International Journal of Social Science Research and Review

http://ijssrr.com
editor@ijssrr.com
Volume 7, Issue 2
February, 2024
Pages: 173-189

# Reimagining STEM Education in South Africa: Leveraging Indigenous Knowledge Systems Through the M-Know Model for Curriculum Enhancement

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http://dx.doi.org/10.47814/ijssrr.v7i2.1951

## *Abstract*

This conceptual paper investigates the integration of indigenous knowledge systems (IKS) into South African Science, Technology, Engineering, and Mathematics (STEM) education, exploring its conceptions, historical roots, significance, and the challenges and benefits associated with such integration. The objective was to understand the role of IKS in enriching STEM education and its potential contributions to global scientific knowledge. A culturally sensitive research approach was employed, with criteria set for selecting relevant literature on IKS and STEM. The results highlighted the profound historical significance of IKS in South Africa and its potential in bridging cultural gaps in education. Pedagogical innovations rooted in indigenous practices were identified as key to revitalising the STEM learning experience. However, challenges such as educational barriers, policy constraints, and institutional norms were also noted. Thus, the Multiple-ways of knowing (M-Know) model is proposed to demonstrate the possibility of using an integrated approach for the inclusion of IKS and enhancement of the STEM higher education school curriculum in South Africa. The model negotiates for a synergic or integrated arrangement between formal STEM curriculum and IKS in terms of using IKS to interrogate, complement, and consolidate the contents and pedagogy of Westernised STEM education in higher education.

***Keywords:*** *Indigenous Knowledge Systems; South African STEM Education; Pedagogical Innovations; Cultural Integration; Multiple Ways of Knowing*

## *Introduction*

The rich tapestry of South Africa's history is intricately woven with a diverse array of knowledge systems, values, and beliefs. These encompass a wide spectrum of aspects such as oral traditions,

engineering, mathematics, agriculture, medicine, cultural traditions, and rituals (Onwu & Mosimege, 2004; Kaya & Seleti, 2013; Apraku et al., 2021). However, the apartheid era brought significant challenges to the propagation and appreciation of indigenous knowledge systems (IKS) (Department of Science and Technology, 2004; Kaya & Seleti, 2013; South African Cultural Observatory, 2021). The legacy of neo-Calvinism during this period resulted in an ideological distortion of education, favouring Western epistemologies over indigenous knowledge (IK) (Conradie & Toit, 2015; Etieyibo, 2021). Despite these enduring challenges, the resilience of IKS in South Africa is evident.

In the agricultural sector, for instance, smallholder farming communities in Limpopo, KwaZulu-Natal, and other provinces in South Africa depend on a combination of IK and skills to improve their crop production and adapt to the adverse effects of climate change and food insecurity (Rankoana, 2022). Local farmers employ IK and adaptation mechanisms in rainfall prediction, preparation of the gardens, change of crops, and planting season to ensure better crop yields (Rankoana, 2022). Earlier research conducted by Mapfumo et al. (2016) and Nwokocha (2020) found that indigenous communities in South Africa used their vast IK, along with local biological and geographical indicators of seasonal forecasts, to make major strategic, tactical, and operational decisions regarding crop production and management of food stocks in the face of climate change.

During the global COVID-19 pandemic, local communities relied on their IK and communication systems, employing indigenous languages to translate and disseminate information regarding the COVID-19 vaccination within their communities (Zavaleta-Cortijo et al., 2023). Nonetheless, the integration of IK and indigenous languages into formal education remains a contentious issue in post-colonial Africa (Nel, 2005; Kaya & Seleti, 2013; Singh-Pillay et al., 2017; Keane et al., 2023).

Scholars such as Mawere (2015) and Moichela (2017) argue that the judicious use of IK can empower African students and improve teaching and learning, even in disciplines traditionally seen as "Western", such as computer science (Dalvit et al., 2008). In science education, Mudaly (2018) suggests that efforts to decolonise the curriculum have been initiated, emphasising the role of IKS in creating transformative educational spaces. Thus, Manathunga (2020) advocates for the decolonisation of the curriculum to ensure that the views and voices of marginalised groups are heard, recognised, and included (Meda, 2020). Building on the arguments of Morreira et al. (2021), this approach will cultivate students as embodied, knowledge-making individuals embedded within communities, as opposed to abstracted individuals who are merely recipients of knowledge rooted in other cultures. Implicit in this stance is a call for teaching that is not only contextually relevant but also meaningful, reflecting the lived realities of students.

