

Prospect of Integrating African Indigenous Knowledge Systems into the Teaching of Sciences in Africa

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Abstract The consideration of cultural backgrounds of the learners in planning and teaching science has informed much recent discussions in making teaching more learner-centered. In many countries today, formal education continues to be Euro-centric in outlook and academic in orientation, reflecting Western scientific cultures rather than the cultures of learners and the teachers. This phenomenon is a major concern in developing countries, where formal education does not put into consideration the way the majorities of learners communicate, think and learn. Learners' underachievement in school has been attributed to the 'cultural gaps' between the expectations of school curriculum and those of the environment in which the learners are socialized. In the developing countries, this gap also existed for majority of the teachers and thus, raises the question of whose and what knowledge is considered worthwhile? The current euphoria for market driven economies and education development make issues such as cross cultural transfer of knowledge, globalized curricula integration and appropriate teaching-learning strategies critically important for consideration. While commendable efforts are being made to better align educational curricula with indigenous realities, the interrelationship and balance between these two different ways of learning remain delicate especially in the African context. This review study focuses among others, the indigenous peoples' systems of knowledge creation and transmission, modern science versus African indigenous knowledge, improving Science teaching in Africa, and the impact of indigenous knowledge system on scientific discovery and development.

Keywords: *indigenous knowledge system, teaching science, knowledge transfer, developing countries*

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1. Introduction

Indigenous knowledge refers to the local knowledge that is unique to a given culture and acquired by local people through the accumulation of experiences, informal experiments, and intimate understanding of the environment in a given culture [1]. It encompasses the technology, social, economic and philosophical, learning and governance systems [1,2] of a community. It was also reported that indigenous knowledge systems are better understood as practical, personal and contextual units which cannot be detached from an individual, their community, or the environment (both physical and spiritual) [3]. Indigenous knowledge system constitutes the core of community development processes such as agriculture; preservation of food; collection and storage of water; animal husbandry and ethnic veterinary medicine. It also forms the basis of indigenous interpretation of meteorological and climatic phenomena; orientation and navigation on land and sea as well as in management of natural resources. Indigenous knowledge is also very useful in local primary health care; preventive medicine and psychosocial care as well as the rule of procreation.

Recently too, it has taken centre stage in poverty alleviation through community savings and lending; confection of clothing and tools; as well as construction and maintenance of shelter.

For thousands of years, the African indigenous knowledge systems existed and have their own education systems, long before western educations were introduced by the European colonialists and missionaries. The introduction of the western educations meant that learners faced the conflicting demands of the new education and those of their home cultures, because the purpose, content, and processes of knowledge transmission conflicts with those of indigenous education [4]. In the various tribes of the world, there exists indigenous knowledge that can be meaningfully integrated into the western school curricula [5] for improved learning outcome. He also noted that the artifacts that are available in the traditional environments are important tools that can be used to bridge the gap between what is usually taught in the classroom and what exists outside the classroom, that is, in society. Additionally, it was argued that education cannot exclude cultural knowledge, since the content of education has value underpinning it and is associated with a particular culture [6].

Several authors have submitted that in order for schools and curricula to positively respond to the need of make teaching and learning more culturally inclusive; there will be a need for a paradigm shift from the current predominantly Euro-centric curricula and school systems of African [4,7,8]. However, it was opined that this paradigm shift is a challenge for teachers who are expected to mediate the interface between the different cultural systems of meanings and values that continue to exist in their schools [4]. As cultural mediators, our teachers in the African context occupy an important but culturally ambiguous position. While their professional training commits them to the rationale and practices of a western-derived school curriculum, their personal identities, together with those of their students, are rooted in their own cultures and traditions. At school, teachers often de-emphasize the values of the students' home cultures, especially if they conflict with the values that the school is trying to promote [4].

Consequently, the learners' prior knowledge becomes detached from the idea being promoted by the school curriculum and in order to progress with the school system (passing and being promoted to the next class), most African children tend to memorize the theory but lack the application expected to differentiate the educated and non-educated citizens in a society. So, it is important that African education developers evolve strategies such as integrating the indigenous knowledge system in the teaching of sciences which has the potential to make our education culturally-inclusive and make the teaching and learning of science easier for both teachers and the learners.

