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Analysis of Teachers' Perspectives Towards the Use of IKS to Improve STEM Education for Sustainable Development

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This study focuses on science, technology, engineering and mathematics (STEM) education teachers' perspectives on integrating indigenous knowledge systems (IKS) into a multidisciplinary STEM framework to promote sustainability. The aim is to understand how integrating the values, ethics and worldviews of the global community can contribute to a sustainable mindset. Through an examination of the research background and pedagogical foundations, as well as a review of existing literature, it becomes evident that teachers' perspectives are pivotal in fostering a sustainable mindset among students. To encourage social dialogue that has the potential to evolve teachers' perspectives, a 6 month workshop focused on dialogic argumentation was provided to a group of basic education and university STEM teachers. The workshop aimed to explore the evidence- and reasoning-based arguments that influenced their perspectives regarding the role of IKS in STEM education. Analysis of data collected through questionnaires and interviews yielded the following findings: (a) initially, most teachers had mixed feelings about the role of IKS in STEM education for sustainable development; (b) a significant number of teachers reported that the dialogic argumentation workshop helped them transition from a negative to a positive attitude towards acknowledging the complexity of the role of IKS in promoting various approaches to achieving sustainability goals; and (c) several others, particularly university teachers, attributed IKS with the potential to enhance reflective reasoning in order to solve complex sustainability problems. The implications of these findings for classroom practice, particularly in terms of utilising IKS to enhance STEM teacher education, are highlighted in the paper.

Keywords: *Dialogical argumentation instruction; STEM education; indigenous knowledge systems; teachers' perspectives; sustainable development goals*

Introduction

As the world continues to move into an increasingly industrialised era, we are faced with various problems that hinder sustainable development, such as energy, economic, climate and environmental crises (Davis & Ebbe, 1995; Olaniyan & Govender, 2023; UNESCO, 2023a; Zidny et al., 2020). For indigenous communities around the world, perhaps the greatest socio-economic crisis is the problem of food insecurity, largely caused by drastic climatic conditions that are themselves not independent of human interaction with nature (Ogunniyi, 2022). Today, no country is completely free from the effects of global warming, environmental degradation, overpopulation caused by the direct effects of globalisation and consequently massive immigration from poorer developing countries to richer countries (UNESCO, 2023a). In the face of all these sources of instability, humanity is faced with an increasing demand for more material resources, while the exploitation of the non-renewable energy sources needed for socio-economic development continues unabated (Gilday, 1995; Moalosi et al., 2017; Ogunniyi & Hewson, 2008).

The denigration and erosion of indigenous knowledge systems (IKS) and cultural practices, and the blind adoption of science, technology, engineering and mathematics (STEM)-based and market-driven economic structures without a deep understanding of indigenous communities' ecological systems have resulted in indigenous communities appearing to have lost their cohesion, cultural identity and clear sense of purpose (Gumbo, 2017; Iwuanyanwu & Ogunniyi, 2019; Paananen et al., 2022; Wane, 2009). Indeed, much of the indigenous knowledge and cultural practices that helped sustain the environment for their continued existence have been fragmented, suppressed, devalued or lost altogether (Iwuanyanwu, 2022). At the World Bank Conference in Washington, DC, Brazilian Indian leader Jorge Terena was quoted by Davis and Ebbe (1995), as saying that the Western world regards its traditional knowledge as:

> primitive knowledge from primitive culture. It is of the past, and therefore it is no good … now, certain scientists are beginning to realize that this knowledge can be considered scientific. Why? Because they know that our community has helped to preserve the Earth, not only the natural resources but humanity as a whole. (p. 7)