Against this backdrop, this review intends to address the following objectives: first, to clearly define IKS; second, to understand the historical evolution of IKS in South Africa and their intersection with Science, Technology, Engineering, and Mathematics (STEM) education over time; third, to investigate the various pedagogical strategies and methodologies employed in integrating IKS into STEM curricula, with an emphasis on highlighting best practices and innovative approaches. Additionally, the review seeks to identify and analyse the challenges educators and institutions face in integrating IKS into STEM, and to explore potential solutions and strategies to overcome these obstacles. Furthermore, it aspires to provide a practical model for policymakers and educators, ensuring the sustainable and effective integration of IKS into STEM education in South Africa.

It is believed that this literature review will highlight some noteworthy benefits for various stakeholders, including indigenous communities, academia, the government, and industry within the South African context. It aims to demonstrate how the incorporation of IKS into STEM can yield significant benefits, ultimately enhancing the economic landscape of the nation. Indigenous communities

stand to gain by preserving their traditional cultural heritage and identity. In the education sector, key players can anticipate enhanced scientific research, marked by alternative perspectives, innovative solutions, and sustainable practices. Moreover, the integration of IK into STEM has the potential to promote social inclusion, spur economic development, and address societal challenges by bridging the gap between modern scientific knowledge and traditional wisdom.

The paper is organised into distinct sections, starting with the main argument, followed by the definition, understanding, and historical evolution of IKS in South Africa and their intersection with STEM education. Additionally, the paper delves into pedagogical strategies and methodologies for seamlessly integrating IKS into STEM curricula. Other sections address the challenges encountered during the integration process and propose strategies for overcoming them. Furthermore, the paper includes a section outlining a practical model for policymakers, ensuring the effective integration of IKS into STEM education in South Africa.

### *Main Argument*

This paper asserts that, given the accelerated loss of biodiversity, natural environments, and cultural practices, there is a pressing need for the study and revitalisation of IKS (Wilder et al., 2016). Furthermore, the preservation of traditional knowledge (TK) and traditional cultural expression (TCE) within indigenous communities (Kasih et al., 2021) is paramount for safeguarding cultural heritage, placing IKS at the forefront of these endeavours. TCE encompasses both tangible and intangible cultural heritages, including various forms of cultures and TK expressed, manifested, or communicated (Susanti et al., 2019). On the other hand, TK refers to the creativity, wisdom, and customs of indigenous and local groups globally, evolving over centuries and tailored to the specific local environment and culture (Bagun, 2019).

Arguably, the above-mentioned perspective creates a different reality in the foundation of learning, offering new approaches to the way people live their lives and how they interact with the land (Paquin, 2023). This stands in contrast to the Western epistemology that has characterised the South African curriculum (Hlalele, 2019). Historically, the educational landscape in South Africa has been largely shaped by Eurocentric paradigms, often sidelining the rich IK that has been passed down through generations (Mawere, 2015). This Western-oriented Eurocentric paradigm forms the basis for STEM, offering an alternative way of knowing compared to IKS, as its foundation is rooted in scientific understanding.

In South Africa, evidence indicates the existence of over 20,000 IKS across the various provinces, as documented by the Department of Science and Innovation (DSI) (Republic of South Africa [RSA], 2022). On Friday, 25 March, 2022, in a hybrid event, the DSI introduced a new registration system designed to safeguard and facilitate access to the rich IK of South African communities (RSA, 2022). This initiative created avenues for researchers, policymakers, and IK practitioners to benefit, as communities had the privilege to contribute their knowledge, participate in the access-benefit-sharing agreement, and become role players in the mainstream economy.

