Incorporating traditional ecological knowledge into science education, a case study of Mbita sub-county

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Abstract

Rationale of Study – The need for sustainable education practices has become more critical in a world grappling with pressing environmental challenges. Indigenous knowledge, developed over generations through direct environmental interaction, offers unique perspectives on sustainable educational practices. This study explored integrating traditional ecological knowledge into science education, recognising its significance in fostering a more comprehensive and inclusive approach to sustainability.

Methodology – The study was conducted in five junior secondary schools in the Mbita sub-county, Homa Bay County, Kenya. A qualitative approach and a case study design were applied. Data was collected using a semi-structured interview and document analysis.

Findings – The findings revealed that teachers understood indigenous knowledge as information acquired from the environment and traditional practices, but their comprehension of traditional ecological knowledge was limited. Some aspects of traditional ecological knowledge identified in the science curriculum include the study of weather, traditional medicine, flora and fauna, and farming methods.

Implications – The study provides practical recommendations, including teacher training programmes on integration practices, the acknowledgement of traditional knowledge by the government and education policies, the establishment of partnerships with indigenous communities, and the provision of resources for documenting traditional ecological knowledge for future use. The study envisions unlocking valuable insights into sustainability, fostering a generation of students well-equipped to advocate for and implement sustainable practices in their communities.

Originality – This study represents my own effort and has not been taken in whole or part without reference to whom or where the information was attained.

Keywords

Sustainable education, indigenous knowledge, integrated science, Junior secondary school, and the competency-based curriculum

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1 Introduction

The need for sustainable education practices has become more critical in a world grappling with pressing environmental challenges (Wals & Benavot, 2017). Achieving sustainability requires a comprehensive understanding of the intricate relationships between humans and the natural world. According to (Molnár & Babai, 2021), while science education has undoubtedly played a pivotal role in advancing knowledge, an untapped resource holds immense potential in shaping the understanding of sustainability through traditional ecological knowledge (TEK). According to Woo et al. (2012), sustainable education practices refer to integrating principles and values that promote the responsible use of resources, "environmental stewardship, and social equity" into the curriculum and operations of educational institutions. This involves teaching students about the importance of conserving resources, reducing waste, and fostering a culture of environmental and social responsibility, ensuring that future generations can meet their own needs without compromising the ability of the planet to support them.

Developers of the competency-based curriculum (CBC) in Kenya acknowledge the importance of indigenous knowledge in the new curriculum. However, "for reasons largely associated with ignorance and arrogance" (Kwanya & Kiplang'at, 2016, p. 1), among education stakeholders in Kenya, knowledge considered to be indigenous to respective counties or communities, unfortunately, remains to be suppressed, stigmatised, vindicated, and neglected (Kwanya & Kiplang'at, 2016). They further attribute the marginalisation of indigenous knowledge to the disintegration of families and globalisation due to its implicit nature.

Integrating TEK, a sub-set of indigenous knowledge, into science education is crucial to preserving invaluable insights at risk of being lost in our rapidly changing world. As contemporary environmental challenges escalate, the neglect of TEK can lead to the erosion of critical ecological practices and cultural wisdom that have been honed over generations. Without incorporating this rich knowledge into educational curricula, future generations may lack the understanding to navigate sustainability issues effectively. Ignoring this knowledge, we risk perpetuating a one-dimensional view of science disconnected from many communities' lived experiences and practices.

Studies by Okui et al. (2021) reveal a decline in young people's knowledge of natural resources and their uses. If TEK is not documented, it may be transformed or lost altogether. Aswani et al. (2018) attribute the loss of forests to inadequate local knowledge.

There is an urgent need to pass down the knowledge. The study by Wilujeng and Prasetyo (2018) found that integrating traditional ecological knowledge in the science classroom holds the promise of fostering substantial learning and bridging the disparity in science education pathways that students acquire within formal school settings and their respective communities. However, this study did not explicitly outline the strategies of inclusion of TEK into the curriculum. There is also little mention of the likely challenges that the integration of TEK would face. In a later study, Zidny et al. (2021)expressed that learning science through the lens of indigenous knowledge fosters deeper connections to the natural world and respect for diverse perspectives. However, there is limited research from Kenya (Owuor, 2007; Ronoh, 2018) regarding incorporating traditional ecological knowledge into integrated science. The limited research on the aspects of TEK to be incorporated into the science curriculum and the strategies to be put in place to ensure a seamless incorporation of TEK have informed the need for this study.

This study aims to explore the integration of TEK into science education, recognising its significance in fostering a more comprehensive and inclusive approach to sustainability. Kenyan scholars decry that indigenous knowledge can anchor survival and stability among communities (Oando & Achieng', 2021), serving as the cornerstone for local-level decision-making in rural areas. Therefore, this study hypothesises that incorporating traditional ecological knowledge into the integrated science curriculum can foster a more inclusive and culturally responsive education system in the Kenyan context.

