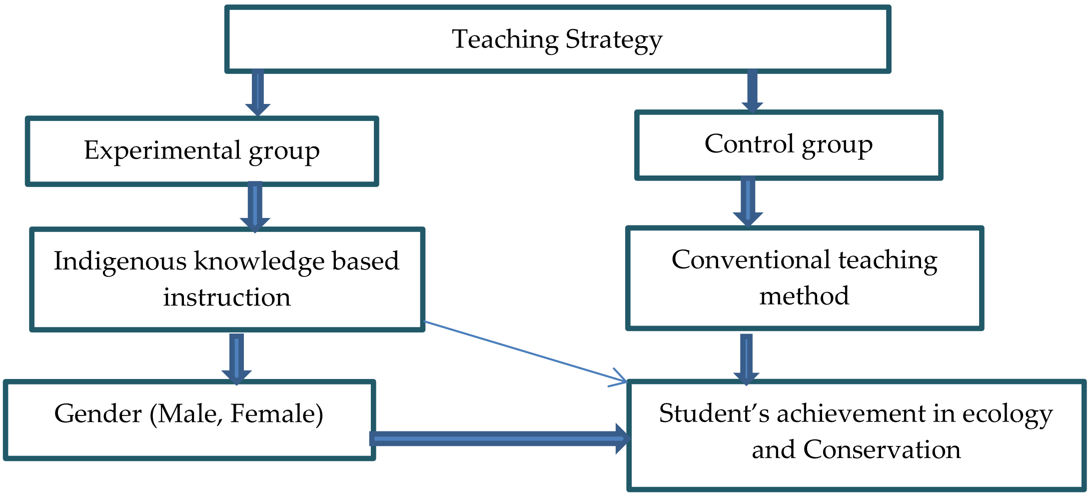
This study is based on Ausubel's theory of meaningful learning, an important concept in science education. Ausubel's theory suggested that meaningful learning occurs when new information is connected to relevant existing knowledge within a learner's cognitive structure. This illustrates the connection between students' learning and their prior knowledge (Ausubel, 2012). The theory suggested that learning happens when a learner's existing knowledge interacts with new material, such as Ethno-ecology knowledge and practices alongside school biology.

Integrating IK into biology education can enhance students' attitudes and understanding, leading to improved performance in the subject (Shishigu et al., 2021). This integration serves as an advanced organiser for new biology concepts, promoting positive attitudes and a deeper comprehension of biology (De Beer & Whitlock, 2009). For example, local Indigenous Knowledge (IK) about soil conservation—such as the traditional practice of using composted organic waste and crop rotation to maintain soil fertility—can serve as an advanced organizer for understanding the scientific concept of the nitrogen cycle. When students relate familiar practices like adding organic matter to soil with the scientific explanation of nitrogen fixation, nitrification, and decomposition, they can meaningfully connect prior experience to new biological concepts. This contextual link not only deepens comprehension of nutrient cycling but also reinforces the relevance of scientific knowledge to local agricultural sustainability, thereby fostering meaningful learning as described by Ausubel's theory.

Figure 1 illustrates the conceptual framework of the study. In this framework, teaching strategies are considered independent variables, while students' biology achievement is the dependent variable. The experimental group received instruction based on IK, whereas the control group experienced conventional teaching strategies.

Figure 1

Conceptual framework of the study



Literature Review

Integration of IK into Biology Teaching

The integration of Indigenous Knowledge (IK) into biology education represents a shift from traditional "cookbook" teaching methods toward a constructivist learning approach. Constructivism emphasizes that learners actively construct new knowledge by connecting it to their prior experiences and understanding (Onyewuchi & Owolabi, 2022). Through a step-by-step learning process, students progressively develop deeper conceptual comprehension (Taber, 2001). Studies show that incorporating learners' prior knowledge—often represented by their IK—enhances comprehension and engagement (Oladejo et al., 2022). Recognizing students' existing knowledge is, therefore, a key strategy for effective science instruction.

The effectiveness of integrating IK depends largely on teachers' expertise and pedagogical competence, which influence the quality of instruction (Ogunniyi (2009); Omorogbe & Ewansiha, 2013) highlighted a growing respect among teachers for IK, reflecting a dynamic relationship between scientific and indigenous worldviews. However, reliance on a single cultural perspective can marginalize students from diverse backgrounds (Mkhwebane, 2024). Teachers are thus encouraged to adopt multiple scientific and cultural approaches, recognizing the contributions of different knowledge systems. This requires identifying learners' cultural strengths and integrating them into science lessons to promote inclusivity and relevance.

Across Africa, governments have urged the inclusion of IK in school curricula to enhance learning outcomes and inclusivity (Oguoma, 2018). Despite this, many biology teachers either disregard this directive or lack the pedagogical skills to apply it effectively (Mavuru & Makhunga, 2020; Ngcobo, 2020). Sitsha (2022) observed that continued use of traditional methods limits student participation, while Cronje et al. (2015) found that IK is often treated as supplementary. Nonetheless, integrating IK fosters student motivation and connection to learning (Upu & Okwara, 2024).

Biology is often perceived as foreign by students; incorporating IK makes it culturally meaningful and relatable. Teaching biology through indigenous perspectives enhances students' appreciation and understanding of the subject (Anane, 2023). Integrating IK within the curriculum allows both knowledge systems to coexist, linking scientific learning with students' social and natural environments (Nwankwo, 2021). This approach promotes experiential, hands-on learning that improves comprehension and application (Liyas, 2019). Strengthening this integration through curriculum development at all educational levels is essential (Latip & Kadarohman, 2024).