2. Indigenous People's Knowledge Creation and Transmission

It has been submitted that *"the elders would serve as mnemonic pegs to each other [9]. They will be speaking individually uninterrupted in a circle one after another. When each elder spoke, they were conscious that other elders would serve as peer reviewer and so they did not delve into subject matter that would be questionable. They did joke with each other and tell stories; some true and some a bit exaggerated but in the end the result was a collective memory. This is the part which is exciting because when each elder arrived they brought with them a piece of the knowledge puzzle. They had to reach back to the teachings of their parents, grandparents and even great-grandparents. These teachings were shared in the circle and these constituted a reconnaissance of collective memory and knowledge"* [9].

Indigenous ways of knowledge creation are based on locally, ecologically, and seasonally contextualized truths. These knowledge are passed down from generation to generation through traditional education, with adults teaching practical knowledge of culture, the environment and survival through demonstrations and a wide range of ceremonies, stories, songs, village meetings and taboos. In contrast to the aspirations of some Western scientific traditions for universal truths, Indigenous epistemologies are narratively anchored in the natural communities characterized by complex kinship systems of relationships among people, animals, the earth, the cosmos, etc. from which knowing originates [10]. As a result, education was

confined to classrooms and children separated from their culture and environment. The teacher-centered nature of formal education also separated children from parents and, consequently, parents became less able to pass on the knowledge they had inherited to their children.

Knowing what a particular Indigenous knowledge system consists of and how it is acquired is fundamental to being able to make use of the knowledge thereby encouraging all parties to be aware of the added value its use will bring [2]. In most Indigenous communities, the knowledge and wisdom of the elderly are transmitted to the younger population through traditional songs, stories, legends, dreams, and practices. Sometimes they are preserved in artifacts handed from one generation to the next. In virtually all of these systems, knowledge is transmitted directly from individual to individual [2]. It is obvious that in the rural communities, knowledge of the locally occurring species of plants and animals are relied on for their use as foods, medicines, fuel, building materials and other products. In making use of nature's gifts, the Elders directly involve their children especially those who are loyal for the purpose of sharing the knowledge and wisdom with them. It has been reported that the world's Indigenous people possess an immense knowledge of their environments, based on centuries of living close to nature [11]. By living in and from complex ecosystems, these people have an understanding of the properties of plants and animals, the functioning of ecosystems and the techniques for using and managing them that is particular and often detailed and are transmitted to the younger generation traditional songs, stories, legends, dreams, and practices.

3. Improving Science Teaching in Africa: The Prospect of Integrating Indigenous Knowledge System

Until recently, the indigenous knowledge was assumed irrelevant, unscientific and outdated. Therefore, few attempts were made to integrate indigenous knowledge into formal education despite its potential value in solving contemporary problems. As a result, education was confined to classrooms and learners separated from their culture and environment [12]. More worrisome, the dominated teacher-centered teaching method of the present formal education system has further separate learners from their parents and, consequently, parents became less able to pass on the knowledge they had inherited to their children. This educational pattern negates the Constructivist theory which believes that *"children actively construct their Knowledge, rather than simply absorbing ideas spoken to them by teachers"* [13]. Thus, for the African child to learn with meaningful practical applications within his/her communities, there is need to extend science teaching in Africa beyond the current practice of *"transmission and indoctrination"* to facilitating subject matter learning through integration of the learner's Indigenous knowledge system in order to transform the subject matter knowledge into comprehensible form that the learner can grab and apply.

Due to repeated failures of existing pedagogical models, curriculum are constantly being reviewed and just recently,