In pursuit of a deeper exploration of TEK and science, this study was structured around the following objectives: to explore the understanding of traditional ecological knowledge and indigenous knowledge among teachers, to explore the aspects of traditional ecological knowledge incorporated into the teaching and learning of integrated science, and to explore the strategies for bridging the gap between TEK and modern scientific concepts.

2 Background of the study

The diminishing application and dissemination of indigenous knowledge have generated discussions in different fields of study (Owusu-Ansah & Mji, 2013). The education sector is not left behind in this debate about a heightened awareness of indigenous knowledge to stimulate new thoughts in teaching and learning, especially in science-related subjects. In this study, indigenous knowledge refers to the collective accumulation of traditional wisdom developed by a specific group of people over time within a particular region, with minimal influence and imposition from external sources (Emeagwali, 2014).

TEK represents accumulated wisdom and knowledge of Indigenous and local communities, passed down through generations (Zidny et al., 2021). "Indigenous" refers to people's cultures and practices native to a particular region, originating there and maintaining a distinct identity over time (Dick et al., 2022). "Local" refers to people, practices, and knowledge specific to a particular area but not necessarily native or original to that region (Molnár & Babai, 2021). According to Li and Han (2022), TEK is a body of knowledge preserved through oral tradition, arts, crafts, and ceremonies. TEK offers a unique perspective that complements scientific education, providing valuable insights into sustainable practices and ecological conservation (Mekonen, 2017).

Integrated science, conversely, involves the seamless integration of diverse knowledge systems, including indigenous knowledge, into scientific inquiry, research, and decision-making processes (KICD, 2022). Incorporating TEK into integrated science recognises the value of multiple perspectives and seeks to create synergies between different knowledge systems for comprehensive and practical problem-solving. For example, the synergies between indigenous knowledge (IK) and science lie in their complementary strengths. IK often offers holistic, place-based, and long-term perspectives, while science provides empirical, quantitative, and experimental methodologies. Integrating these approaches can achieve a more comprehensive understanding of the complex environmental and societal issues, leading to a more effective and culturally relevant solution.

The significance of incorporating TEK into science education is underscored by the growing recognition of its potential to bridge the gap between classroom science and the practical needs of communities (Kim et al., 2017). However, there is a limited focus on how TEK can be restored and stored in the formal settings of our education system, more specifically, on how it can be incorporated into the integrated science curriculum in Kenya. Integrating TEK into educational frameworks fosters a deeper appreciation for the natural world among students, equipping them with the knowledge and skills necessary to address environmental challenges from a holistic perspective.

The Competency-Based Curriculum (CBC) emphasises the integration of diverse knowledge systems, including traditional ecological knowledge, into science education (Ministry of Education, 2019). CBC is an educational approach focusing on developing students' skills, knowledge, and attitudes through practical and student-centred learning experiences. It provides open avenues for integrating TEK into science education,

particularly within the learning area of Integrated Science (KICD, 2022). This integration is envisioned to foster a comprehensive and inclusive approach to environmental stewardship.

3 Conceptual framework

The conceptual framework that guided this study is adapted from Gopalam and Reddy (2006), who developed a model that describes the synergy between the aspects of TEK and Western science and how the inclusion of indigenous knowledge can result in environmentally conscious individuals.

One approach to teaching Integrated science is inquiry-based learning, which involves hands-on activities (Ministry of Education, 2019). This area's content is hinged on Dewey's social constructivism theory (Hickman et al., 2020). Social constructivists emphasise the power of social interaction in education, viewing schools as social institutions capable of driving positive social change.

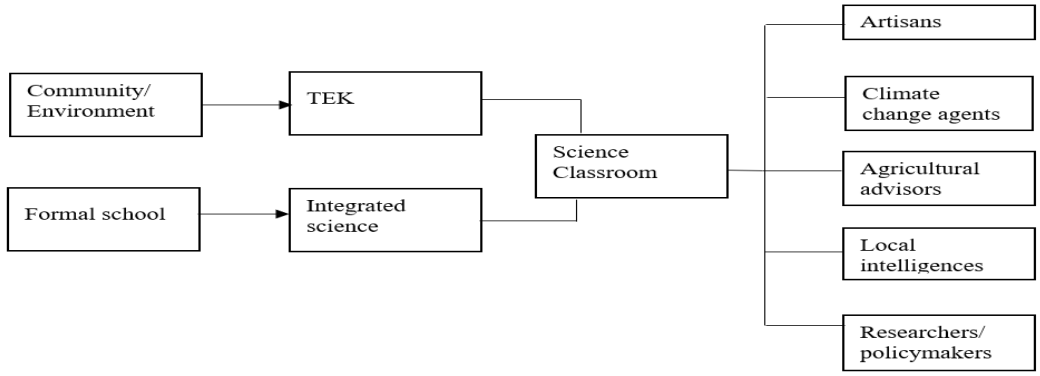

Figure 1: Conceptual framework for results of integrating TEK in science

This framework is in the community or environment where traditional ecological knowledge exists. According to this study, the learners enter the school with a conceptual understanding of their immediate environment. One of the learning areas in the school curriculum is integrated science. Within the science classroom, through the learner, integrated science meets traditional ecological knowledge. Integrating TEK into integrated science is envisaged to produce culturally responsive learners who may become professionals in artisans, climate change agents, agricultural advisors, local intelligence, and policymakers.