Research shows that integrating IK into science subjects improves students' understanding, achievement, and attitudes (Chongo & Baliga, 2019; Mukuka, 2019; Shishigu et al., 2021). To enhance performance in biology, incorporating Ethiopian biological customs is vital. Achievement defined as the extent to which educational goals are met (Ibe, 2017; Shehzad & Aziz, 2019) in this context reflects students' ecological understanding as demonstrated through assessment outcomes.

Teaching Method and Gender Interaction

Due to the assumption that females are less valuable than males, males are given greater opportunities and authority in society due to gender factors associated with their views and beliefs (Uduaka et al, 2024). It is interesting to observe how these viewpoints permeate the educational system and, as a result, affect academic performance. That is to say, among other things, gender affects biology students' performance.

A study by Singh & Chibuye (2016) revealed that a higher percentage of females than males found biological concepts difficult to understand. This indicates that learning experiences may differ by gender. Similarly, Audu (2017) found that more females than males struggle with biological concepts, which could be linked to various factors such as socialisation and classroom experiences. Additionally, research by Chongo and Baliga (2019), and Mukuka (2019) noted significant differences in academic performance between male and female students, with male students outperforming their female counterparts.

In contrast, Agboghoroma & Oyovwi (2015) found that gender, whether male or female, had no effect on students' achievement in science. Both male and female students demonstrated improved performance when indigenous knowledge and practices were integrated into their learning compared to conventional methods (Ugwu & Diovou, 2016). This suggests that we cannot yet conclude whether gender influences understanding in biology, or which gender achieves higher in this subject. Therefore, this study incorporated gender to determine if it impacts students' achievement when integrating indigenous knowledge in teaching ecology and biodiversity conservation.

Students' Perception of Integrating IK into Biology Teaching

Omenka (2019) assert that students' interest in studying science is influenced by their perceptions of the subject. Specifically, students' interest in biology may be impacted by their views of the teaching environment. Many students appreciate IK-based instruction because it is relatively easy to understand and apply, which can enhance performance, productivity, and learning effectiveness (Anane, 2023). Additionally, lessons that incorporate IK are generally grasped more quickly. Omenka (2019) suggests that students' perceptions of school biology could improve if the curriculum bridges the gap between scientific concepts and IK, thereby addressing differences in worldviews and fostering greater student achievement.

According to Cimer (2012) and Cepni et al., (2017), students' perceptions of science are positively influenced when the subjects are taught in a way that relates to their daily lives. Additionally, Arboleda (2020) found that when students have high expectations in class, a positive attitude toward science significantly contributes to meaningful science learning. Generally speaking, students' positive perception of a subject or topic greatly improves their achievements. Adesoji (2008) suggests that investigating the impact of incorporating IK into biology instruction as a teaching strategy could be highly relevant for enhancing students' performance

Methodology

Research Design

A non-equivalent pre-test-post-test quasi-experimental research design with a mixed-methods approach was utilised. This design involved the simultaneous collection of both quantitative and qualitative data to support and validate the quantitative findings. In this approach, the quantitative method serves as the primary focus of the research, while the qualitative method acts as a secondary source that provides additional context. The qualitative component is considered less prioritised and is embedded within the dominant quantitative framework. This design is referred to as a concurrent embedded mixed research design (QUAN/qual), where the quantitative results are used to select the best participants for the qualitative study deliberately. Subsequently, the qualitative data help to clarify any quantitative results that need further explanation. As shown in figure 2 QUAN/qual notation indicates that the qualitative method is integrated within the quantitative method, with both occurring simultaneously. For the quantitative approach, the quasi-experimental pre-test-post-test non-equivalent control group design was chosen, allowing for greater control over extraneous variables (Nel, 2006).

A primary limitation of the non-equivalent pre-test–post-test quasi-experimental design is the potential for selection bias, as intact classes are used rather than randomly assigning students to groups. This means that pre-existing differences in students' abilities, motivation, or prior knowledge could influence the results independently of the intervention. To address this issue, a pre-test was administered to both the experimental and control groups to measure baseline equivalence. The resulting pre-test scores were then included as a covariate in the ANCOVA (Analysis of Covariance), which statistically controlled for these initial differences. This approach enhanced the internal validity of the study by ensuring that any observed post-test differences could be more confidently attributed to the intervention rather than pre-existing group disparities.

Figure 2

Concurrent embedded mixed research designs

Sampling Technique and Procedures

This study was conducted in Injibara City Administration, Awi zone, Amhara region, Ethiopia. As displayed in figure 3 the study used a population of six private and twelve governmental primary and middle schools in the Injibara city administration. Private schools were excluded from the study because they were not comparable to governmental schools. Private schools, compared to governmental schools, were better equipped regarding teaching infrastructure, including smart classrooms and highly qualified teachers, and students were selected and joined the schools based on their academic achievement. Even private schools were taught additional subjects like supplementary science, supplementary mathematics and spoken English, which were not in governmental schools. Again, four governmental schools were excluded based on learners' characteristics and school facilities and due to security problems. Two of these schools, Basa and Hidase, experienced security problems during data collection. The other two schools, Kosober and Bahunk, are relatively better in terms of facilities, and the learners differ in language and family background since these schools are located in the downtown area.