Thus, the integration of IKS into STEM, especially in higher education, establishes a bridge between students' home and school lives. This connection allows students to see themselves in the content, provide students with new avenues for thought, and help them identify any prejudices they may have about the beliefs of another knowledge system (Paquin, 2023). The integration of IKS into higher education holds the potential to profoundly transform educational practices globally (Wilder et al., 2016). Moreover, such an approach aligns with the urgent call for the decolonisation of the Eurocentric curriculum currently implemented in the South African school system.

**What are Indigenous Knowledge Systems?**

Indigenous knowledge systems, also known as traditional knowledge (TK), native knowledge (NK), or local knowledge (Semali & Kincheloe, 1999; Onwu & Mosimege, 2004; Naidoo, 2010; Eze & Ike Nnia, 2013; Bruchac, 2014; Petzold et al., 2020), have gained significant interest and attention, especially in the political arena and among academics in South Africa and various other countries. Interestingly, IKS has not yet garnered a universally accepted definition, possibly due to the diversity in practices, experiences, approaches, and methodologies employed by practitioners of IK across the globe (Onwu & Mosimege, 2004; Nel, 2005). Nonetheless, there is a common convergence in understanding of what it is made up of and where it is available or found. Thus, a broad definition of IKS is that it is a knowledge system comprising *local, indigenous, or traditional forms of knowledge and skills, found either locally or within and among specific people or communities. These knowledge forms are shaped by the language and challenges of the people embodying that language and possess transferable or applicable qualities beyond their original geographical context.*

Semali and Kincheloe (1999) assert that the term "indigenous knowledge system" denotes a mode of reasoning or rationalisation that rewards the people who live in a given area. Expanding on this, they elaborate that such reasoning or rationalisation shows the dynamic ways in which the inhabitants of a given area have come to comprehend their identity in relation to their natural environment. It also delineates how they organise their TK or understanding of flora and fauna, cultural beliefs, and history to improve their way of life. Similarly, Onwu and Mosimege (2004) maintain that this type of knowledge is all-encompassing, spanning technologies and practices that have presently and historically been employed by indigenous and local communities for the purpose of sustaining their existence, ensuring survival, and adapting to diverse environments. In this regard, the authors provide an extensive scope of IKS, encompassing domains such as agriculture, architecture, engineering, mathematics, medicinal and indigenous plant varieties, governance, and other social systems.

Considering the preceding perspectives on IKS, three fundamental definitional components emerge as integral to IKS:

(a) a specific knowledge base
(b) belonging to a particular people within a defined cultural locale or community, and
(c) comprising practices that are adaptable and can evolve in response to the needs of the community.

Therefore, IKS can be defined as a knowledge base generated by people existing within a particular locale, shaped by their continuous interaction or engagement with their immediate environment. It encompasses contents and practices, including techniques, crafts, or methods used to transform local resources or raw materials into products and services for domestic or commercial use. These knowledge systems are dynamic, not static, displaying fluidity as they interact with other forms of knowledge. Furthermore, engagement with IKS practices and experiences is facilitated through membership or integration within the community of a local cultural area of practice. As emphasised by Semali and Kincheloe (1999), IKS does not exist in a vacuum; rather, it belongs to the community, and access to it is only possible through direct association with that community. Simply put, it implies that IKS cannot be accessed or experienced indirectly or through proxy means.

**Origin and Evolution of IK in South African Communities**

IK, deeply rooted in the cultural fabric of societies, is a culmination of wisdom, practices, and beliefs passed down through generations (Bruchac, 2014). In South Africa, this knowledge has played a pivotal role in shaping the lives of its diverse communities, providing insights into their relationship with the environment, health practices, and socio-cultural norms (Department of Science and Technology,