4 Literature review

Integrating Traditional Ecological Knowledge (TEK) into science education has been widely acknowledged for its potential to enhance environmental awareness and sustainability practices. Many scholars agree that TEK, deeply rooted in indigenous communities' cultural and ecological contexts, provides valuable insights into resource management, biodiversity preservation, and ecological conservation (Joa et al., 2018; Nelson & Shilling, 2018). For instance, Casi et al. (2021) argue that TEK reflects a deep understanding of the interconnectedness between humans and nature, which complements the reductionist approach of Western science. By embedding TEK into science curricula, students can develop a holistic understanding of ecosystems and cultivate environmental stewardship (Kim et al., 2017). This claim rests on the assumption that combining indigenous and scientific knowledge systems enriches the learning experience and fosters sustainability education aligned with the Sustainable Development Goals (SDGs). However, critics contend that merging these knowledge systems risks diluting the unique cultural aspects of TEK when framed through a Western lens (Greenall & Bailey, 2022).

A crucial aspect of this discussion is the role of TEK in promoting biodiversity conservation and sustainable development. Many studies, such as those by DeClerck et al. (2016), highlight that TEK is essential for developing sustainable strategies in resource management, health, and agriculture, particularly in rural and indigenous communities. TEK's strength lies in its capacity to adapt to environmental changes and preserve biodiversity through context-specific knowledge systems (Albuquerque et al., 2021). This argument is supported by research showing that TEK-based climate adaptation strategies are more effective because they cater to the unique needs of local communities (Hosen et al., 2020). Nonetheless, a counterclaim suggests that while TEK provides practical insights into sustainability, it should not be viewed as a replacement for scientific ecological knowledge (SEK) but as a complementary resource. Therefore, the integration of TEK into educational curricula should aim to balance both knowledge systems without undermining scientific rigour.

Despite the recognised benefits of TEK integration, there is a notable gap in the literature concerning the ethical considerations and challenges of incorporating TEK into formal education. Several scholars, including Finn et al. (2017), argue that TEK must be handled carefully, ensuring that indigenous knowledge's intellectual property and cultural significance are respected. This concern is particularly relevant when TEK is integrated into Western-based education frameworks, which often prioritise scientific knowledge

over traditional practices. The warrant for this argument is the risk of cultural appropriation or the distortion of indigenous knowledge to fit Western educational paradigms, as noted by Greenall and Bailey (2022). As a result, there is a need for educational policies that include ethical guidelines for TEK inclusion, such as collaboration with indigenous communities and the recognition of indigenous knowledge custodians as vital contributors to the educational process.

Finally, while many studies focus on the theoretical benefits of TEK integration into science curricula, there is a lack of empirical research examining its long-term impact on student outcomes. For instance, while Kim et al. (2017) suggest that TEK enhances students' critical thinking, ecological awareness, and appreciation for cultural diversity, few studies have evaluated how these outcomes manifest over time in different educational settings. Moreover, there is limited research on the practical implementation of TEK in diverse contexts, particularly in non-indigenous or urban classrooms where students may not be directly connected to the ecological knowledge being taught. This calls for further empirical studies to develop assessment tools that measure the effectiveness of TEK integration in improving sustainability education, as well as the potential challenges educators face in adopting this approach. Without such research, it remains unclear how well TEK can be universally incorporated into science education without losing its cultural and ecological significance.

5 Methodology

The study sought to explore the social, cultural, and historical factors that shape TEK and how these factors influence its incorporation into science. Underpinned by constructivism epistemology and a qualitative approach, a case study design was ideal for this study. The choice of qualitative approach was informed by its ability to foster an understanding of the context in which TEK is used and practised (Creswell & Poth, 2016). A case study design allows for in-depth exploration and experience of a specific phenomenon or context (Hollweck, 2015; Hudson & Hudson, 2013). This makes it suitable for investigating the incorporation of traditional ecological knowledge in integrated science in junior secondary schools, mainly because a case study provides rich contextual insights which enable a comprehensive understanding of the complexities involved in the educational process.

Data was collected through in-depth interviews, and document analysis augmented the claims made. A total of ten teachers were interviewed, including five teachers of integrated science and five head teachers of junior secondary schools. In 2023, when this study was

conducted, the junior secondary school had a single pioneer class. The schools selected for the study had science teachers employed by the Teachers' Service Commission. It is worth noting that some schools did not have science teachers whom the commission employed because JSS was just at its inception, and many changes were still being made.

