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Life Sciences Teachers' Views on Using Interactive Whiteboards to Integrate Indigenous Knowledge in Cellular Respiration Teaching

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Abstract. This study critically examines Grade 11 Life Sciences teachers' perceptions of using interactive whiteboards (IWBs) to integrate Indigenous Knowledge (IK) into teaching cellular respiration, a complex and abstract topic. While curricula such as South Africa's Curriculum and Assessment Policy Statement (CAPS) advocate for IK integration, its implementation remains inadequate, particularly for technologically inclined learners. Employing quantitative research design, the study utilized a questionnaire administered to 153 Life Sciences teachers from schools in Johannesburg and Ekurhuleni. Descriptive and inferential statistics were used to analyze the data. Findings reveal that teachers value IWBs as effective tools for enhancing learner engagement and understanding by bridging cultural contexts and aligning with learners' technological preferences. However, the integration process faces significant challenges, including limited access to reliable IK resources, insufficient professional development, and technical issues with IWBs. The study argues for systemic reforms to address these challenges, emphasizing the need for improved access to IK materials, targeted teacher development, and institutional support for teaching IK. By fostering meaningful IK integration through IWBs, Life Sciences education can become more culturally responsive, enhancing learners' connection to scientific concepts. Policymakers must prioritize resource allocation and capacity-building to achieve this goal.

Keywords: Cellular respiration; interactive whiteboards; indigenous knowledge; life sciences teachers; quantitative research

1. Introduction

Integrating Indigenous Knowledge (IK) in Life Sciences teaching has become an essential practice in South African classrooms to address the persistent Eurocentric bias in the curriculum. The predominance of Western perspectives

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in the content knowledge prescribed for Life Sciences teaching excludes the diverse cultural realities of learners, most of whom come from indigenous cultural backgrounds (Sitsha, 2023). This exclusion hinders their ability to relate to scientific concepts, making the learning experience disengaging, less effective, and less meaningful (Mkhwebane, 2024). Teaching and learning, which are engraved in content knowledge, encompass concepts, processes, ideas, theories and scientific laws (Shulman, 1986). However, they currently fail to reflect South African learners lived experiences and cultural heritage, creating a disconnect in understanding scientific concepts (Edson & Govender, 2021; de Beer & Whitlock, 2009).

In response to this misalignment, the South African Department of Basic Education (DBE), through the Curriculum and Assessment Policy Statement (CAPS), has issued a clarion call urging Life Sciences teachers to integrate IK when teaching different topics (Mavuru, 2022). This policy aims to create a culturally relevant, engaging, and inclusive learning environment that respects indigenous cultural perspectives and enhances academic performance in Life Sciences (de Beer, 2019). Several studies have shown that IK provides learners with accessible and culturally familiar vocabulary and concepts, making scientific ideas less cognitively demanding and more relatable (Cindi, 2021; Selepe et al., 2022). By bridging the gap between abstract scientific concepts and learners lived experiences, IK integration can foster a deeper understanding of and connection to content knowledge (Edson & Govender, 2021).

Mothwa (2011) highlights that the integration of IK into South African classrooms remains a significant challenge despite the directives of the CAPS document (DBE, 2011). Many teachers either do not integrate IK at all or do so ineffectively, treating it as a superficial addition rather than embedding it meaningfully within the curriculum (Cronje et al., 2015; Mothwa, 2011). This superficial treatment diminishes learner engagement and undermines the transformative potential of IK in science education (Sitsha, 2023; Mavuru, 2024). Furthermore, traditional teaching methods exacerbate this issue by limiting opportunities for interactive and learner-centered approaches that could enhance the positive impact of IK integration. The lack of contextual relevance in Life Sciences content further alienates learners, as it does not align with their lived experiences or cultural backgrounds (Mandikoza, 2019).