2004). According to Seile et al. (2022), IKS in South Africa have been intricately woven into the everyday lives of its people, serving as the foundation for primary health care and treatment of various ailments. Medicinal plants, for instance, have been an integral part of these systems, with communities relying on them for countless generations (Mashego et al., 2021). The significance of such plants is exemplified in the case of African ginger, scientifically known as Siphonochilus aethiopicus. Indigenous to South Africa, this plant has been used to treat a myriad of health conditions, from coughs and colds to more severe ailments like asthma (Erhabor et al., 2020). Supporting this perspective, Seile et al. (2022) argue that African ginger continues to be a popular indigenous plant species for various health, spiritual, or cultural purposes within South African communities. Expanding on this notion, Mashego et al. (2021) assert that the use of medicinal plants as a therapeutic resource within indigenous healthcare systems is the oldest form of healthcare provision and remains the panacea of primary health services in South African rural communities. However, the commercial trade and over-harvesting of these plants have raised concerns regarding their sustainability, prompting discussions on conservation strategies rooted in IK (Seile et al., 2022).

In the agricultural sector, the use of IKS among rural communities is not a recent phenomenon. According to research by Ballard (1986), smallholder farmers in KwaZulu-Natal devised strategies for adapting to adverse weather and climate uncertainties as early as the 1700s. The strategies include the diversification of crops adapted to drought conditions, migration to non-drought-affected areas, and market exchange (Ballard, 1986). Over the years, indigenous agricultural practices in South Africa have continued to evolve, adapting to local climates, soil conditions, and available resources (Vilakazi et al., 2019; Nwokocha, 2020). Smallholder farmers have developed indigenous strategies to cope with extreme weather conditions and sustain agricultural production (Nwokocha 2020). Aligning with this perspective, Olaopa and Ayodele (2022) propose that IKS hold the potential to mitigate some of Africa's interrelated sustainable challenges and address some of the critical Sustainable Development Goals (SDGs), such as SDG 2, which seeks to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture. Building on these insights, Mkwanazi et al. (2019) note that the inclusion of IK to enhance livestock veterinary care is widely acknowledged in South Africa.

While IK has been a beacon of wisdom for local communities, the educational landscape in South Africa has predominantly been influenced by Western paradigms (Keane et al., 2023). The growing calls for a decolonised curriculum emphasise the necessity for integrating IKS into the educational framework (Hlalele, 2019). This integration not only ensures that the curriculum is rooted in local knowledge and language but also challenges the dominant Western ideologies, epistemologies, and axiologies. The narratives of rural teachers, as highlighted by Hlalele (2019), highlight the importance of dislodging Western epistemologies to embrace indigenous communities and their wealth of knowledge.

**An Overview of the Journey of Stem Education in South Africa**

Historically, STEM fields have been dominated by White men (Mkhize, 2022). This phenomenon can be traced back to colonial ideologies that deemed Africans intellectually, socially, and culturally inferior to their white counterparts in STEM disciplines (Mkhize, 2022). However, the demographics of the STEM landscape are undergoing a gradual transformation, with an increasing number of individuals from other racial groups, especially indigenous Black Africans, entering these fields (Nyamnjoh, 2016). Notably, Science, Technology and Engineering witnessed the highest enrolment in South African public higher education institution between 2020 and 2021 (Department of Higher Education and Training [DHET], 2020, 2021).

According to the DHET's statistics on post-school education and training in South Africa, 319,902 students enrolled for Science, Engineering and Technology disciplines in 2020 (DHET, 2020). This number dropped slightly to 313,788 in 2021 (DHET, 2021). From the above figures, one can infer that more Black South African students enrolled in STEM fields between 2020 and 2021 given that Black

South African students accounted for 78.7% (86,2313) of all students enrolled in public higher education in 2020 (DHET, 2020) and 79.5% (849,246) in 2021 (DHET, 2020).

The increased enrolment of Black African Students in higher education, particularly in STEM disciplines, can perhaps be attributed to the transformation policies and initiatives undertaken by the government and universities in South Africa to attract more Black South African students, especially women, to pursue STEM fields (Nyamnjoh, 2016). To promote higher education enrolment, particularly among historically disadvantaged groups and, more specifically, in STEM fields, the Government of South Africa implemented the National Student Financial Aid Scheme (NSFAS) (Manuel, 2019), while the private sector introduced several other funding initiatives. According to Matukane and Bronkhorst (2017), the NSFAS was introduced in 1994 to support and encourage previously disadvantaged students to gain access higher education.