However, eight governmental schools were comparable in terms of the backgrounds of their teachers and students, such as teachers' and students' exposure to Awi IK, teachers' qualifications and their facilities. Two intact groups were randomly selected to eliminate any potential for subject interaction: an experimental group from Bida (Grade 8, Section C) and a control group from Bata (Grade 8, Section A).

Grade 8 was deliberately chosen as a transitional point between primary and secondary education, marking a critical educational journey. The curriculum becomes more advanced at this level, and students are expected to take greater responsibility for their learning. This transition is essential for their development and helps prepare them for high school. According to Meece (2003), the middle school years are a crucial turning point in the lives of young people. Therefore, we have focused our efforts on this grade level to enhance and establish a strong foundation for student achievement. Additionally, grade eight students were selected because they are beginning to mature, paying closer attention to their education, and adjusting better to the school environment than students in lower grades. For these reasons, conducting interventions in the 8th grade is timely and supported by evidence.

Figure 3

Sampling Procedures

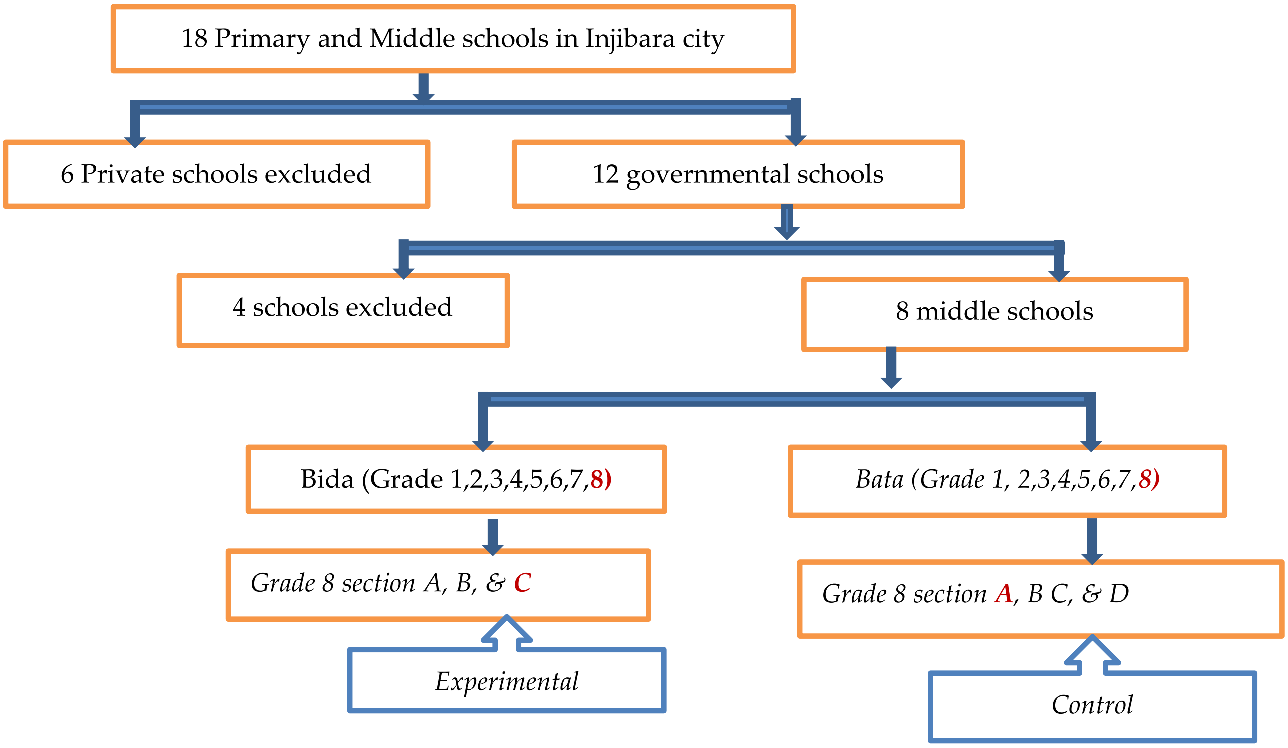
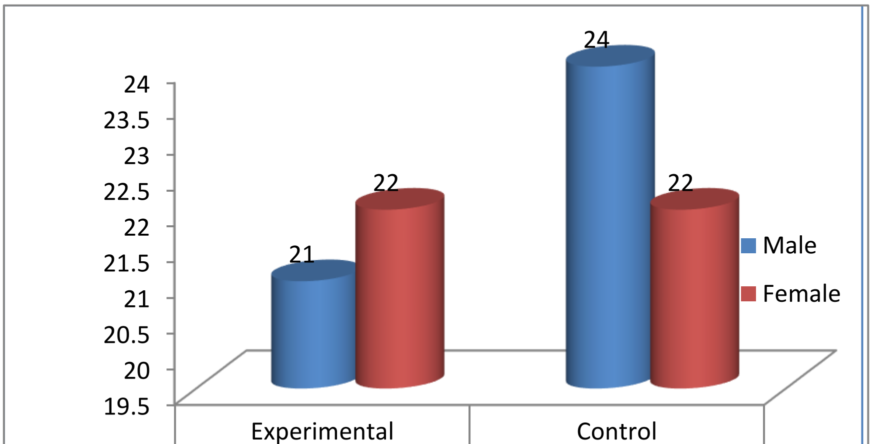


Figure 4 displayed the ***study participants***, which involved 89 students, 44 of whom were females, and 45 of whom were males (Figure 4). The control group had 46 participants, which constituted 51.7% of the entire participants, while the experimental group had 43 participants, which constituted 48.3% of the entire participants.