the Namibia Ministry of Education announced a dramatic review of the country's Basic education curriculum in which the new curriculum of the senior primary phase (Grades 5 to 7) will now include mother tongue instruction [14]. This is an important and a bold step taken by the present government in recognition of the prospect of integrating indigenous knowledge system to improving teaching and learning outcome. Obviously, certain scientific concepts can be best understood by learners and the meanings easily contextualized within the learning environment if translated in an indigenous knowledge popularly used as a medium of communication. This teaching approach has the potential to help learners carry out activities which will lead them to construct a sustainable understanding of the subject matter and hence, make them responsible for building their own knowledge and understanding. Proper integration of indigenous knowledge system into science teaching activities will greatly assist African science teachers and learners to make extensive use of hands-on activities, investigative laboratory activities, open-ended questions, inquiry-oriented discussion, co-operative learning, and in fact performance assessments as pedagogical tools. Within each of these knowledge systems is a body of complementary knowledge and skills which, if appropriately applied and leveraged, can serve and strengthen the quality of educational experiences for Indigenous students [15]. Under properly integrated indigenous knowledge system, an indigenous science teacher will become capable of developing learners' understanding beyond simple memorization of facts since critical concepts will be presented in local meanings. In this way, learners could acquire analytical skills that can be applied to other problems and situations, rather than merely accepting teachers' explanations. Constructivists generally maintain that when information is acquired through transmission models, it is not always well integrated with prior knowledge and is often accessed and articulated only for formal academic occasions such as examinations [16].

It has been observed that what a person "knows" is not passively received, but actively assembled by the learner [17]. Thus, the following principles were suggested as helpful guides for teachers [17].

i. **Learning requires mental activity.** The learner should be an active contributor to the teaching process since knowledge is not a thing that can be simply given by teacher at the front of the classroom to students in their desks. Learners can only be active contributors in the teaching process if their prior knowledge is relevant to the subject matter and this is where integrating the learners indigenous knowledge in the teaching becomes pertinent. The learners' current knowledge and experience are critical in new learning situations and need to be taken into account.

ii. **Learning occurs due to dissatisfaction with present knowledge.** For meaningful learning to take place, learners must be put in situations that might challenge their previous conceptions and that will create contradictions that will encourage discussion; and thereafter bring about cognitive restructuring for new learning to occur.

iii. **Learning has a social component.** Learners construct knowledge not only by physically and mentally

acting on objects but also through social interactions with others. Cognitive growth results from meaningful learner-learner and learner-teacher dialogue. Learning is facilitated by "real talk" in which domination is absent while reciprocity, co-operation and collaborative involvement are prominent.

iv. **Learning requires application.** Applications must be provided which demonstrate the utility of the newly acquired knowledge and the learners' prior knowledge of the concept- the indigenous understanding which will assist the learner to see the knowledge as relevant to solving his everyday problems.

In achieving the above, science curriculum must be structured to permit flexible understanding of the subject matter by learners within their immediate environment. In this case, integrating the learners' indigenous knowledge system with which they view concepts and the outside world becomes critical.

4. Impact of Indigenous Knowledge System on Modern Science Development

4.1. Indigenous Agricultural Science

The traditional agriculture in Africa is seen as an indigenous agricultural system that has developed over time with cropping patterns based on an agricultural knowledge system expressed in the local language, viewed to be in dynamic equilibrium with the environment, influenced by innovations emerging from within the system as well as those adopted from other indigenous systems and the national and international agricultural systems [18]. The deliberate maintenance of diversity in domesticated and non-domesticated plants and animals characterizes farming systems across the African continent as well as in most other parts of the world, providing an important opportunity for systematic in situ maintenance of genetic resources [19]. The informal agricultural research and development systems parallel those of modern agriculture, providing opportunity for national agricultural research and extension services to work with the creative interests and activities of farmers and other indigenous people.

Traditional agriculture is an ecologically tolerant and resilient crop production system. It has optimized production security through an evolution which stresses low risk through adaptation to the local environment [1]. Crop security essential to subsistence farmers is assured through the development of a complex system involving such factors as diversity of crops, well dispersed plantings, heterogeneous genetic resources, minimum tillage, and varying fallow, as well as sharing of food and labour. Such practices are often rational responses to local conditions and are logical adaptations to risks [1]. The use of plant derivatives for insect control was common in the tropics before the advent of synthetic pesticides. The mixture of crops is often made up of varieties that have different moisture, soil nutrients, and resilient levels. The practice ensures that the entire farm is not devastated in case of disease outbreak or pest attack. It also facilitates recycling of nutrients through crop and weed-residues and ensures constant vegetative cover. Modern agricultural scientists explore these indigenous adaptive strategies to

develop ecological adaptive crops for improved yields and food security.