Additionally, the headteachers of the selected schools provided valuable insights based on their experience. The headteachers were mostly members of the community where the research was done. Some were custodians of traditional knowledge and could share information relevant to the study. This study, thus, employed a purposive sampling technique. Tafur-Arciniegas and Purzer (2015) view purposive sampling as a non-random sampling method in which subjects or cases are purposefully chosen according to standards pertinent to the study goals. The criterion used in this study was expertise.

The data analysis involved familiarisation with the data, transcribing interviews, and reading observation notes and documents. After transcription, a data analysis matrix was drawn in Microsoft Excel. The initial codes were then generated by labelling important data features relevant to the research questions. After that, the initial codes were clustered into potential themes, followed by systematically collating all relevant data segments within each identified theme. After the themes were identified, a report was produced by selecting vivid, compelling extract examples for each theme and relating them to the research questions and literature.

Throughout the study, the three ethical principles of informed consent, anonymity, and reciprocity guided the researcher. The participants' consent was considered by informing them of the purpose of the study and their rights. The study also considered their confidentiality by using pseudonyms to safeguard the participants' data. As Arifin (2018) noted, ensuring the protection of human subjects in research necessitates using appropriate ethical norms.

6 Findings

This study sought to establish whether and how traditional ecological knowledge is incorporated into the integrated science syllabus of junior secondary schools in Kenya. In particular, the study intended to establish teachers' understanding of Indigenous knowledge and TEK, the enabling factors for integrating TEK into the integrated science curriculum, and the barriers to integrating TEK into the integrated science curriculum. The findings are reported under three broad themes: understanding indigenous knowledge and

TEK, aspects of TEK incorporated in science and factors hindering the incorporation of TEK into integrated science.

Table 1 shows the profile of the participants of the semi-structured interview:

Table 1 Participant profiles

Name	Position in the school	Highest education qualification	Gender	Age	Teaching Experience (years)
HT01	Head Teacher	Degree	Male	38	13
HT02	Head Teacher	Degree	Male	48	20
HT03	Head Teacher	Degree	Male	45	23
HT04	Head Teacher	Degree	Male	45	23
HT05	Head Teacher	Degree	Male	47	20
ST01	Science Teacher	Masters	Male	48	20
ST02	Science Teacher	Degree	Male	29	4
ST03	Science Teacher	Degree	Male	26	5
ST04	Science Teacher	Degree	Female	41	15
ST05	Science Teacher	Degree	Male	38	10

6.1 Understanding of indigenous knowledge and traditional ecological knowledge

Data analysis from interviews with science teachers and headteachers revealed diverse perspectives on indigenous knowledge (IK). Some teachers defined Indigenous knowledge as:

> "…*knowledge borrowed from our traditional life*…" (HT01)
>
> … *originates from the traditional aspects*…" (HT02),

While another referred to IK as:

> "…*the knowledge they are trained at home*" (ST03).

Moreover, participants, especially ST01, emphasised that indigenous knowledge is acquired outside the formal educational system. ST01 remarked,

> "*Yeah, in this Indigenous knowledge, I may understand as the knowledge that is with the people in their communal setting. What the people themselves know about things about things within their environment*". (ST01)

Another participant further supported this perspective, stating that learners come to school with pre-existing knowledge from their environment.

> *"...what I understand is that no learner, that is born when the brain is empty. He/she is having something and most of the things he learns from the environment…"* (ST02)

A recurrent theme in the discussions with headteachers and science teachers is the association of indigenous knowledge with the local environment. Participants highlighted that this knowledge is sourced from the community and is a result of interactions with one another and the surrounding environment. In response to the question about how they understand indigenous knowledge, one headteacher asserted:

> *In my understanding, indigenous knowledge is knowledge that is known locally. That is what the local people know and understand. So, it is not from a foreign source, not another source, but from the environment where they grew up. Traditional is something that has been passed from one generation to another.* (HT03)

In finding the teachers' perspective on traditional ecological knowledge (TEK), the following question was asked to the science teachers: What is your understanding of ecological knowledge? The head teachers, on their part, were asked: How familiar are you with the concept of traditional Ecological Knowledge?

The responses showed that teachers had varied understandings of traditional ecological knowledge. In most cases, they gave examples or instances where TEK is applied in science instead of definitions. Generally, the teachers showed a lack of understanding of TEK. One teacher of science had this to say:

> *Ecological knowledge (…) is the relationship between organisms… can we use plants to cure ailments at home? Can we use plants for food? Can we use predictions to tell the weather? Can we, for those people unable to afford electricity, how can they still preserve their food and keep it fresh for some time? How can they store this food for future use*?... (interview ST05).