Emerging digital technologies in the Fourth Industrial Revolution (4IR), such as interactive whiteboards (IWBs), offer a promising solution to address these challenges (Kulcuta et al., 2019). Despite the recognized benefits of ICTs in education, there is limited research on leveraging ICTs, such as IWBs, for IK integration in Life Sciences classrooms (Sitsha, 2023). IWBs offer dynamic and interactive features, including multimedia presentations and simulations, which can make teaching more engaging and learner-centered (Mokoena et al., 2019). Arguably, these tools can transform the integration of IK, making it more meaningful and impactful in addressing learners' needs. By leveraging the interactive capabilities of IWBs, teachers can create immersive learning experiences that align with learners' cultural contexts and stimulate their interest in scientific inquiry (Mihai, 2019). Importantly, integrating IK using technology can be more appealing to modern-day technologically inclined learners, thereby improving the teaching and learning of Life Sciences.

De Silva et al. (2018), Kulcuta et al. (2019), Mihai (2020), and Ndlovu (2021) advocate that IWBs facilitate an active and interactive learning environment, making learning responsive to learners' needs. Slay et al. (2008) and Ndlovu (2021) similarly found that IWBs enable physical interaction between teachers and learners. The authors further praised IWBs for enabling learner engagement through annotation, highlighting, revealing, and drag-and-drop functionalities. A qualitative study conducted by Mihai (2020) focusing on the use of IWBs in Gauteng urban schools revealed that Life Sciences teachers involved learners in the lessons by dragging and dropping images or texts on the board. Mokoena et al. (2021) found that teachers allowed learners to write their opinions and answers on the board.

Against this backdrop, this study argues that integrating IK into teaching cellular respiration through IWBs holds significant potential for making Life Sciences teaching culturally responsive and interesting. This approach not only values and incorporates learners' diverse cultural backgrounds but also enhances the relevance of education by making it more meaningful and contextually grounded (Mkhwebane, 2024). In the context of teaching cellular respiration, Indigenous Knowledge offers several relevant and meaningful entry points for integration.

For example, indigenous fermentation practices—such as the brewing of sorghum beer (*umqombothi*) or the fermentation of milk to produce *amasi*—serve as culturally familiar analogies for anaerobic respiration, which is central to understanding glycolysis and fermentation processes in cells (Mavuru, 2022; Sitsha, 2023). These practices reflect indigenous understandings of biological processes, often passed down orally through generations (Edson & Govender, 2021). Therefore, this study considers these IK practices central to meaningful integration, enabling teachers to make the topic of cellular respiration more accessible, relevant, and inclusive.

2. Literature review

2.1 Conceptualizing indigenous knowledge

IK, also referred to as traditional or local knowledge, encompasses a range of definitions reflecting its diverse interpretations (Department of Science and Technology [DST], 2004). This study adopts McKnight's (2015) definition of IK as informal knowledge rooted in traditional practices, including beliefs, customs, skills, and values. These practices are transmitted across generations through creative cultural expressions, such as songs, dances, poems, rituals, and fashion (Magni, 2016). This study aligns with Reddy et al.'s (2017) view that IK should not be viewed solely from an African perspective and emulates Ndlovu-Gatsheni and Msila's (2021) argument that all human groups possess valuable and validated forms of knowledge. Consequently, the authors in the current study do not advocate for the dismissal of Western scientific knowledge in preference of IK but rather encourage the recognition and validation of diverse knowledge systems across cultural groups, thereby promoting inclusivity and cultural relevance in education.

2.2 Interactive whiteboards: its features and functionality

An IWB is a large, touch-sensitive screen connected to a computer or laptop and a digital data projector, allowing for interactive manipulation of digital content (Alfaki, 2014; Alshaikhi, 2017). According to de Silva et al. (2016), projectors are commonly mounted on desks or ceilings in South African classrooms, particularly in Gauteng schools, to facilitate this. IWBs permit users to interact with the computer interface directly on the board using a finger or an electronic pen known as a stylus, eliminating the need to switch between the board and computer (Preston & Mowbray, 2008; Kulcuta et al., 2019).

Mata et al. (2016) and Mihai (2020) have highlighted that this seamless interaction enhances usability and efficiency, making IWBs a powerful tool for dynamic and engaging teaching practices. Through their versatility and user-friendly interface, IWBs provide teachers with the means to effectively present multimedia content, simulations, and other resources, fostering an interactive learning environment that can support the integration of IK into Life Sciences classrooms.