The comments made by Davis and Ebbe contribute to the growing need to address sustainable development concerns. Similarly, UNESCO (2012, 2023a) has emphasised the importance of involvement from STEM educators, academic institutions and policymakers in tackling sustainability challenges. The success of our efforts to address these problems globally will depend on how well we shape the attitudes and perspectives of STEM teachers, who face the challenging task of reconciling different dimensions of knowledge within STEM, including IKS. According to previous research in the area, STEM teachers generally have a misconceived view of indigenous knowledge (IK) and its place in the STEM curriculum (e.g. Aikenhead & Elliot, 2010; Ogunniyi, 2007, 2020; Van Wyk, 2002). Despite what view you hold about IK, its potential for sustainable development can no longer be denied. As STEM ideas manifest themselves differently in different social or cultural contexts, the South African Curriculum and Assessment Policy Statement (CAPS) emphasises the need for STEM teachers to practise culturally sensitive STEM-IK integration that is compatible with multicultural South African classrooms (Department of Education, 2011; Iwuanyanwu & Ogunniyi, 2019). This is to ensure that teachers have a good sense of the web of knowledge, skills and practices that link STEM and IK to issues of sustainability when teaching in a multicultural STEM classroom. With this in mind, we explored STEM teachers' perspectives on how indigenous knowledge can be used to enhance STEM education for sustainable development, before and after participating in the STEM-IK project, which was essentially delivered through dialogic argumentation instruction (Erduran & Park, 2023; Iwuanyanwu, 2023a; Schwarz & Baker, 2017). In the scope of this research, the purpose of dialogic argumentation instruction is to create a platform for STEM teachers to share and/or refine their perspectives on the utilisation of IKS in enhancing STEM education for sustainable development. This initiative goes beyond the confines of their individual practices, allowing for a broader exchange of ideas. To achieve this goal, we sought answers to the following question:

> What were the teachers' perspectives on the role of IKS in STEM education to address sustainability issues before and after participating in the STEM-IK project, mediated through dialogic argumentation instruction?

Review of Literature

The advancement of science and technology in today's world has yielded social and economic benefits, but has also contributed to more pressure on sustainability prospects. Consequently, the application of scientific and technological methods to address sustainability challenges through STEM tools has highlighted the importance of incorporating other knowledge domains, such as IK, to achieve a balance between environmental needs and sustainable development (UNESCO, 2023a). This approach also recognises the need to address various dimensions of sustainability problems, including economic, socio-scientific and ethical considerations (Zidny et al., 2020). While the integration of STEM and IKS has generally been praised (Gaotlhobogwe, 2023; Olaniyan & Govender, 2023; UNESCO, 2012) and has shown positive outcomes for students (Chahine, 2022), many teachers seem to face challenges when attempting to incorporate STEM-IKS into their classrooms (Ogunniyi & Hewson, 2008; Hewson, 2015; Onwu & Mosimege, 2004). Therefore, it is crucial to understand how to effectively support teachers and students in STEM education, enabling them to take local action and assume responsibility for their environment. This can be achieved through an informed pedagogy that promotes dialogue (Iwuanyanwu, 2023b). The core principle of informed pedagogy, which encourages teachers and students to freely express their perspectives on any subject matter, is best exemplified by dialogic argumentation instruction (DAI). The dialogic argumentation instruction has proven to be effective in fostering classroom discourse and facilitating collaborative consensus on contentious topics, such as the integration of STEM and indigenous knowledge systems (e.g. Belland, Glazewski, & Richardson, 2011; Diwu & Ogunniyi, 2012; Erduran & Park, 2023; Iwuanyanwu, 2020). According to Koichu et al. (2022) and Schwarz and Baker (2017), both learners and teachers benefit from DAI as they share their diverse lived experiences within a multicultural classroom setting (Evagorou & Osborne, 2013).

The theoretical foundations of DAI are rooted in two frameworks: Toulmin's (2003) argumentation pattern based on Aristotelian logic and the contiguity argumentation theory based on logical and non-logical arguments (Ogunniyi, 2007). These frameworks were selected owing to their incorporation of both logical and non-logical elements, which are commonly observed in the arguments presented by STEM teachers when discussing the socio-scientific issues related sustainable development (Gumbo, 2017; Lederman et al., 2014; Moalosi et al., 2017). Non-logical arguments in this context refer to conductive arguments that are not solely constrained by Aristotelian logical syllogism, but also encompass culturally valid arguments frequently employed by indigenous communities to advance knowledge on conservation and sustainability issues. As an informed pedagogical framework, the learning and teaching engagement facilitated by DAI occurs within a community of practice, commencing with individual arguments or self-conversation (intra-argumentation). According to Szaz (1996, p.2), self-conversation is a prevalent human experience, in which 'thinking manifests as self-conversation … engaging in dialogue with oneself through speaking and listening is a commonplace of typical phenomenon'. In light of this, the initial personal perspectives of teachers regarding STEM-IKS are examined through intra-argumentation. We evaluate the reasonableness of their perspectives from various lenses related to the STEM-IKS discourse between two arguers or among a small group of arguers (inter-argumentation), seeking justifications or evidence they employ to support any claims concerning the use of IKS to enhance STEM education for sustainable development. Furthermore, a whole group discussion (trans-argumentation) may be utilised to further deliberate on initial perspectives and evidence provided, in order to establish a collaborative consensus on any phenomena as a way to resolve conflicts.