4.2. Indigenous Science and Technology

Indigenous people improve their livelihood through the use of simple technology. Many of these communities work on finding and developing technologies that improve the lives of the poorest and provide openings for small local enterprises. These include bee-keeping, making soap from local materials, planting weeds that lure animal pests away from the fields, and traditional crop varieties that grow best in local conditions. Modern sciences have used this indigenous knowledge system to advance the modern day science and technology innovations and applications.

4.3. Indigenous Health Care Delivery

Indigenous Africans like other indigenous peoples elsewhere, rely on plant and animal-based medicine to meet their health care needs. A wide variety of plants and animals (birds, reptiles, amphibians, fishes, mammals, and insects) are vital components of African traditional medicine. A study in Ghana established distinguishing features of indigenous healers who provide health care with plant, animal or mineral substances and use methods that are based on socio-cultural and religious beliefs of the people [20]. The author listed the following categories of indigenous healers: herbalists, traditional priests, traditional birth attendants, and bone setters. The herbalists, for example, are knowledgeable in the medicinal uses of indigenous herbs and other naturally occurring substances, while bone setters use herbs and other naturally occurring substances to heal patients with fractured bones [20]. In some communities in Nigeria too, traditional bone setters treat a fractured bone by breaking a similar bone of a live hen or cock or goat at the same position the patient has fracture. While setting the fractured bone of the animal, the patient heals simultaneously with the animal without any physical treatment on the person. This knowledge is highly respected and has remained helpful in these communities and many such cases are referred from far and near for treatment. Interestingly, it is some of this deep-rooted indigenous knowledge in health care delivery that account for the clamour for supremacy between orthodox and unorthodox medicine. Thus, with such records of effectiveness of the traditional health care delivery system which has relied solely on the indigenous knowledge of the people, it will only be wise for western science to seek synergy with the existing knowledge rather than operating in isolation.

4.4. Biodiversity and Natural Resource Management

The UN Conference on Environment and Development (UNCED) in 1992 submitted an urgent need for developing mechanisms to protect the earth's biological diversity through local knowledge [21]. Similarly, the World Conference on Science in Budapest in 1999 recommended that scientific and traditional knowledge be integrated in interdisciplinary projects dealing with links between culture, environment and development in areas such as the conservation of biological diversity, management of natural resources, understanding of natural

hazards and mitigation of their impact [1]. Many indigenous communities did not need any sermon from global agencies and external interventions to appreciate the importance of effective and efficient natural resource management and as such keep close watch of their environment's quality and protection. For example, most of the features around us today: plants, animals, and landscape have survived because they are considered to be sacred. For several Indigenous communities, the forest fulfils many functions: it serves as protection, provides them with medicinal plants and food and is a place for the conservation of flora and fauna. It also serves as a place for important socio-cultural meetings and serves as a last living testimonial for future generations of what a true forest is. In west Africa the ancient tradition of community forest management seems to hold the ancient keys for a meaningful model of forest conservation [1].

4.5. Indigenous Sustainable Development

Sustainable development has been variously defined and explained. For example, the International Union for the Conservation of Nature and Natural Resources (IUCN) explains that, "for development to be sustainable it must take into account the social and ecological factors, economic factors, the living and non-living resource-base, and the long and short term advantages and disadvantages of alternative actions" [22]. In another opinion, the World Commission on Environment and Development (WCED), also refers to sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." These definitions are both critical to the need to reflect on the potential role the integration of African Indigenous knowledge system has in sustainable African science teaching and learning. Learners' knowledge in science should move from the level of abstraction to application so as to maximally justify the ideal behind education and development. African philosophies explain that there is a duty on the present generation to look beyond itself to future generations as well as to look back at the past and respect departed ancestors. This can help to reinvigorate our science teaching as well as enhance the principles underlying sustainable educational development.

4.6. Traditional Ecological Knowledge

The term Traditional Ecological Knowledge (TEK) includes intimate and detailed knowledge of flora, fauna, natural occurrences and the development and use of traditional technologies [23]. The amount of TEK in Africa, for instance is vast and its development provides clue mainly to the wide diversity of peoples, cultures, landscape, eco-zones and eco-regions. Knowledge stemming from a long-term association with the ecosystem allows local fishing operations to compete with the large, commercial fishing operations which do not have a full understanding of the fishing areas [24]. Local fishermen often possess 'mental maps' of fishing areas and the seabed and a fishing location is often memorized using a triangulation method. There cannot be any sustainable use of any resource if the interests of the local traditional communities are not taken into consideration. Modern science must therefore, accommodate the indigenous knowledge system and vice versa.