Additionally, Mtshali (2021) and Ndlovu (2021) identified three key built-in software features for teachers to use in IWBs: 'drag and drop,' which allows objects to be moved without erasing or redrawing; 'hide and reveal,' which enables teachers to hide and reveal content as needed, facilitating assessment; and 'highlighting and annotating,' which allows teachers to emphasize important sections. Mihai (2020) noted that IWBs allow for the integration of other technologies. Teachers can create content, diagrams, simulations, and videos using other apps and technology (Mihai, 2020) and display them on the IWB. Additionally, advanced tools such as robotics and augmented or virtual reality can be used to generate content facilitated through the IWB.

2.3 Using IWBs to Integrate IK in Life Sciences Teaching

Life Sciences classrooms must rapidly evolve to align with the demands of the 21st century and the 4IR era. Kulcuta et al. (2019) argued that IWBs enhance the development of problem-solving, reasoning, and communication skills in the classroom. Similarly, Cindi (2021) found that integrating IK into Life Sciences promotes problem-solving, creative thinking, and innovation skills among learners. Engaging with IK encourages learners to think critically about its relevance in the classroom and its application solving current community problems. Edson and Govender (2021) concurred, noting that IK integration fosters curiosity and critical thinking among learners. This suggests that integrating IK with IWBs can amplify the development of 21st-century skills.

Cindi (2021) further confirmed that IK encourages learners to think critically and devise innovative and novel solutions, which aligns with the DBE's goal to produce digitally literate learners outlined in the e-Education policy (DBE, 2004). In addition, the integration of IK into science classrooms, as advocated by

Madlela (2021), aids in the acquisition of entrepreneurial skills among learners, potentially addressing the youth unemployment issue in South Africa. Learners can use IK and its practices as a source to devise innovative and novel artifacts to help address local issues in their communities.

In Life Sciences classrooms, particularly among Indigenous learners, there is a prevalent issue of demotivation and difficulty in understanding content knowledge. Scholars attribute this to many reasons, such as abstract and complex content knowledge (Akerele, 2016). According to Mtshali (2021), the concepts and terminology taught to learners are derived from Latin. Edson and Govender (2021) highlighted that learners do not find content knowledge applicable, relevant, and meaningful to their everyday lives. As a result, learners are demotivated and less interested in Science, Technology, Engineering, and Mathematics (STEM) subjects (Jin, 2021). Da Silva et al. (2023) argued that learners come to STEM classrooms with prior knowledge from their local environment and communities.

Hence, Akerele (2016) called for science teachers to use local knowledge and practices, such as IK, as a steppingstone to bridge the gap between new scientific knowledge and learners’ prior local knowledge. Arguably, integrating IK in Life Sciences teaching can deepen learners’ understanding and bridge the gap between the knowledge they acquire at home and school (Edson & Govender, 2021). Additionally, Gnanasekaran (2021) found that the current cohort of learners in the classrooms shows more significant interest in ICT tools such as IWBs, as it enables interactive lessons. Therefore, by leveraging IWBs for IK integration in Life Sciences teaching, learners' interest, motivation, and academic performance may be reignited.

Edson and Govender (2021) criticized the current Life Sciences curriculum for its content and pedagogy, perpetuating Western colonial knowledge, culture, practices, and languages. Odora-Hoppers (2005) added that Western knowledge and pedagogy dominate South African classrooms. This has resulted in the sidelining and marginalization of other forms of knowledge, such as IK (Jan 2019). This has led Ndlovu-Gatsheni (2013) to call for the decolonization of the curriculum, as it has been pushed to the margins of society. Ndlovu-Gatsheni & Msila (2021) attribute this to the legacy of colonialism and apartheid, which systematically marginalized IK in favor of Western science. Edson and Govender (2021) have proposed that integrating IK in formal classrooms should be encouraged to decolonize the science curriculum. Decolonizing science curricula entails dismantling colonial ideologies and the dominance of Western thought, knowledge, and approaches in the science classroom (Da Silva et al., 2023). Moichela (2017; Nwokocha & Legg-Jack, 2024) argued that integrating IK in teaching is a human right, essential to the struggle for social justice, and the transformation of the curriculum in post-apartheid South Africa. Hence, this study calls for teachers to integrate IK when teaching Life Sciences so that Indigenous thought, knowledge, practices, and perspectives are central to teaching and learning.