The teacher understood TEK as a relationship between organisms. Further, he describes the benefits man gets from the environment. In agreement with this, another teacher of integrated science said:

> "*We can, we can say, mean ecological knowledge about the environment. To me, the way I can say about ecological knowledge is about the environment where the learners are coming from*." (ST02)

One of the science teachers understood it as a means of finding solutions to daily challenges. He remarked:

> *It would be anything the community has that probably helps you solve some of their problems in life. They could learn about their family activities related to the weather changes, which would help them in their day-to-day activities.* (ST01)

In responding to whether they were familiar with the term traditional ecological knowledge, the head teachers described it as the relationship between plants and animals, the effects of climate and weather on ecosystems, and how to manage resources sustainably. A male head teacher, aged 38, manifested this as he remarked:

> "*… and we have seen herbalists using medicinal trees to cure diseases. We have seen pests being controlled by locally available resources. We have seen it with snake venom being cured by the herbal drugs…*" (HT01)

According to this participant, TEK involves using plants to cure diseases. He mentions using medicinal trees as pesticides and as a traditional snakebite cure. Another headteacher reiterates this sentiment:

> *…most of these drugs that we have normally used came from the plants used in the traditional form of treatment even before the formal or the modern type of medicine we have nowadays...* (HT05)

According to the participants, traditional ecological knowledge is helpful because people can find solutions to their daily problems in their surroundings.

For some of the teachers, defining TEK was difficult. A head teacher, for instance, when asked about his understanding of TEK, said:

> … "*I am getting old; some of these terms are too difficult…*" (HT04)

However, when probed further, he said:

> "*…then traditional ecological knowledge is people's knowledge of their surroundings. They interrelate.*"

6.2 Aspects of TEK incorporated in science

The sixth national goal of education states: "Promote respect for and development of Kenya's rich and varied cultures: Education should instil in the learner appreciation of Keny's rich and diverse cultural heritage. The learner should value and respect other people's culture and embrace positive cultural practices in a dynamic society." (source: Kenya Basic Education Curriculum Framework (BECF)). This aspect supports the incorporation of traditional ecological knowledge into the science curriculum.

Additionally, chapter two, article 11 (3b) of the 2010 Kenya Constitution, further allows for the restoration of cultural practices. It states: "The state shall recognise and protect the

ownership of indigenous seeds and plant varieties, their genetic and diverse characteristics and their use by the communities of Kenya."

During document analysis, the integrated science textbook enumerated several topics that outline traditional ecological knowledge's aspects. The teachers also identified various topics (strands) where TEK could be applied. Some of the areas mentioned included the study of the weather, vegetation, plants and weeds, mixtures, acids and bases, traditional methods of food preservation, skin diseases, and farming methods. They also mentioned human reproduction and pest control.

From the semi-structured interviews, the following aspects of TEK were mentioned to be incorporated into the science curriculum:

6.2.1 Study of the weather

This study's findings reveal that one aspect of traditional ecological knowledge incorporated into integrated science is the study of the weather. This includes the study of weather patterns and how they affect the environment and the resources available to the community. HT02 said,

> "…*the study of the weather. We have traditional ways of studying the weather*: by *observing the movement of the birds, by looking at the stars at night*…"

This was also confirmed by another head teacher who remarked:

> *"Traditionally, there were some birds that, if at all you see them hovering around, a group of birds, then that one would be an indication that the rains were about to come. Moreover, there were even some frogs. At night, you would hear some sounds of frogs and again would predict that rain was just about to come. Moreover, even some older adults in our villages would complain of some pain in some body parts. They say the rain is about to come whenever they feel pain, like the lower part of the spine.*" (HT05)

Some of the traditional ways of predicting the weather that the teachers mentioned include the movement of birds, the croaking of frogs, the positions of the stars, the direction of the winds, body sensations, and, as HT05 added:

> *"Again, the movement of the moon would predict the weather depending on the direction; in the absence of the moon, we would say that it would rain, and when the moon was up at night, then we would say that the rain would be delayed a little bit until it goes into darkness.*" (HT05)

Integrating traditional weather knowledge into integrated science reflects the richness of Traditional Ecological Knowledge.

6.2.2 Traditional medicine

The Kenya Basic Education Curriculum Framework recognises indigenous healthcare practices, such as herbal medicines and traditional healing methods. The curriculum promotes an understanding of traditional medicine as a healthcare option and a vital part of a community's cultural heritage.

From the interviews, several participants mentioned the aspect of traditional medicine. However, the findings reveal a correlation between scientific concepts and traditional practices. This was evident from what the head of the school said:

> "…*those who cannot go to the hospital will find them getting some of the medicine from their grandparents, and they use them to treat some common diseases, especially things like stomach aches. Then, we will take some herbs from the surroundings and use them in treatment*…" (HT04)

The headteacher emphasised that some of the learners knew about the medicinal value of some herbs. They get this information from the communities where they come from.

In teaching science, I remember a topic where learners were asked to name some medicinal and harmful plants. They could cite the plants they use at home to cure some diseases.

> *"So, I believe that one that concept, that knowledge, they are bringing it right from the community to school."* (HT05)

Even among science teachers, the use of traditional medicine was adversely mentioned. However, some could not establish how to include it in science teaching. This was realised by assessing their schemes of work and lesson plans. There was a lack of evidence that they planned to include these aspects in their teaching, much as they said during the interviews.