Recently, the South African Government intensified efforts to promote STEM careers and raise awareness about the opportunities available in these fields. The latest of these efforts is the launch of the "Presidential PhD Initiative" by President Cyril Ramaphosa (News24, 2023). The initiative, which received an initial funding of R1 billion from the National Skills Fund, is expected to create opportunities for South Africa's "brightest young minds" at world-leading universities and research institutions (News24, 2023). The funding will be increased to R5 billion by 2030. Justifying this initiative, the South African President emphasised the country's potential to harness technology and innovation for economic development and global competitiveness, thus accentuating the strategic and aggressive need to invest in education and skills development. According to the report, the initiative will focus on STEM skills and areas such as "artificial intelligence research", "advanced biotechnology", "fuel cell development", "batteries and other storage", and "next-generation mining" (New24, 2023). This underscores the pivotal role of STEM fields in South African economic development, emphasising the intentional efforts made to train and elevate individuals' skills to the highest levels.

Nonetheless, the throughput rate for Black African students in STEM fields remains low (DHET, 2020), while the attrition rate is on the rise (Otu & Mkhize, 2018). This observation is corroborated by Sikhosana et al. (2023), whose study revealed that a majority of students from previously disadvantaged communities and schools faced challenges coping with the STEM course workload and language of instruction (English) in higher education. A year earlier, Mkhize (2022) argued that more Black South African students are enrolling in STEM fields; however, the majority of these students do not progress to postgraduate studies or become academics (Mkhize, 2022). This is attributed to institutional legacy, epistemological, marginalisation, ontological and socio-cultural factors, as well as a hostile outlook toward STEM education in the country (Mkhize, 2022).

Similarly, a study conducted by Bengesai and Paideya (2018) revealed that African students in Engineering courses are less likely to graduate within the stipulated time compared to other racial groups in South Africa. Furthermore, the results of the study suggest that African students in the Engineering department had a lower throughput than their Indian counterparts. Building on this, Mkhize (2022) argues that the transformation process in STEM disciplines is progressing at a very slow pace. The author contends that movements in STEM fields in South Africa should be described as reform and not transformation as being portrayed.

Despite the emergence of the Fourth Industrial Revolution (4IR) and its potential to reshape societies in unprecedented ways, concerns persist that the challenges faced by Black South African students, who constitute the majority of previously marginalised groups, in STEM fields will endure (Carrim, 2022). The emphasis on 4IR and STEM is evident in how education is perceived, with a technicist approach that sometimes overlooks the existing inequalities in the South African educational

system (Carrim, 2022). Furthermore, the customised curricula promoted by the 4IR may limit the potential for deep learning, as they might not adequately address the unique challenges and needs of the South African higher education context (Carrim, 2022).

The aforementioned suggests that epistemological access and success in STEM disciplines remains a challenge, especially for individuals from rural or indigenous communities, such as Black South Africans. These individuals may possess identities, lived experiences, or ways of knowing that are entirely disconnected from the prevailing epistemological disposition and pedagogical approaches in higher education contexts. Therefore, it is imperative to expatiate policies and practices geared towards making teaching and learning contextually relevant to students' cultures, lived experiences, and knowledge systems, to halt the epistemic marginalisation of African students in STEM fields.

**Proposed Methods and Techniques of Integrating Indigenous Knowledge in STEM Education – The Multiple Ways of Knowing Model (M-Know)**

According to Semali and Kincheloe (1999), the ability to use community or IK derived from local history is vital for developing literacy skills essential for survival in an African context. Accordingly, Semali and Kincheloe (1999) suggest that incorporating the knowledge local people possess about their environment, such as that embedded in African traditional medicine, agriculture, and climate change adaptation practices, must be integrated into the planning and implementation process of education in African contexts. Likewise, Ogunniyi and Ogawa (2008) and Ameyaw (2014) highlight that educators have recognised that students experience difficulties in the sciences, particularly the 'hard' sciences, such as biological, physical, and natural science. This challenge may arise due to the disjunction between learners' home culture (experiences) and science culture (teaching and learning).