4.7. Indigenous Natural Disaster Management

In Africa, local communities have well-developed indigenous knowledge system for environmental management and coping strategies, making them more resilient to environmental changes. This knowledge had, and still has, a high degree of acceptability amongst the majority of populations in which it has been preserved. Specifically, from time immemorial, natural disaster management in Africa has been deeply rooted in local communities which apply and use indigenous knowledge to master and monitor climate and other natural systems and establish early warning indicators for their own benefit and future generations. These communities can easily identify with this knowledge and it facilitates their understanding of certain modern scientific concepts for environmental management, including disaster prevention, preparedness, response and mitigation. For example, floods can be predicted from the height of birds' nests near rivers. Moth numbers can predict drought. The position of the sun and the cry of a specific bird on trees near rivers may predict onset of the rainy season for farming. The presence of certain plant species indicates a low water table [25]. These indigenous knowledge systems have links to the modern knowledge of the natural disaster management strategies.

5. Indigenous Knowledge Systems Versus Western Science

When we look at the state of the African science education and the inability of western science and technology to wholeheartedly achieve the educational goal of sustainability, we are led to begin a search for new paradigms in science and new ways of negotiating the scientific agenda. In their nature and structure, both indigenous knowledge and the Western and scientific systems are fundamentally alike. They both consist of complex webs of propositions and interpretations drawn and agreed upon by groups of scientists. Both require some sort of faith, or acceptance of a particular picture of the world and both are socially negotiated pictures of the universe which inform the ongoing life of the society. Each of the knowledge system bears with it certain strengths and limitations. Therefore, it is impossible to say that one system is more suitable to the present educational needs than the other because each system develops certain dimensions of truth at the expense of others. Additionally, each system has evolved to suit the needs of the scientists in the community.

The table below summarizes three major issues for consideration in negotiating indigenous knowledge system and western science towards a common goal.

Table 1. Major issues for consideration in negotiating indigenous knowledge system and western science towards a common goal [12]

Aspects of Education	Indigenous Education	Formal Education
View of Knowledge	<ul style="list-style-type: none"> • Sacred and secular together; includes the spiritual • Holistic and integrated – based on a whole systems view of knowledge • Stored orally, in cultural practices and artifacts • Powerful predictability in local areas (ecological validity) • Less valued in distant areas 	<ul style="list-style-type: none"> • Secular only; often excludes the spiritual • Analytical or reductionist – based on subsets of the whole • Stored in books and computers • Powerful predictability in natural principles (rational validity) • Weak in local use of knowledge
Objectives	<ul style="list-style-type: none"> • Long-term recall • Cultural and ecological sustainability • Practical: for use in everyday life • Integration of critical thinking and cultural values in decision making 	<ul style="list-style-type: none"> • Short term recall • Economic sustainability • Abstract: to pass examinations • Use of logical and critical thinking in making decisions
Methods of Teaching and Learning	<ul style="list-style-type: none"> • Lengthy period of acquisition • Learning through experience • Teaching through example, modelling, ritual and storytelling • Tested in practical life situations 	<ul style="list-style-type: none"> • Rapid acquisition • Learning by formal education • Teaching through abstract concepts and didactic methods • Tested artificially in examinations

role that IKS and Western science could play to effectively support science development in Africa.

6. Conclusion

The opinion expressed in this study revealed that both Indigenous Knowledge System (IKS) and Western science can collectively support the teaching of science to have common ground in Africa. While western science offers broader appreciation of context beyond the local level, the IKS offers depth of experience in a local, culture-specific context. This suggests that IKS and Western science are complementary or parallel rather than fundamentally incommensurable. This could be anchored on the fact that both IKS and western science rely on direct observation, experience, experimentation, and interpretation. Therefore, for improved science teaching and learning outcome in African systems, it is recommended that educational researchers should urgently and vigorously pursue case based studies with a view to establishing the complimentary

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