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Edson and Govender (2021) concurred, noting that IK integration fosters curiosity and critical thinking among learners. This suggests that integrating IK alongside IWBs has the potential to amplify the development of 21st-century skills. Cindi (2021) further confirmed that IK encourages learners to think critically and devise innovative and novel solutions, which aligns with DBE's goal to produce digitally literate learners outlined in the e-Education policy (DBE, 2004).

Although the current study focuses on Life Sciences classrooms in South Africa, numerous international studies affirm the pedagogical value of IWBs in science education. For instance, Mata et al. (2016) emphasized that IWBs improve conceptual understanding and learner interaction in science classrooms by enabling dynamic visualizations and simulations. Similarly, Gnanasekaran (2021) found that IWBs enhanced learner motivation and engagement among science teacher trainees. Studies from Turkey, the UK, and South Korea have also shown that IWBs facilitate inquiry-based learning and support multimodal teaching strategies in STEM subjects (de Silva, 2016). These findings support the integration of IWBs in Life Sciences, particularly when teaching complex topics like cellular respiration.

2.4 Theoretical framework

Cognitive justice calls for the recognition, respect, and equal acknowledgment of diverse knowledge systems (Visvanathan, 1997, 2000, 2009). Odora-Hoppers (2015) emphasized that cognitive justice demands equal recognition of all societal knowledge systems. Leibowitz (2017) and Sefotho and Letseka (2024) argue that cognitive justice promotes the diversification of knowledge production and distribution processes. According to Odora-Hoppers (2015), cognitive justice ensures that all knowledge systems, including traditional knowledge, coexist harmoniously in the public domain without the suppression of any knowledge system.

Visvanathan (1997) introduced cognitive justice to challenge the dominance of Western science in former colonies like India and South Africa. He criticized modern science for its exclusion and marginalization of other forms of knowledge, mainly traditional knowledge or IK (Visvanathan, 2000). This view is supported by Ndlovu-Gatsheni and Msila (2021), who argue that European nations enforced their knowledge systems to subjugate IK. Scholars such as Van der Velden (2006) affirmed that modern science often marginalizes IK, dismissing it as 'junk' or 'pseudo' science—a view echoed by de Beer and Whitlock (2009) and Cronje et al. (2015). In line with cognitive justice, this study calls for the integration of diverse knowledge systems, including IK, in teaching Life Sciences. The integration of diverse knowledge systems in multi-cultural South African classrooms ensures that learners experience an equitable and socially just learning environment.

2.5 Research aims and questions of the study

To this end, this study investigated Life Sciences teachers' perceptions of using interactive whiteboards to integrate Indigenous Knowledge when teaching cellular respiration.

Based on this aim, the following research questions guided this study:
1. What are Life Sciences teachers' perceptions about using interactive whiteboards to integrate Indigenous Knowledge when teaching cellular respiration in Grade 11?
2. What is the relationship between teachers' perceptions and their use of interactive whiteboards when integrating Indigenous Knowledge?

3. Research methodology

3.1 Research design

This study employed a quantitative research approach (Creswell & Creswell, 2018) to explore Life Sciences teachers' perceptions of using IWBs to integrate IK when teaching cellular respiration. The researchers designed a 5-point Likert scale questionnaire based on the literature on IK and IWBs integration. This design ensured that more participants were reached through a closed-ended questionnaire, as participants prefer questionnaires over open-ended and long questions (Creswell & Creswell, 2018). Hence, 153 teachers responded to the questionnaire.