Given the aforementioned challenges in learning science, Ameyaw (2014) insists that the effective delivery of science for positive learner outcomes in Africa requires a reconsideration of the entire process of educational delivery, structures, and processes, so as to allow learners to engage their local knowledge as a starting point for learning STEM courses. In that sense, a more fruitful exploration of IKS could begin by shifting the focus towards constructing IK in terms of its practical application and utility. This involves examining how IKS is accessed, transferred, and applied as a component of the M-Know model proposed in this paper. The M-Know model seeks to integrate, complement, interrogate, and consolidate learning content and practices as currently pursued in STEM within the South African higher education context.

Given the diverse array of IKS practices and experiences across South Africa and Africa at large, it is crucial for higher education policymakers and gatekeepers to take decisive steps and timely actions to ensure the inclusion of IKS practices in the STEM curriculum. Specifically, practices applied in African traditional medicine, smallholder/rain-fed agriculture, and various other field should be seamlessly integrated.

The South African higher education system has the opportunity to adopt Semali and Kincheloe's (1999) proposed idea of indigenous literacy, wherein information is conveyed through local culture and languages, showcasing local innovations and techniques. This is evident in activities such as pest control, herbal remedies, and the utilisation of plants for disease control. Practices involving the collection of roots, herbs, and plants, along with the processes used to transform them into local medicines, can be valuable resources for informing and supporting teaching from an IKS knowledge strand in Biological and Medical Sciences courses or modules at the university level.

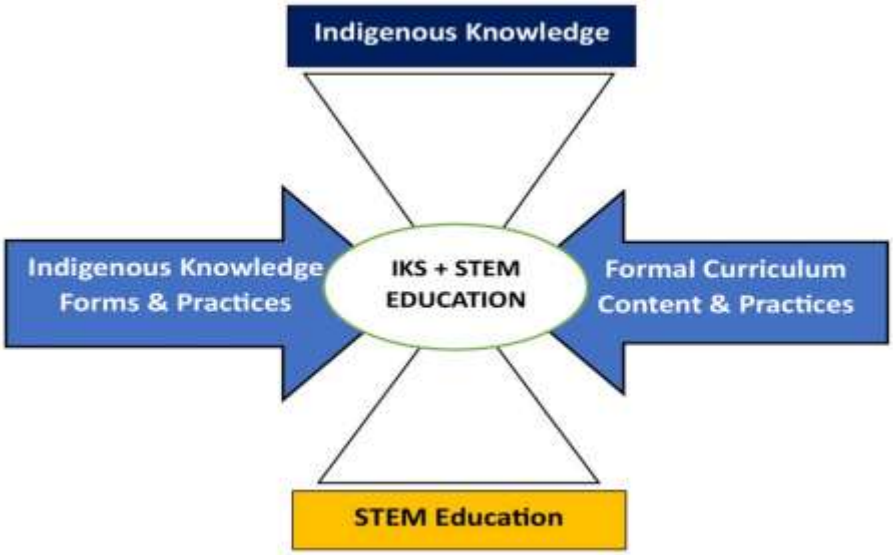


*Figure 1: M-Know model applied to integrating IK in STEM curricula in South Africa*

However, reaching this goal may face challenges if knowledge holders are isolated or not adequately engaged in the resourcing and implementation of the M-Know model. Therefore, concerted efforts should be made to involve local IK custodians, such as traditional medicine men and women, herbalists, and others, in the identification, codification, synthesis, and systemisation of IK content and practices. Additionally, it is crucial to involve them in discussions regarding the pedagogical requirements and practices for effectively imparting this knowledge, with the aim of assessing, evaluating, and ultimately incorporating it into the school curriculum.

## 1. The Impact of Integrating IKS into STEM Education

The successful integration of IKS into higher education STEM programmes would have significant implications, especially for the South African educational system. This integration presents an opportunity to bridge the gap between traditional wisdom and modern scientific understanding, thereby fostering a more inclusive, culturally responsive, and holistic educational landscape. Generally, integrating IK into STEM fields not only enriches scientific understanding but also fosters an appreciation for diverse cultures, promoting the development of more comprehensive and sustainable methods of scientific investigation and advancement. From a deductive standpoint, and building on our argument, this paper holds significant importance and contributes to knowledge in various areas, including holistic understanding, sustainability solutions, respect and equity, alternative methodologies, and collaborative research.