Figure 4

Gender distribution of participants in each group



	Experimental	Control
Male	21	24
Female	22	22

Data Gathering Instruments

This study employed two primary instruments for data collection: the Ecology Achievement Test (EAT) and focus group discussions. The researchers developed a 25-item EAT, administered to control and experimental groups to assess students' ecological knowledge during pretests and posttests. Each of the 25 multiple-choice questions offered four response options labelled A-D. The pretest and posttest questions contained the same number of items and covered the same content, but the arrangement of the items was different. The instrument underwent face and content validation, with input from advisors, two biology teachers, and a measurement and evaluation teacher. Their corrections and recommendations were incorporated into the final version. A preliminary test of the EAT was conducted with 26 non-sample students.

The reliability of the EAT was evaluated using the Kuder-Richardson Formula 20 (K-R20), which confirmed a reliability coefficient of 0.83. The test items were carefully developed based on the Grade 8 curriculum guide, ensuring each question reflected specific learning competencies related to ecology and biodiversity conservation. Topics such as ecosystem interactions, the importance of biodiversity, and conservation practices were covered to match the intended learning outcomes. This alignment ensured that the test measured the knowledge and skills outlined in the curriculum, thereby strengthening its content validity.

Following the intervention, focus group discussions were conducted to explore students' perceptions regarding the influence of integrating Indigenous knowledge in the teaching and learning of ecology and biodiversity conservation. It is important to gather data from various sources to enhance the credibility and validity of the study's findings. The researchers developed a self-composed FGD guide titled "Indigenous Knowledge System and Practices FGD Guide." This guide was initially prepared in English and then translated into the local language, Awgni. Discussions were also conducted in Awgni, and the researchers subsequently translated the conversations into English for thematic analysis.

A total of 12 participants (6 males and six females) from the experimental group were selected based on their scores on the achievement test, ensuring the inclusion of high achievers while also considering gender balance. The selection of only high-achieving students for the focus group discussions (FGDs) was a purposive sampling strategy aimed at gathering in-depth insights from students who were most likely to have fully engaged with the indigenous knowledge (IK)-based instructional approach. High-achieving students were expected to have a deeper understanding of the content and could articulate their experiences and reflections on the learning process more clearly, providing rich qualitative data about the effectiveness and reception of the intervention.

Intervention Procedure

Before the start of the experiment, the researcher visited the participating schools. Two sections were selected and assigned: the treatment group (Bida) and the comparison group (Bata). Permission was obtained from the authorities of the participating schools, and the students consented to voluntarily participate in the study, understanding that they could withdraw their participation at any time. The experimental and control groups received similar concepts, materials, assessment styles, and learning objectives. The key difference was that the experimental group incorporated IK concepts through various instructional activities.

As illustrated in figure 5 the teacher of the experimental group received specialised training on integrating IK into ecology subtopics, while the control group was not provided with this instruction. This training, conducted by the researcher, lasted for five days. At the beginning of the training, the researcher explained the purpose of the study, the methods for implementing the intervention, the tasks to be completed during the intervention, and the timetable.

During the training, local knowledge of soil, ecosystems, and natural resource conservation was identified and documented. These pieces of local knowledge were selected based on curriculum objectives and categorised into ecosystem and natural resource conservation. The discussion also covered integrating the identified local knowledge into the school curriculum. For instance, the Awi community traditionally practices terracing and mixed cropping on hilly farmlands to prevent soil erosion and maintain fertility. This practice was linked to the scientific concept of soil conservation and nutrient cycling, helping students understand how controlling runoff and maintaining organic matter supports the nitrogen and carbon cycles in ecosystems. A commonly shared Awi folktale describes how the fox, sheep, and grass depend on one another within the natural order. This story was used to illustrate the food web and trophic relationships, allowing students to connect local ecological stories to the biological concepts of energy flow and interdependence among organisms. The Awi people use small-scale irrigation systems and seasonal water storage pits to conserve water during dry seasons. This practice was connected to lessons on ecosystem sustainability and the water cycle, showing how indigenous methods align with scientific principles of water conservation and ecosystem balance.

Based on this discussion, the researchers developed an instructional package in the form of a lesson plan. This package was designed to guide the experimental teacher in teaching students using IK. It included performance objectives, teaching resources, lesson content, and activities for teachers and students, all aligned with the selected themes. The instructional package was intended for six weeks, with lessons scheduled for four periods per week, each lasting 40 minutes.

Both groups underwent a pretest before the treatment began, and the data collected were recorded and analysed. The pretest utilised the Ecology Achievement Test (EAT), administered by two teachers, to assess the students' prior knowledge. Students were informed about the purpose of the tests and completed the questions independently.