Dichotomisation of STEM-IKS

Semali (2016) notes that learners are losing interest in STEM education because it is being dissociated from their indigenous sciences. He suggests that the use of culturally informed pedagogy could help shift the focus from this false dichotomy to a relational one. Semali's idea aligns with the Ogunniyi's (2007) idea of focusing on the commonalities of knowledge systems rather than their differences. As an integrationist, he does not support the dichotomisation of knowledge systems, for example, STEM and IKS in the narrow sense. Rather, he considers them as alternative explanatory models of the world. Le Grande (2007) shares the same view on the continuity of knowledge and furthermore emphasises the need to focus on the performative aspects of STEM and IK rather than on their distinctly different features. For example, if we emphasise how knowledge is, that is, how it has been produced in all cultures across time and place, we are likely to develop a deeper understanding of their shared or relational properties than would otherwise be the case. After all, all knowledge, regardless of its different epistemologies, methodologies, logical or cognitive structures or socio-economic contexts, has a certain social space, localisation and heterogeneity that only becomes coherent through the use of social and technical strategies. Historically, modern STEM had metaphysical, mythical and anthropomorphic roots before adopting a mechanistic perspective from the fifteenth/sixteenth century onwards. Indigenous knowledge systems, on the other hand, have never completely moved away from these roots. Be that as it may, it is noteworthy that STEM, especially modern astrophysics, still uses many of its mythological Greek names to refer to various astronomical phenomena. The more knowledge about different phenomena increases, the more one realises that dichotomising knowledge into different disciplines or fields, except for pragmatic reasons, is a futile attempt. Any subject we study is complex and requires the mobilisation of knowledge from different fields or disciplines to gain a more comprehensive understanding of that subject.

The Need for STEM-IKS Education for Sustainability

In the face of the energy, economic, climate and environmental crises around the world, learners and teachers are becoming increasingly aware of the relevance of sustainable development. According to UNESCO (2012), sustainable development relies on avoiding the depletion of natural resources to meet current needs without sacrificing future access to natural resources. While efforts to raise awareness about the sustainability crisis in various educational settings such as STEM have long been recognised, scholars and the international community have also recognised over time that STEM knowledge alone is not sufficient to address the sustainability crisis, warranting the recognition and inclusion of other forms of knowledge such as IKS. This is because there are many complex socio-scientific problems in societies that can be addressed using local traditional knowledge, including ecological problems, biodiversity loss and conservation problems. To support this concern, teacher education would need to train STEM teachers with the prospect of culturally responsive education that incorporates not only STEM domain knowledge but also indigenous knowledge systems (Gumbo, 2017; Iwuanyanwu, 2023b; Onwu & Mosimege, 2004). In this regard, studies have shown that the use of an informed pedagogy that includes a dialogic framework can provide a forum for STEM learners and teachers to express their perspectives and consequently draw on their STEM-IKS competence to support the construction of knowledge and actions needed in society to address sustainability issues (Chahine, 2022; Iwuanyanwu & Ogunniyi, 2019). Additionally, the International Council for Science (2011) has emphasised the need to transform scientific practices into more sustainable practices, recognising that STEM disciplines alone cannot offer exhaustive solutions to sustainability challenges. This call to action underscores the importance of responsible engagement with socio-scientific issues, including the integration of STEM-IKS to address sustainability problems. Consequently, it is imperative to examine the perspectives of STEM teacher education on these issues. By examining various related sustainability issues, educators and institutions can act and begin to address complex problems facing current and future generations.

Method

The mixed methods research, incorporating a one group pre–post-test design (Iwuanyanwu, 2019), was deemed the most appropriate approach for investigating teachers' perspectives on the role of IKS in STEM education to address sustainability issues. The study involved a convenient sample consisting of 23 STEM teachers (nine females, 14 males, aged 26–60) from urban and suburban areas of South Africa who voluntarily participated in the research after the STEM-IKS project was approved by the research ethics committee. Of the participants, 10 were university lecturers and 13 were high school teachers. Before participating, teachers and lecturers gave their consent by filling out the POPIA consent form as mandated by the Ethics Committee. In accordance with POPIA protocols, every learning task submitted and assessed during the research was treated with confidentiality, and all personal data of the participants were anonymised.