6.2.3 The study of flora and fauna

The study's findings also revealed that the study of plants is an aspect of TEK that can be incorporated into integrated science in grades seven and beyond. ST02 remarked:

> *"For example, I am teaching about the Wandering Jew in science about weeds. First, I have to ask them, this wandering Jew, how do we call them in the rural area environment, how they call it? What does it look like? So, they will tell me then after telling me. Even when discussing these characteristics of plants grown in dry areas, like the Nephites and Acacia. When we use indigenous language, they understand it better because they already have that knowledge. Now teaching this one becomes easier*…" (ST02)

According to the teachers, understanding the properties of vegetation and plants becomes easy when locally available plants are used as examples during the lesson.

6.2.4 Farming methods

The study also found farming methods as another aspect of TEK in science. The teachers mentioned the types of weeds, how farmers would control them, and pests, apart from weather patterns already mentioned above. HT01 remarked:

> "*…like wood ash was previously used to control pests. They even have some weeds like... How do you call this weed? Mexican Marigold is a weed that can be used to control pests in the store and the field at the same time…*" (HT01)

The findings on these aspects of traditional ecological knowledge show that teachers apply TEK, in most cases, unconsciously. Using TEK enhanced the learner's understanding of the scientific concepts.

6.3 Strategies for bridging the gap between TEK and modern scientific concepts

The need to incorporate traditional ecological knowledge into integrated science cannot be overemphasised. Therefore, it is important to investigate the strategies that can facilitate this implementation. Some of the strategies this study established included instilling a positive attitude in teachers and learners, documenting what counts as knowledge, training the teachers, making TEK part of the curriculum, allocating resources, collaborating with the community, and respecting the people's culture.

6.3.1 Documentation and storage

It was noted that much of what counts as knowledge is slowly depreciating due to the quest for modernity and the lack of proper channels of transmission of information. The findings point to documentation as a key strategy to ensure the continuity of traditional knowledge. One teacher of science said:

> *"…modern instruments that can be used to store information in terms of videos or such. So, when you teach, you can have videos which they can watch as you explain…"* (ST01)

His remarks point to the use of modern technologies to store information. This will make the information available for posterity and be used through generations.

The Basic Education Curriculum Framework (BECF) promotes the use of local languages in education, acknowledging their significance in transmitting traditional knowledge and culture.

6.3.2 Teacher training

Teachers need to be trained in the best ways to incorporate traditional ecological knowledge into science teaching. An analysis of the basic education curriculum in 2017 revealed that educators are encouraged to adapt teaching methods responsive to the learners' cultural backgrounds.

During the interview, the teachers expressed that workshops and seminars would help tutors become aware of the importance of TEK and how to use it in the classroom.

> *"I think that the government should come up with an institute or some institutes that deal with teaching sciences to junior secondary schools. So that our teachers may be fully equipped to handle this field/area… our teachers, who have been posted to our junior secondary schools, are fresh from college, and this CBC has not been incorporated in the university…"* (HT02)

Another teacher also had this to say:

> *"…Several teachers do not know the importance of integrating TEK into integrated science. If there can be a framework, a modality in which this thing can be brought in and even them, they can be retooled on the same…"* (ST05)

According to them, the teachers posted to teach in junior secondary schools lack the necessary pedagogical skills to teach science at that level. ST01 adds,

> *"…science is one subject that is so practical that it should be the easiest. So, teachers should be taken to seminars and encouraged to pursue sciences…"*

6.3.3 Change of attitude

Teachers and learners' attitudes are key to the learning process. If the teachers have a positive attitude, they can research the best techniques for integrating TEK into the science classrooms. They will gather resources that facilitate the learning process. One of the science teachers candidly pointed out:

> *"I would encourage your teachers to have a positive attitude towards traditional knowledge because it is vital in teaching science because it helps the children, the learners, to have a deep understanding of what they learn…"* (ST01)

This teacher expresses that with a positive attitude, integration of TEK into science is a possibility.

6.3.4 Inclusion into the curriculum

The teachers also proposed that one of the strategies for bridging the gap between traditional ecological knowledge and scientific concepts is the inclusion of TEK into the curriculum. One of them said:

> *"…curriculum developers can make it part of the curriculum in integrated science; it will be just like they came up with life skills and they came up with health education…"* (ST05)

According to this teacher, traditional ecological knowledge should be considered an independent learning area compared to life skills and health education. This can also mean that TEK should be present in science, health education, and life skills learning areas.

6.3.5 Resource persons and collaboration with the community

The teachers also suggested that the incorporation of TEK into the science curriculum would be successful if the teachers respected the culture of the community members and collaborated with them to make them part of the goings-on within the school.

> *"…collaboration with the community This is very key. We collaborate with the community; we let the community understand what is being learned in school. So that they can see that even then, if this is the kind of learning that is taking place…"* ST05

Resource persons can also educate the teachers on some of TEK's traditional practices and aspects that can be integrated into science. A resource person, in this case, is a person who has expertise in traditional indigenous practices. They can be experienced community members or teachers who have used TEK before.