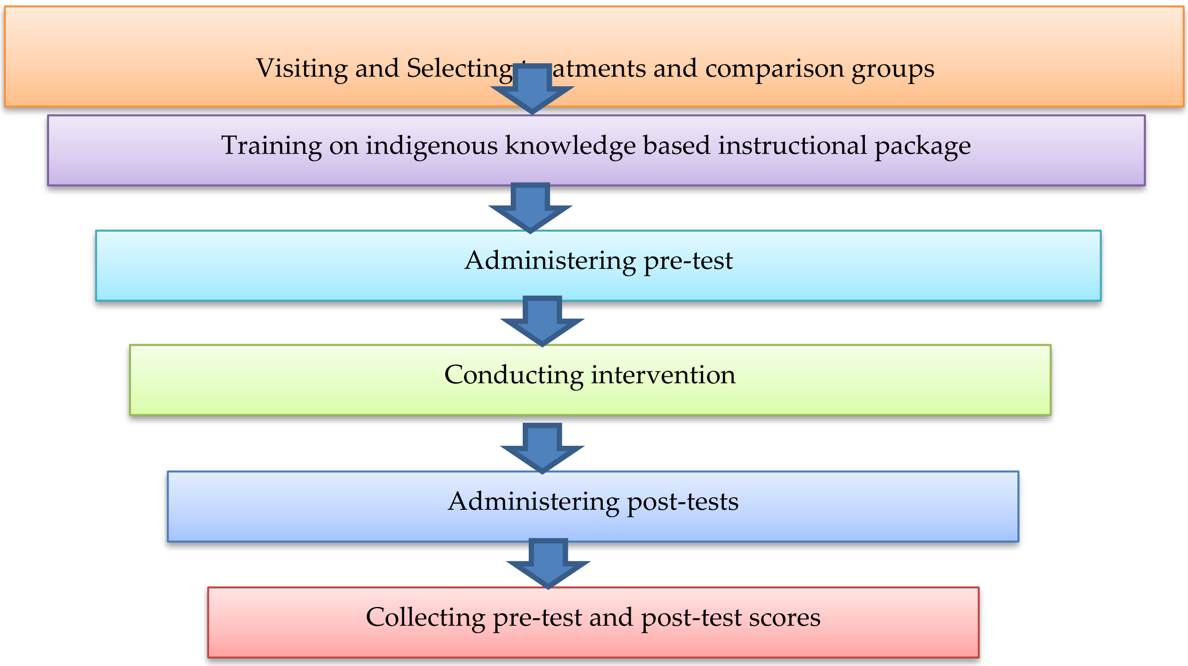
Over the course of six weeks, the topic "Ecosystems and Conservation of Natural Resources" was taught. The treatment group was instructed using an IK-based teaching approach, while the control group followed conventional instructional methods delivered by their regular teachers. For the experimental group, instruction was implemented step by step. Each lesson began with the teacher introducing the topic, followed by an invitation for students to describe and reflect on their cultural beliefs and practices related to the topic, sharing their cultural knowledge with their peers. The teacher then highlighted the differences between the students' cultural perspectives and the topic, establishing connections between the two. The lesson concluded with the teacher sharing additional cultural knowledge related to the topic gained from the students' discussions. In contrast, the control group teacher employed a traditional lecture method, focusing primarily on delivering information for students to listen to and absorb.

To ensure implementation, the researchers periodically visited both the experimental and control classrooms. In the experimental group, we were confirmed that the teacher consistently applied the indigenous knowledge (IK)-based approach, while in the control group, we were verified that the teacher followed the conventional teaching method. In addition to observations, lesson plans, were reviewed to ensure that each teacher adhered to their assigned instructional method. These measures helped confirm that the intervention was implemented as designed, supporting the internal validity of the study.

At the end of the treatment, a post-test was administered by the regular teachers after the instructional program concluded. These tests were administered carefully, with no observable differences between the two groups concerning time allotted, supervision, or the students' willingness to take the tests. Finally, the researcher collected pre-test scores, post-test scores, and questionnaires. Focus group discussions (FGDs) were conducted after the intervention.

Figure 5

Intervention procedures



Data Analysis Methods

This study investigated the effects of an IK-based teaching approach compared to conventional teaching methods on students' achievement in ecology tests before and after the treatment. Additionally, the study examined students' perceptions of the IK-based teaching approach after the treatment and explored gender differences in outcomes. Data were analysed using both qualitative and quantitative methods. The researchers conducted qualitative analyses of Focus Group Discussion (FGD) results, while the achievement tests were analysed quantitatively.

After coding and cleaning the data, it was entered into the Statistical Package for Social Sciences (SPSS) version 26 for recording and analysis. The data were analysed using both descriptive and inferential statistics. Descriptive statistics were summarised, and the results from the experimental and control groups were compared in terms of mean scores and standard deviations.

Inferential statistics, including independent sample t-tests and ANCOVA, were employed to determine mean score differences between the experimental and comparison groups, assessing their respective teaching strategies and different variables. Specifically, the inferential statistics examined the differences in ecology achievement test scores between the experimental and comparison groups before and after treatment and pre- and post-test scores within the experimental group. ANCOVA was also utilised to evaluate the effect of gender on students' achievement.

The qualitative data from the FGDs were transcribed and translated from the Awgni language to English. The transcripts were then reduced, coded, categorised, and reported thematically. Subsequently, the qualitative data were manually analysed and triangulated with the quantitative results.

Results

Effects of Integrating IK on the Academic Achievement of Students

Descriptive statistics were generated to evaluate basic statistical assumptions, including independent measurement, regular distribution of dependent variables across each group, and equal variance of the dependent variable (Pallant, 2020). The research design maintained independent measurement by selecting intact classes and testing each group under a single treatment condition. Normal distribution was assessed using skewness, while the Levene's test was employed to analyse the homogeneity of variances among the data sets. The results presented in Table 1 confirmed some of the statistical assumptions, indicating that all variables had skewness values ranging between -1 and 1, which suggests a normal distribution within each group.