Instrumentation

The data collection instruments utilised in this study were modified versions of those developed in a previous study conducted by Ogunniyi in 2007. The initial version of the STEM-IKS instrument consisted of 10 open-ended items, which were then presented to a panel of 20 STEM educators who possessed extensive knowledge of indigenous knowledge systems. The purpose of this panel was to provide critical feedback on the suitability of the items for the study. Taking into consideration their comments and suggestions, the instrument was subsequently reduced to seven open-ended items. To establish the validity and reliability of the instrument, four STEM educators were selected to independently rate the clarity of the items on a five-point scale (1 = poor; 2 = fair; 3 = good; 4 = very good; 5 = excellent). The inter-rater agreement coefficient, calculated using a modified Spearman rank difference formula, yielded an average score of 0.97. The instrument's average score was considered satisfactory for use in data collection. The study began with the administration of the STEM-IKS questionnaire to collect baseline data on the teachers' perspectives regarding the role of IKS in STEM education for sustainable development. The baseline data collection lasted for 2.5 hours.

Implementation of the STEM-IKS-based Workshops

In line with the instrument, several STEM-IKS topics were identified as relevant to the study's theme of integrating STEM and IK for sustainable development purposes. These topics included indigenous methods of preparing dyes, soaps and local wine, soil conservation and other ecological indices presented during the workshops. The aim of these workshops was to enable the participants to identify the similarities and differences between STEM and indigenous ways of doing things, or the ways in which the two describe, explain and predict diverse phenomena for sustainability purposes. The teachers were then exposed to hands-on workshops on various phenomena, such as climatic changes, STEM vs. indigenous conservation of water, detection of water pollution, indigenous medicinal plants, indigenous methods of food preservation, methods of food processing and storage, genetically modified crops and static electricity in nature twice a month (first week and last week) on Friday afternoons (14:00–17:30) and Saturday mornings (9:00–13:00). The bi-monthly workshops were structured around alternating phases of preparation and reflection, creating a continuous flow that ultimately transitioned into the next round of IKS-STEM dialogic argumentation instruction (e.g. Erduran & Park, 2023; Iwuanyanwu & Ogunniyi, 2020; Koichu et al., 2022). Based on DAI, we provided a platform for teachers to freely express their opinions, construct and defend arguments regarding their individual viewpoints (intra-argumentation), engage in group discussions (inter-argumentation) and participate in whole group tasks (trans-argumentation) throughout the 6 months period. These different levels of engagement offered ample opportunities for brainstorming, exploring and integrating various concepts from the realms of STEM and IKS knowledge. Teachers were encouraged to express their perspectives openly, seek clarification for any doubts and ultimately reach collaborative consensus and make informed decisions on specific tasks. This process was guided by the research team and supported by valid logical reasoning (deductive–inductive), culturally valid reasoning (Ogunniyi, 2007), practical reasoning (Norris, 1992) or case-by-case reasoning where relevant factors were cited to support a claim (Govier, 1987). We gathered post-test data on the final day of the 6 month study period, using the same instrument for a duration of 3 hours. A follow-up reflective response interview was conducted, consisting of five open-ended statements, in order to explore any additional perspectives or insights that may not have been captured by the questionnaire items. Through a thorough review process involving the comments of the 20 reviewers and a stepwise validation approach, the five open-ended statements were reduced to three. The average interrater coefficient for the reflective interview stood at 0.92. The high coefficients of the two instruments serve as evidence of the credibility, dependability and reproducibility of both instruments, as demonstrated in the study conducted by (Ogunniyi, 2007).