> *"…use the resource person people from the village, those old mamas, there are some of the topics which you need to bring up on board so that they can discuss with them their ways of doing it."* (ST02)

6.3.6 Respect for the culture of the people

One final strategy the teachers suggested is respect for the cultural practices of the society from which the learners come. Traditional ecological knowledge is drawn from the community. The successful integration of TEK and science is possible when the teachers understand and respect the culture of the learners. This will make them embrace it and respect the culture of others. One of the middle-aged science teachers had this to say:

> *"…let us consider the cultural background of the learners. And let us also motivate the learners to acquire more knowledge on the training at home in the ecological sciences…"* (ST03)

7 Discussion of results

The findings revealed that the teachers understood indigenous knowledge as knowledge acquired from the environment because of the people's interaction with their surroundings. It is the knowledge that is associated with the traditional practices of the people. The teachers view this as knowledge unique to a given community and not acquired from the outside environment. These findings are consistent with Rugambwa et al. (2023), who define indigenous knowledge as the distinct knowledge exclusive to a particular culture or society, encompassing an understanding of the natural world, social dynamics, artistic expressions, and spirituality. The teachers understand indigenous knowledge and may not be challenged to include it in the curriculum. The accurate definition or understanding that teachers have provides a ground for relating the aspects of indigenous knowledge that can be applied in teaching and learning integrated science.

Regarding the concept of traditional ecological knowledge, while results show that the teachers had an idea of ecology, adding the words 'traditional' and 'knowledge' made them not accurately define TEK. The study found that teachers understood traditional ecological knowledge as the relationship between organisms or the relationship between plants and animals. At the same time, this understanding agrees with Casi et al. (2021), who define TEK as a comprehensive understanding of the interconnectedness between humans and their environment. It is inconsistent with the expectation that TEK would be viewed as an aspect of indigenous knowledge. The definitions provided by the teachers notwithstanding, the research objective seeking the aspects of traditional ecological knowledge incorporated into the integrated science was still met. The study sought to determine the teachers' understanding of this aspect of indigenous knowledge since they are the implementers. The findings were adequate to enable the implementation of TEK, an aspect of IK, in the integrated science in junior secondary schools in Kenya.

This study's traditional ecological knowledge comprises environmental knowledge, sustainability and conservation, spiritual significance, and biodiversity. The study sought the aspects applicable to junior secondary school integrated science in Kenya. McCarter and Gavin (2011) argue that traditional ecological knowledge (TEK) can make formal education systems more relevant to students' lives, help them develop a stronger sense of place and identity, and make them more effective overall. Developing on this understanding, coupled with the findings, the incorporation of TEK is possible in the Kenyan CBC curriculum in its learning area of integrated science.

On the question of what aspects of TEK are incorporated into the integrated science, the study found that aspects such as the study of the weather, traditional medicine, study of flora and fauna and farming methods are applied by most teachers during the teaching of the integrated science in junior secondary schools in Kenya as evident in most lessons observed. According to Albuquerque et al. (2021), aspects of TEK include the interactions between natural phenomena, plants, animals, landscapes, and the timing of occurrences utilised in lifeways, such as forestry, fishing, hunting, and trapping. The findings agree with this study and seek to make more specific aspects directly applicable to the curriculum.

The CBC curriculum design outlines the strands such as acids and bases, mixtures, human reproductive system (safe motherhood and menstrual hygiene), and human excretory system (human skin). The lesson observation revealed that the learners get actively involved when these topics are taught while including aspects of TEK. This finding agrees with Perdana et al. (2017), who found that integrating TEK into science education can increase student engagement and motivation, improve understanding of science concepts, enhance critical thinking skills, and promote environmental stewardship. The use of TEK in teaching and learning of science cannot be overemphasised. It leads to an enhanced understanding of scientific concepts, promotes sustainable practices, improves decision-making and strengthens community relationships.

While the findings revealed some aspects of TEK that can be applied in science teaching, the lesson observations presented a different scenario. In most of the lessons, the teachers relied mainly on the textbook. They gave class activities drawn from science books. The teaching and learning resources used by the teachers were more aligned with the textbook recommendation rather than what exists in the local environment of the learners. Despite knowing where to apply traditional ecological knowledge, the teachers may lack the techniques for involving TEK in their practice. At the same time, an analysis of the lesson plans and schemes of work showed a lack of actual practice in these aspects. Therefore, a different research design may be used by future researchers to establish the actual aspects of TEK that are incorporated into integrated science.

The study sought to establish hindrances to incorporating traditional ecological knowledge into integrated science. Some of the significant challenges the findings established included a lack of documentation of what counts as knowledge, lack of resources, inadequate teacher training, diversity of culture, quest for modernity and unwillingness to share aspects of TEK.