Table 1 presents the pre-test and post-test results for a study's experimental and control groups. The control group had a pre-test mean score of 31.04 and a post-test mean score of 36.78, resulting in a mean gain 5.74. In contrast, the experimental group recorded a pre-test mean score of 30.47 and a post-test mean score of 50.33, yielding a mean gain of 19.86. The experimental group's mean gain of 19.86 significantly exceeded the control group's mean gain 5.74, indicating greater performance on the ecology achievement test. However, further inferential statistics are required to reach a definitive conclusion.

Table 1

Mean and standard deviation of students' scores in both experimental and control groups in pre- and post-achievement tests

Group	Variable	N	Mean	SD	Min	Max	Skewness	Kurtosis	Mean Gain
Experimental	Pre-test	43	30.47	12.358	12	64	.344	-.383	
	Post-test	43	50.33	18.273	20	84	.088	-1.261	19.86
Control	Pre-test	46	31.04	12.882	8	60	.392	-.634	
	Post-test	46	36.78	15.586	12	68	.499	-.448	5.74

A pre-test was conducted to determine if the two groups were comparable or homogeneous in achievement, as shown in Table 2. An independent samples t-test was used to assess student achievement differences between the experimental and control groups. No significant difference was found in pre-test scores between the experimental and control groups (t (87) = -.216, $p > .05$, η2 = .0049), indicating that both groups were in the same ecological achievement status before the intervention, suggesting any difference after the intervention can be attributed to the intervention.

Table 2

Independent Samples t-test analysis to compare the experimental and control groups on pretest

Test	Group	N	Mean	SD	SDE	Df	t	P	η^2
Pre-test	Experimental	43	30.47	12.353	1.885	87	-.216	.829	.0049
	Control	46	31.04	12.822	1.890				

Note. Eta squared = $t^2 / t^2 + (N1 + N2 - 2)$; $-.216^2 / -.216^2 + (43 + 46-2) = 0.0014$

As shown in table 3 an independent samples t-test was used to compare the achievement of two groups after the intervention. The Levene's variance equality test was insignificant (p >.05), indicating that the two groups had statistically equal variance. A significant difference was found in mean post-test scores between the two groups (t (87) = 3.77, p < .05), indicating that the experimental group taught by integrating IK had higher achievement scores than the control group.

Table 3

Independent samples t-test analysis to compare the experimental and control groups on the post-test

Test	Group	N	Mean	SD	SDE	Df	t	P
Post-test	Experimental	43	50.33	18.273	2.787	87	3.770	.000 .
	Control	46	36.78	15.586	2.298			

Effects of Integrating IK on the Achievement Scores of Male and Female Students

Table 4 shows the male and female students' mean achievement scores in the experimental and control groups. In the experimental group, male students' mean achievement score was 21.71, whereas female students ' was 18.08. In the control group, the mean achievement scores of the male and female students were 5.34 and 6.18, respectively. As a result, male and female students' mean achievement improvements were greater in the experimental group than in the corresponding control group. This suggests that no relationship exists between gender and teaching strategies and students' ecological achievement. This indicates that IK-based instruction is not gender biased.

Table 4

Comparison of means and standard deviations of achievement scores between male and female students in experimental and control groups (n=89)

Group	Test	Gender							
		Male				Female			
		N	M	SD	Mean gain	N	M	SD	Mean gain
Experimental	Pretest	21	32.19	12.99	21.71	22	28.82	11.78	18.08
	Posttest		53.90	17.96			46.91	18.31	
Control	Pretest	24	33.33	13.27	5.34	22	28.55	12.11	6.18
	Posttest		38.67	15.22			34.73	16.06	

Two-way ANCOVA was used to investigate the impact of instructional strategy and gender on the mean achievement scores of students in ecology. Table 5 presents the analysis results indicating no significant difference in mean achievement scores between male and female students taught ecology and conservation using IK-based instruction. F (1, 88) = 0.103, p > 0.05 indicates that this instruction is not gender biased. Eta for sex was about .001, which is smaller than a typical effect. Sex and group (control and experimental) did not significantly interact with ecology achievement (F (1, 88) = 2.487, p > 0.05). The impact of teaching method on ecological achievement is not significantly different for boys and girls. Therefore, there is no discernible difference in the mean achievement scores for ecology and conservation between the students' gender and the teaching methods.

Table 5

Two-way ANOVA testing the effect of gender and teaching approach on ecology achievement

Source	Sum square	Df	Mean square	F	Sig	Eta Square
Corrected model	24747.493	4	6186.873	121.310	.000	.852
Intercept	454.481	1	454.481	8.911	.004	.096
Pretest achievement	19967.267	1	19967.267	391.510	.000	.823
Teaching method	4500.204	1	4500.204	88.238	.000	.512
Sex	5.231	1	5.231	.103	.750	.001
Group*Sex	126.827	1	126.827	2.487	.119	.029
Error	4284.058	84	51.001			
Total	196096.000	89				
Corrected total	29031.551	88				

The Perceptions of Students on IK-based Teaching Strategy

Following the intervention, Focus Group Discussions (FGDs) were conducted to obtain qualitative insights that complemented the quantitative findings. The objective was to explore students' perceptions of how the integration of Indigenous Knowledge (IK) influenced their learning and academic achievement in biology. A structured set of discussion prompts was developed to encourage reflective and detailed responses. The FGDs involved 12 high-achieving students from the experimental group, six males and six females. Participants were divided into two groups, each consisting of six students, and were coded as S1–S6 for anonymity. The data were organized under two major themes:

Theme 1

Participants expressed overwhelmingly positive views about the integration of Indigenous Knowledge into ecology instruction. Several students (S1 and S4) described it as one of the most effective teaching strategies they had experienced, noting that it simplified complex biological concepts and enhanced understanding. They explained that the approach provided concrete examples drawn from their local environment, making abstract ecological and biodiversity concepts more accessible and meaningful. This connection between local experiences and scientific content led to a more lasting and practical understanding of the subject matter.