Data Collection and Analysis

In the study, a follow-up interview was conducted with a group of willing teachers who had participated in a bi-monthly DAI workshop for a duration of 6 months. These teachers were specifically asked to share their experiences with the STEM-IKS Project, particularly in relation to socio-STEM issues such as sustainable development, climate change, cold fronts, scientific and indigenous methods of food storage, and food security. Owing to space constraints, only a limited number of data derived from the interviews are presented in this paper. The collected data were analysed quantitatively using open coding and the creation of categories, following the methodology proposed by Creswell and Creswell (2018). Additionally, a text analysis was conducted based on the emerging categories, as recommended by Silverman (2001). This approach entailed establishing categories and calculating the frequency percentage of each category occurrence in relation to the questionnaire items. The resulting frequency percentages are presented in Table 1, providing a clear overview of the distribution of categories across the responses. This method allowed for a systematic examination of the data, enabling us to identify patterns and trends within the participants' perspectives. By utilising both quantitative and qualitative analysis techniques, a comprehensive understanding of the data analysed thematically was achieved, enhancing the validity and reliability of the study findings. The findings regarding the teachers' perspectives on certain fundamental assumptions that underlie their understanding of STEM and IKS in relation to addressing sustainability issues or any other subject matter are presented in Table 1. It should be noted that Table 1 includes responses from only six out of the total 23 teachers with pseudonyms (e.g. Adam, Benita, Chucks, Jef, Patricia and Modise) who completed the pre–post-tests.

Findings and Discussion

The research results illustrate the perspectives of STEM educators and university lecturers on the fundamental principles of STEM and IKS in relation to sustainability, revealing a combination of scientific and indigenous viewpoints. Their understanding of these knowledge systems influences how they approach socio-STEM issues and their views on nature. The importance of STEM teachers' comprehension of nature is highlighted in relation to the role of IKS in addressing sustainability challenges within STEM fields. Understanding the foundational assumptions of the knowledge systems they teach is essential for STEM teachers, as highlighted in a study conducted by Chahine (2022). This knowledge is crucial for effective teaching and integration of these systems into their practices, ensuring that students are equipped with the necessary knowledge and skills to address sustainability challenges effectively. Additionally, understanding teachers' perspectives can help shape the implementation of CAPS, ensuring that it aligns with the needs and aspirations of educators and students alike. For example, in the study, the teachers' agreement with the fundamental assumptions

Table 1. The teachers' perspectives about the underlying assumptions of STEM and indigenous knowledge systems (IKS)

	Pre-test (%)	Post-test (%)
Underlying assumptions of STEM		
1. It is highly probable that the universe occurred by chance and undergoes continuous evolution	44	78
2. Time is real, continuous and irreversible	56	67
3. Space is real and has definite dimensions	22	67
4. All events have natural causes	56	67
5. Matter is real, observable and testable	78	67
6. Sense perceptions are the only valid and reliable means to understand nature	67	44
Underlying assumptions of IKS		
1. The universe was created by a supreme/supernatural being	67	67
2. Time is real, continuous and cyclical	22	44
3. Space is real and has definite and indefinite dimensions	23	33
4. Events have both natural and supernatural causes	56	78
5. Matter is real, partly observable and partly testable	44	56
6. Sensory perceptions are not the only means of understanding nature, i.e. certain experiences defy sense perceptions	67	44

(items 1–5) of STEM is primarily influenced by a mechanistic STEM-based worldview. The teachers' agreement with a mechanistic worldview remains consistent at the post-test, with the exception of item 6, where 44% of teachers agree, probably owing to the influence of the STEM-IKS Project they were exposed to. By adopting a mechanistic approach, teachers are able to break down complex concepts into smaller, more manageable parts, allowing students to grasp the fundamental principles of sustainability. This worldview emphasises the interconnectedness of various STEM disciplines and highlights their relevance to sustainability. Through this lens, teachers can effectively convey the significance of sustainability issues to students, fostering a deeper understanding and encouraging them to become active participants in creating a sustainable future. However, the presence of an indigenous or anthropomorphic worldview regarding sustainability is evident, albeit in a moderately suppressed state (e.g. items 1 and 4) and to some extent item 6 with 56% agreement), compared with the assumptions held under STEM. In other words, the teachers still maintain to some extent an anthropomorphic worldview, as seen in items 1, 4 and 5, despite their overt demonstration of a mechanistic worldview regarding socio-STEM issues and sustainability (e.g. Aikenhead & Elliot, 2010; Gunstone & White, 2000; Ogunniyi, 2007).

Overall, it appears that the teachers' perspectives are predominantly influenced by a scientific worldview rather than indigenous knowledge worldview. The following excerpts provide further insight into this phenomenon. It is evident that despite their adherence to a mechanistic worldview, the teachers have not completely abandoned their inherent anthropomorphic worldview. This aligns with Gunstone and White's (2000) conclusion, drawn from an extensive review of existing literature, that learners hold onto their home-based funds of knowledge regardless of their school experiences. This phenomenon is also confirmed to be true for the teachers involved in this study.