### Sustainable Solutions

IKS play a crucial role in offering sustainable solutions, particularly through practices that prioritise environmental sustainability. Across the globe, indigenous communities are often recognised as leaders in conservation efforts. For instance, the Bambuti-Babuluko community actively contributes to the protection of one of Central Africa's last remaining tracts of primary tropical forest in the Democratic Republic of Congo. Similarly, the semi-nomadic Chahdegal Balouch oversees the conservation of 580,000 hectares of fragile scrubland and desert in Iran (United Nations [UN], 2021). While in Canada's

far north, Inuit leaders are actively involved in efforts to restore caribou herds, whose numbers had been in steep decline (UN, 2021). Therefore, the integration of IKS into STEM education in South Africa has the potential to foster innovative sustainable solutions, particularly in fields such as agriculture. By incorporating the knowledge of local communities into environmental governance, tapping into their wealth of experience, and involving them in conservation and restoration efforts, there is a positive impact on their quality of life. Moreover, this approach contributes to the sustainable use of nature, benefiting society as a whole (UN, 2021).

**Cultural Preservation**

IKS encompass culture, traditions, languages, and practices. Integrating IKS into STEM education has the potential to enhance inclusivity and diversity in scientific research and development. Additionally, it brings valuable perspectives to the curriculum, enabling students to connect their daily lives with their educational experiences (Zidny et al., 2020). These scholars further argue that students often find the STEM curriculum irrelevant, boring, and unengaging, while IK provides rich contexts to spark learning interest and connect STEM education to more holistic worldviews that support sustainability (Zidny et al., 2020). A study on an indigenous community shows support for the increase in achievement among indigenous students who considered their culture relevant to modern practices (Paquin, 2023).

**Holistic Understanding**

The integration of IKS into STEM education provides learners with a holistic understanding of a particular phenomenon. Constructivism suggests that knowledge is constructive, implying that individuals have the capacity to construct knowledge based on experience (Taber, 2014). This supports the argument that indigenous science, a product of indigenous people's thinking about the physical world (Abonyi et al., 2014) through constructivism, exposes them to the constructive understanding in blending Western scientific views (Zidny et al., 2020). The integration of both knowledge strands presents a broader view of the learning framework, allowing learners with an IK background to comprehend the role of the societal and cultural context in the production of scientific knowledge (Aikenhead & Michell, 2011). The implication is that such integration has the potential to facilitate students in making sense of their world and reinforcing their existing interpretations of natural phenomena (Zidny et al., 2020). Furthermore, a study by Ugwu and Diovu (2016) found that the integration of IK and practices into a chemistry course enhanced students' understanding of chemistry concepts and improved their overall achievement.

**Respect and Equity**

The integration of IKS into STEM education in South Africa serves as a means to promote respect and equity, particularly given its multiracial context. In addition to enhancing scientific literacy, the curriculum seeks to improve community well-being, foster an aesthetic appreciation of nature, and fortify ties to the learners' home environment (da Silva et al., 2023). This integration aims to create respect and equity for community members whose aspirations are rooted in an educational framework that facilitates development while preserving their cultural heritage (da Silva et al., 2023).

**Alternative Methodologies**

While Western STEM methodologies offer broad-based methods for addressing complex problems in the natural world, they may not be universally applicable to every situation (Paquin, 2023). The integration of IKS into STEM education, on the other hand, introduces alternative methodologies for approaching diverse problems in various situations. This integration is regarded as an opportunity to build on the principles of STEM education and improve the provision of more contextualised and comprehensive solutions (Baul & McDonald, 2015). For instance, in their study, Baul and McDonald

(2015) emphasised how farmers in the Middle Hill region of India demonstrated a high level of local knowledge in addressing the issue of climate change.