Other participants (S2, S3, and S6) highlighted that the method made learning engaging and culturally relevant. They appreciated that the lessons incorporated examples consistent with their community's ecological beliefs and conservation practices. Before each lesson, students were encouraged to explore traditional practices at home and later share their findings in class, which the teacher complemented with scientific explanations. This exchange deepened comprehension and strengthened the bridge between cultural wisdom and formal scientific knowledge.

S6 stated that the approach "made theoretical aspects easy to understand," adding that the traditional lecture method often made biology appear abstract and difficult. Through the IK-based approach, she developed a stronger appreciation for biology, particularly when learning about traditional agricultural practices, such as the use of lupine to improve soil fertility. Similarly, S5 described the lessons as "amazing," noting that they promoted self-directed learning and curiosity. S4 remarked that the experience "cannot be forgotten," as it inspired discussions with family members about ancestral ecological practices, further reinforcing classroom learning through intergenerational knowledge sharing.

Theme 2

Students reported that the IK-based lessons fostered active participation and enthusiasm in class. Several participants (S1, S2, S4, and S6) stated that this approach was more interactive than traditional methods, as it encouraged question-asking, discussion, and sharing of local knowledge. Teachers supported the process by providing contextual examples and guiding inquiry-based activities. Students expressed that these lessons were enjoyable and motivating, creating an inclusive learning environment where every participant contributed.

According to S3, the incorporation of IK "captured students' attention" and maintained engagement throughout the lesson. Participants (S2, S3, and S5) agreed that the method was more appealing and less stressful than conventional teaching. They valued its ability to simplify complex topics and instil confidence in learners, enabling even less confident students to express ideas freely. Students also expressed a strong desire for teachers to apply this approach in other science topics and subjects, as it made learning both relevant and enjoyable.

Furthermore, S2 noted, "I was happy to see ecology presented in a way relevant to my environment," recommending that all teachers use IK-based strategies to connect abstract scientific ideas with familiar contexts. Likewise, S4 emphasized that the lessons were "meaningful," as they allowed students to remember, explain, and apply concepts effectively. The teaching process involved students investigating local practices, sharing their findings, and receiving clarification from the teacher—an approach that reinforced understanding through collaborative and experiential learning.

FGDs revealed that integrating Indigenous Knowledge into biology lessons fostered deeper conceptual understanding, sustained interest, and active student engagement. Participants viewed the approach as culturally relevant, intellectually stimulating, and pedagogically effective. The use of IK-based strategies not only improved comprehension of ecological concepts but also strengthened connections between scientific learning and local environmental realities. These findings underscore the pedagogical value of integrating Indigenous Knowledge into science education as a means of promoting meaningful, participatory, and contextually grounded learning experiences.

Discussion

Based on the overall performance evaluation of the students, the experimental group outperformed the control group on the ecological achievement test. The control group, which was taught similar subjects without incorporating IK, scored significantly lower than the experimental group, which learned about ecology through the lens of IK. Integrating IK into ecological instruction has improved students' understanding and achievement in biology. The likely explanation for this outcome may be connected to the fact that instruction based on IK helped learners integrates their cultural backgrounds and immediate environments with what they learned in the classroom.

The results of this study align with those of Ugwu and Diovu (2016), who stated that integrating IK and practices into chemistry instruction enhances students' understanding of the fundamental principles of the subject and, as a result, improves their academic performance. This finding is further supported by Nwankwo (2021), who discovered that ethno-science education effectively boosts students' achievement in basic science. Additionally, the study's findings reinforce the conclusions of Chongo and Baliga (2019), which indicated that students taught using ethno-physics-based instruction achieved significantly higher scores than those not instructed with this approach. A study conducted by Liyas (2019) examined the influence of IK on pupils' learning outcomes in Basic Science. The findings indicated that incorporating IK practices into biology education results in a more practical and objective approach, which enhances understanding of biology and its applications. This aligns with the findings of the current study. The similarities between this study and other research suggest that IK-based instruction promotes a better understanding of scientific content, thereby enhancing academic achievement. Drawing from Ausubel's theory of meaningful learning, the use of familiar IK concepts could have served as powerful cognitive anchors that facilitated the assimilation of new scientific information. When learners relate new content to their prior cultural and experiential knowledge, they are more likely to construct deeper understanding and retain the material longer. In this study, the incorporation of IK-based instruction may have allowed students to connect abstract scientific principles with real-life experiences and community practices, making learning more relevant and meaningful. Explicitly linking these findings to Ausubel’s framework thus reinforces the theoretical grounding of the study and highlights the pedagogical strength of contextualized science instruction.