Teachers' Responses to STEM–IKS Integration for Sustainable Development

The findings from the teachers' responses to the questionnaire on STEM and IKS indicate that, despite their indigenous backgrounds, the majority of teachers hold predominantly STEM-based worldviews. However, there were a few exceptions, as some teachers demonstrated a clearer understanding of the fundamental assumptions of STEM at the post-test compared with the pre-test. This improvement can probably be attributed to the influence of the STEM-IKS programme, which the teachers had been exposed to. The following excerpts reflect the teachers' perspectives on nature, which may be linked to their underlying understanding of the basic assumptions of STEM and IKS, as well as their cosmological worldview, attitudes, values and sociocultural commitments. These excerpts, which are attributed to fictitious names, are representative of the teachers' perspectives on nature and emphasise the importance of sustainable practices.

Chucks: Everything on earth, water, seas and heavens were created by God who has an objective existence to sustain the universe and mankind, an existence independent of man …

Patricia: There is so much about nature that we don't know. Our current collective knowledge is a drop in the ocean. Nature is influenced by physical (seen) and the spiritual (unseen) aspects or/and principles. Most important principle in nature is striving to create balance at physical and spiritual levels. No single culture truly understands all aspects of nature. GOD is the source of nature. Everything originates from one entity called/referred to as GOD.

Adam: God created nature and the laws/rules governing it. So, when we talk about Newton's laws, it is simply that he could put a theory/model together that explains e.g. the relationship between acc and mass. The laws governing the environment causes the environment to be in harmony. But because of greed/power some superpowers (USA) would exploit nature and thereby causing all kinds of disharmony (e.g. use of atomic bomb on the Japanese; use of CFO's on a large scale-causing greenhouse effect; El Nino; acid rain etc).

Modise: Nature nurtures. Nature is the source of our living and sustainability. Nature accommodates everything e.g. plants, animals, gases, etc. Nature is wonderful and needs to be conserved at all times. The medicine we use comes from the nature, so nature is the human life span.

Jef: Nature is a wonderful creation of God. God gives us the grace, power and the task to preserve and conserve nature. Where people have no respect for nature, it is due to the fact that they only think about themselves. In many cases, such persons have no respect for other human beings as well. Nature's greatest enemy is the human race. Not everything in nature can be explained …

Benita: Nature can provide a biological environment to us. A lack of understanding of nature will plunge us into a crisis which will be difficult to remedy. Science is a reflection of nature. A good understanding of nature will enable you to develop the science and technology needed to improve society and the lives of people in general.

In light of the above excerpts from teachers, previous research suggests that their perspectives on sustainable development are contingent upon the preservation of nature (Lederman et al., 2014; Zidny et al., 2020). However, it is challenging to reconcile these assertions with the low levels of agreement regarding statements such as 'A Supreme Being created and controls the universe and can sustain mankind', 'Nature is real, partly observable and partly unobservable', 'Events have both natural and unnatural causes' and 'Humans should harmonise with nature rather than exploit nature'. With the exception of Benita and, to a certain extent, Modise, the majority of the educators depicted nature primarily in anthropomorphic or religious terms. Nearly all of the STEM teachers referenced the necessity of conserving nature for the sake of sustainability.

From the foregoing, it is evident that the indigenous peoples' relationship with nature is more comprehensive than that of STEM. This worldview also influences their approach to environmental conservation. It is likely for this reason that the Revised National Curriculum Statement and subsequently, the CAPS, will emphasise the importance of teachers integrating IKS with STEM in their classrooms (Department of Education, 2011). This key issue is further supported by excerpts taken from teachers' responses to the questionnaire and reflective interviews, which indicate an increased awareness of the value of IKS in understanding sustainability issues after participating in the STEM-IKS Project. The purpose of the reflective interviews was to determine how the teachers applied their new-found knowledge from the STEM-IKS Project to their implementation of the CAPS in their classroom practices. The following excerpts provide a representative sample of the teachers' perspectives:

Modise: STEM should not be made to exist in isolation and teachers should be thoroughly trained so that they are able to address the problems learners bring to classroom … STEM is culture free, has no respect to socio-cultural activities (pre-). Curriculum must be sensitive to other worldviews in the sense that a room must be opened to accommodate the other worldviews (post-).