One of the challenges mentioned by the participants during the study was the lack of documentation and storage of traditional knowledge. The teachers pointed out that traditional ecological knowledge is transmitted orally. The people who own the knowledge are mainly the elderly members of the community. They also rely purely on the memorised versions, and worse, some of these older adults are hard to come by since the majority are dead or too old to give much information. The teachers decried that this information, unlike Western science documented in books, does not have a reliable point of reference. These results build on the existing evidence of Hiwasaki et al. (2014). The lack of mechanisms for transmitting Indigenous knowledge threatens to preserve this prestigious heritage. If the knowledge is not passed down through the generations, it risks being eroded. Traditional teachings and oral stories can be recorded and stored as videos or audio recordings, and communities can be encouraged to write down traditional practices, rituals, and medicinal knowledge.

The other challenge was the people's unwillingness to share traditional knowledge. According to these people, sharing knowledge would diminish its worth because they use it commercially. The participants said obtaining information from the people who owned them was difficult since they traded them for money or other gifts. They only share it with the trusted members of their clan, which may not be assured. Choudhary and Sarikwal (2017) contend that people hesitate to share their knowledge because they worry that doing so may result in a decline in their status, reputation, and organisation. However, contrary to this finding, the socio-cultural value that TEK bestows upon people's lives outweighs the potential monetary value it earns the custodians (Dutfield, 2017). People need to be educated on why sharing this information is necessary. The quest for monetary gains may lead to complete loss, especially when the knowledge owner dies.

While the findings sought to identify the challenges hindering the incorporation of TEK into the integrated science curriculum, future studies need to ask participants to identify practical solutions to these challenges. The suggestions may provide a basis for laying out recommendations that can facilitate the successful implementation of TEK.

8 Conclusion

In conclusion, the findings indicate that teachers have a general understanding of indigenous knowledge but have limited knowledge of traditional ecological knowledge. The study reveals the potential benefits of incorporating TEK into the science curriculum, such as enhancing relevance and fostering community engagement. Strategies like

documenting and storing TEK, including TEK in the curriculum, and collaborating with the community should be implemented to bridge the gap between TEK and modern scientific concepts. By recognising and integrating indigenous knowledge, education can become more inclusive, culturally sensitive, and relevant for all students.

9 Implications of the study

Including TEK in the curriculum can make science education more culturally relevant for students, particularly those from indigenous backgrounds. This relevance can increase student engagement and motivation as they see their culture and histories reflected in their studies. Engaged students are more likely to develop a commitment to sustainability. Additionally, TEK often includes practical knowledge about sustainable practices, such as crop rotation, water conservation, and the use of native plants. Teaching these practices can provide students with actionable strategies for sustainability that they can apply in their lives and communities.

Incorporating traditional ecological knowledge into secondary science education can unlock valuable insights into sustainability. It can foster a generation of students who are knowledgeable about ecological principles and equipped to advocate for and implement sustainable practices in their communities.

10 Recommendations for practice

Since teachers may be willing to incorporate aspects of traditional ecological knowledge but lack adequate knowledge of pedagogical practices, the curriculum development institute (KICD) should develop comprehensive training programs for teachers to enhance their understanding of indigenous knowledge and TEK. These can include workshops, seminars, and collaboration with Indigenous communities to gain firsthand knowledge. These training sessions can help improve the teachers' understanding and give a signpost on how best to implement the aspects of TEK in their teaching.

TEK should be incorporated into the science curriculum by developing modules or units focusing on traditional ecological knowledge. This can help students appreciate the value of indigenous knowledge and its relevance in understanding scientific concepts. It would also help improve teachers' awareness and outline the best pedagogical practices to successfully incorporate TEK into integrated science in Kenyan schools.

Schools should establish partnerships with indigenous communities to create a collaborative learning environment. This can involve inviting community members as

resource persons, organising field trips to indigenous sites, and involving community elders in curriculum development. This aligns with the finding that integrating TEK into the curriculum directly links the community and the school. The improved relationship and partnership will enhance parental involvement in their children's learning.

The Ministry of Education should encourage the documentation and storage of TEK using various media formats, such as video, audio, and books. This will ensure that indigenous knowledge is preserved, easily accessed, and shared with future generations. One of the major challenges raised by participants was the lack of sources of traditional knowledge. The knowledge can be collected and stored through the ministry so future generations can access it.

Finally, the government should provide adequate resources, including funding and materials, to support the effective incorporation of TEK into the science curriculum. This can include books, equipment, and technology that align with this integration.

11 Suggestions for future research

Since the study revealed that teachers had a limited understanding of TEK, further research can focus on developing comprehensive definitions and conceptual frameworks for TEK. This can involve exploring the different aspects of TEK, such as its relationship with biodiversity, land management, and sustainable practices. A study of factors hindering the incorporation of TEK into science education may also be considered. Additionally, research can focus on developing methods and tools for storing, documenting, and preserving TEK. This can involve exploring multimedia formats like videos, audio, and books to record and transmit TEK and addressing issues related to intellectual property rights and the commercialisation of indigenous knowledge.

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