The present study also showed no statistically significant difference in ecology achievement between genders. Male and female students taught ecology using IK-based instruction did not show significant differences in their academic achievement. There is no notable difference in ecological achievement between male and female students when IK is integrated into ecology instruction. This could be since both genders engage with local customs and are thus familiar with the related processes and knowledge. The selected IK practices and examples reflected shared community experiences, both genders may have had comparable levels of prior exposure and understanding. Additionally, the interactive and participatory nature of IK-based instruction might have provided equal opportunities for engagement, collaboration, and discussion, thereby minimizing any pre-existing differences in interest, confidence, or background knowledge. This suggests that the pedagogy itself, emphasizing inclusivity and shared cultural relevance, could have contributed to the balanced academic performance observed between male and female students.

Furthermore, the results indicate that students' ecological achievement is not affected by the interaction of gender and the teaching approach used. This indicates that incorporating IK and practices into biology teaching is more effective than the traditional lecture approach for enhancing achievement in biology among male and female students, since gender does not interact with the teaching approach to influence students' performance.

This finding is consistent with Oluboyo (2021), who also reported no significant interaction between instructional methods and gender regarding academic performance. Additionally, it supports the work of Ugwu and Diovou (2016), who found no statistically significant difference in the achievements of male and female students. In contrast, this study opposes the results of Mukuka (2019) and Chongo and Baliga (2019), who identified a statistically significant difference in academic achievement between male and female students, concluding that male students performed better than their female counterparts. This study also contradicts the findings of Nbina & Wagbara (2012), who reported that girls performed better than boys using the indigenous knowledge teaching strategy. In conclusion, while the indigenous knowledge-based teaching approach improved students' academic achievement, it exhibited no gender bias, unlike conventional teaching methods.

The result of the qualitative study supports the quantitative findings, indicating improvements in students' academic performance. Focus group discussions revealed that students had a very positive perception of the IK-based teaching strategy. After being exposed to this method, students’ perceptions improved significantly. Their interest in IK-based teaching increased because it simplifies complex topics, such as ecological interactions, and accommodates diverse learning styles. During the focus group discussions, all students expressed joy and excitement about their experience with the IK- based teaching approach, particularly in understanding challenging concepts in ecology.

The opinions expressed by the students align with the findings of Mawere (2015), who, through his study of African IK systems, demonstrated that learners can readily appreciate their language, cultural identity, and the wisdom their ancestors contributed to knowledge and technological advancement. Exposure to an IK learning approach has enabled the students to value their culture and recognise its relevance to science and technology for their development. Similarly, Abony (1999) stated that an ethno-science-based instructional package fosters greater interest in science than conventional teaching methods.

Conclusion and Limitations

Within the context of this quasi-experimental study, the findings strongly suggest that integrating locally relevant Indigenous Knowledge (IK) into Grade 8 biology instruction can be an effective pedagogical strategy for enhancing student achievement in ecology and biodiversity conservation. The results revealed that students taught through IK-based instruction significantly outperformed those in the control group, indicating that contextualized learning experiences grounded in students' cultural backgrounds can lead to deeper understanding and improved academic performance.

Furthermore, the study found no statistically significant difference in achievement between male and female students, suggesting that the IK-based approach benefits both genders equally. This outcome may be attributed to the inclusive and participatory nature of the instruction, which allowed all learners to connect meaningfully with the content regardless of gender.

Students' responses further reinforced these findings, as they expressed enthusiasm and positive attitudes toward the IK-based lessons. They reported that incorporating Indigenous Knowledge made learning more engaging, simplified complex and abstract ecological concepts, and strengthened their appreciation for biodiversity conservation.

Overall, the study underscores the potential of integrating Indigenous Knowledge into science education as a culturally responsive and effective approach to improving learning outcomes, fostering positive attitudes toward science, and promoting environmental awareness among students.

This study acknowledges certain limitations that may influence the interpretation of its findings. The small sample size limited to two classrooms within a single city constrains the generalizability of the results to wider populations or diverse educational settings. Such a restricted scope may not adequately represent variations in students' socio-cultural backgrounds, instructional environments, or regional educational practices. Consequently, the findings should be interpreted with caution when applied to broader contexts. To enhance the robustness and applicability of future research, it is recommended that subsequent studies employ larger, more diverse, and randomized samples, alongside rigorous experimental designs. Such methodological improvements would strengthen the empirical evidence supporting the integration of Indigenous Knowledge into biology education and its broader educational implications.

Implications

The findings of this study indicate that biology teachers should foster classroom environments that deliberately integrate Indigenous Knowledge (IK) into their instructional practices. Incorporating IK across various biology topics promotes active student engagement throughout the learning process, which in turn enhances academic achievement and deepens students' conceptual understanding.

Furthermore, curriculum developers are encouraged to design systematic frameworks that facilitate the integration of local IK within national science curricula. These frameworks should be informed by culturally responsive pedagogical principles and align with existing educational standards to ensure meaningful engagement with indigenous epistemologies.

Finally, pre-service and in-service teacher education programs should incorporate specialized modules on culturally relevant pedagogy. Such modules must equip educators with the theoretical knowledge and practical skills necessary to identify, validate, and respectfully incorporate local IK into classroom practice, thereby fostering culturally inclusive and effective science education.

Competing interests

We declare that there are no competing interests regarding the research and authorship.

Acknowledgements:

We sincerely thank the Federal Ministry of Education of Ethiopia for partially funding this study. We would also like to express our heartfelt gratitude to the grade 8 students and teachers of Bida and Bata Middle Schools who participated in this study.

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