Adam: It is important for the learner not to view science, technology, society and environment as the 'enemy' (pre-). If this outcome could be realised it would expose learners to a more holistic view of science—unlike what has been happening in the past in science classes (post-).

Patricia: If STEM education cannot be applied and used to influence society and environment, then it is sterile. First STEM teachers need to be sensitive to IKS. They also need to learn about IKS before 'bridging' can take place. Traditional worldviews will make science contextual (pre-). IKS is contextual, science is not. Learning must be contextual (post-).

Jef: STEM education should be aimed at equipping students with knowledge and skills that will enable them to solve problems in the real world (society). I use scientific knowledge and skills to verify and understand the physical world (pre-). Indigenous knowledge reflects the wisdom of people who have lived a long time ago. We must find a way to integrate learner's knowledge into the curriculum. I use the learners' previous experience as a point of departure in providing relevant science learning experiences that engage and build on existing knowledge (post-).

The teachers have made comments that are similar to those of previous studies (e.g. Gumbo, 2017; Wane, 2009), which include utilising concepts that can be elucidated through information derived from students' home culture and scientific sources. The teachers also advocate for exposing learners to a diverse range of experiences, enabling them to make informed decisions regarding their beliefs about sustainable development. Critics may argue that STEM education should prioritise technical skills over cultural sensitivity, viewing the integration of diverse worldviews as a distraction from core scientific concepts. However, the viewpoints presented suggest that IKS-STEM integration could enhance learning outcomes and prepares students for real-world challenges by fostering a deeper understanding of societal and environmental sustainability issues. Furthermore, they emphasise the interconnectedness of STEM and IKS in their teachings, rather than highlighting their disparities. The findings of this research reinforce the significance of exploring the perspectives of teachers regarding the integration of IKS in STEM for the purpose of achieving sustainable development. These results are consistent with previous studies conducted on the same subject matter (e.g. Gumbo, 2017; Ogunniyi, 2022; Olaniyan & Govender, 2023; UNESCO; 2023a; Van Wyk, 2002; Zidny et al., 2020). While some teachers did not propose any specific strategies for integrating STEM with IKS, the majority concur with the notion of integrating STEM-IKS thought systems in addressing sustainability issues. This implies that by motivating educators to acquire the skills to cultivate a mindset of sustainability, it could potentially assist their students in developing comparable characteristics (Onwu & Mosimege, 2004; Semali, 2016).

Conclusion

The findings of this study have provided valuable insights into the potential benefits of implementing a DAI for STEM teachers in order to enhance their ability to promote awareness of environmental sustainability among their students. Additionally, it is crucial for STEM teachers to be exposed to effective instructional strategies that allow for open discussions on socio-STEM issues and other controversial topics, such as the integration of STEM with IKS, within their classrooms. The STEM teachers involved in the study have expressed the advantages of integrating IKS into their teaching practices, as it enhances their understanding of nature of science and IKS, the underlying assumptions that support them, and the goals of the CAPS. Given the minimal differences between the conceptions of STEM and IKS held by teacher educators and STEM teachers, higher education institutions must review their academic programs to ensure their compatibility with the current multicultural STEM classroom context. In light of this, today's teachers should go beyond the traditional STEM knowledge found in textbooks and recognise STEM as a social enterprise that addresses socio-economic issues, particularly the preservation of our fragile planet, which is essential for our survival.

In the future, our intention is to conduct a more thorough examination of the sustainability issues that have emerged from our study. These issues include the teachers' ability to develop a more accurate understanding of the nature of STEM and IKS, as well as the underlying assumptions on which these subjects are based. We also aim to explore the contextual realities of a multicultural South African classroom and the discrepancy between the STEM curriculum and its implementation by teachers, particularly in relation to socio-STEM issues such as sustainability in a world facing various bio-physical environmental crises. This investigation is crucial because STEM teachers have long expressed dissatisfaction with the lack of or poor quality of the crash programs implemented by the Department of Basic Education. In light of the numerous obstacles to sustainable development, including energy, economic, climate, and environmental crises, we believe that reforming STEM curriculums and increasing teachers' awareness about sustainability issues should not be seen as a one-time event, but rather as a continuous and iterative process.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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