### Collaborative Research

Effective collaborations with specialists in the field of IK are essential to comprehend nature from an indigenous perspective (Kim & Dionne, 2014; Garroutte, 1999). Thus, involving the custodians of knowledge within the domain of IKS is paramount to avoid diminishing or misrepresenting information (Kim et al., 2017). This is exemplified in the partnership network between IK holders, STEM professionals, and other stakeholders, as observed in the DSI hybrid event mentioned earlier, which creates avenues for mutual learning, respect, and cooperation. Such collaborations have the potential to yield rich research outcomes and applications that benefit both indigenous communities and broader society (RSA, 2022). Another argument in favour of collaboration is the partnership between indigenous, rural, citizen, and professional scientists in the recovery of more languages and biodiversity, given that the crisis in biocultural diversity is more complex and time sensitive (Wilder et al., 2016).

## 2. Implications for Future STEM Education in South Africa and Beyond

The integration of IKS into STEM education, especially in the South African school system carries significant implications for policy, research, and practice. From a policy perspective, this integration opens the door to the development of comprehensive frameworks or models. These frameworks aim to identify, value, and seamlessly integrate IK into STEM practices. They will systematically address legal, educational, ethical, and cultural aspects, ensuring the equitable representation and protection of IKS. On a practical level, this integration fosters innovation, sustainability, and inclusivity in scientific research and development, thereby enhancing the livelihoods of indigenous people and the broader population. Moreover, it substantiates the preservation and revitalisation of IKS and indigenous practices, while addressing regional issues through a more comprehensive lens that combines modern scientific techniques with traditional wisdom.

The research implication of such integration involves encouraging a more thorough, inclusive, and culturally sensitive approach to scientific investigation that recognises the importance of varied knowledge systems in promoting innovation and research. Accordingly, the scope of research is broadened to incorporate multiple knowledge systems, providing room for wider perspectives on scientific phenomena from diverse cultural viewpoints. This, in turn, promotes a holistic approach to problem-solving, considering social, environmental, and cultural aspects alongside scientific analysis.

### Limitations and Suggestions for Further Study

Inherently, every research project is embedded with certain limitations. Thus, while this paper has offered valuable insights and highlighted the research implication of integrating IKS into STEM education in South Africa, it is limited in its conclusions due to the context coverage and approach employed, lacking empirical inquiry. Therefore, it is suggested that further studies involving primary data be conducted on the subject matter to ascertain the full potential of integrating IKS into STEM education in the stated context.

## *Conclusion*

This paper explored IKS and argued that it upholds replicable potentials for enriching the teaching of STEM disciplines in South Africa, utilising an IKS-informed model known as the M-know model. The research delved into the possibility of integrating IKS into STEM curricula in South Africa, with a particular emphasis on enhancing localised learning experiences and fostering collaborative

partnerships among indigenous communities, knowledge custodians, and educational institutions. The paper posits that localised learning experiences, rooted in IK, offer a culturally sensitive pedagogical method. These experiences not only foster a sense of belonging and connection among students, but also enhance and diversify the STEM curriculum. This ensures that STEM education becomes more inclusive, resonating deeply with students' cultural and lived experiences. While acknowledging the important role of representing IKS in disciplines where they have been previously underrepresented, this paper advocates for the practical application of such knowledge in STEM education processes, aiming to transform learning processes for contextual and epistemological relevance. Therefore, the incorporation of IKS, as emphasised in the M-Know model, extends beyond the mere addition of content; it fundamentally changes our perception and appraisal of knowledge, highlighting the significance and richness of diverse knowledge systems.

In conclusion, this paper contends that the integration of IKS content and practical knowledge into the higher education curriculum has the potential to improve the effectiveness of teaching and learning in STEM education. Failure to incorporate IKS may lead to what Semali and Kincheloe (1999) described as a "pedagogical tragedy". The utilisation of the M-Know model is therefore recommended, highlighting an experiential/practical approach to resourcing and delivery, underscoring the importance of involving knowledge holders in supporting the integration of IKS in the pursuit of STEM education in South Africa today.

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