3.2 Participants and sampling

One hundred and fifty-three participants were purposefully selected from eight high schools in Johannesburg and Ekurhuleni Metropolitan municipalities in the Gauteng Province. Participants were selected according to specific qualifying criteria (Cohen et al., 2017). The selection required that all participants be Grade 11 Life Sciences teachers with a minimum of two years of teaching experience and proven familiarity with CAPS document implementation in their classrooms. These teachers were therefore well-positioned to provide informed responses based on their classroom realities. Teachers were drawn from a larger estimated pool of 200 eligible Life Sciences teachers across the eight schools, resulting in a response rate of approximately 76.5%. Although the sample size was adequate and demographically representative, the lack of participation from a minority of eligible teachers introduced the potential for non-response bias. It is possible that those who opted not to participate may have limited confidence or experience in using IWBs or integrating IK, which could have influenced the overall findings.

The sample reflected diversity in terms of race, gender, highest qualification, and teaching experience. This diversity is presented in Table 1.

Table 1: Life Sciences teachers' biographical information

Characteristics	Category	n	Percentage (%)
Gender	Female Male Other	79 74 0	51,6 48,4 0
Race	African/Black White Coloured Indian/Asian	103 16 24 10	67,3 10,5 15,7 6.5
Home language	Afrikaans English Nguni (IsiZulu, SiSwati, IsiNdebele, IsiXhosa) Sotho (Sesotho, Setswana, Sepedi) Xitsonga/Tshivenda	21 28 61 29 14	13,7 18,3 39,9 19,0 9,2
Highest qualification	Diploma Undergraduate (B.Ed) Postgraduate (PGCE, B.Ed Honours, M.Ed, PhD)	0 107 46	0 69,9 30,1
Life Sciences Teaching Experience	1-2 years 3-5 years 6-10 years More than 10 years	36 63 33 21	23,5 41,2 21,6 13,7
Total		**153**	**100**

Table 1 presents the demographic profile of the participating Life Sciences teachers, showing near-equal gender representation (51.6% female, 48.4% male) and a predominantly African/Black sample (67.3%). Teachers speak a range of home languages, with Nguni speakers comprising 40%, followed by Sotho (19.0%) and English (18.3%) speakers. Most participants held a B.Ed. degree (69.9%), while 30.1% had postgraduate qualifications. In terms of teaching experience, 76.5% have more than two years, indicating that the sample is experienced and well-positioned to reflect on curriculum implementation and the use of IWBs to integrate IK.

The eight participating schools were selected based on two key criteria: (1) confirmed access to functional interactive whiteboards (IWBs) in Grade 11 Life Sciences classrooms and (2) formal permission and willingness from school management teams to participate in the study. Schools were identified in consultation with district officials to ensure diversity in the school context and resource availability across Johannesburg and Ekurhuleni. Four schools were in a township with no rich resources for teaching and learning, while the remaining four were in urban areas and were rich in resources.

3.3 Data collection and analysis

Data collection involved administering a closed-ended questionnaire to 153 Life Sciences teachers using the Google Docs application to explore Life Sciences teachers' perceptions of using IWBs to integrate IK when teaching cellular respiration. The questionnaire was emailed to the teachers with a link for online completion. The questionnaire required the teachers to select responses from predetermined options. Responses ranged from strongly disagree (1) to strongly agree (5). Moreover, the questionnaire had four constructs: teachers' perceptions of using IWBs to integrate IK when teaching cellular respiration, teachers' perceived affordances of using IWBs to integrate IK, teachers' perceived challenges of using IWBs to integrate IK, and teachers' use of IWBs to integrate IK.

A Statistical Package for Social Sciences (SPSS) version 26 was used to analyze the data gathered from the questionnaire. Both descriptive and inferential statistics were computed and analyzed. Descriptive statistics were used to compare and interpret the responses of Life Sciences teachers (Sheard, 2018). Additionally, the exploration factor analysis (EFA) was performed to measure the constructs of the questionnaire.

3.4 Reliability and validity of the study

The questionnaire was developed following a structured process grounded in the literature on IK integration and the use of IWBs in Life Sciences teaching. The four constructs—teachers' perceptions, affordances, use, and challenges—were derived from key themes in existing studies (e.g., Cindi, 2021; Mavuru, 2022; Sitsha, 2023) and operationalized through self-developed items. The development process included consultation with research supervisors and a statistician from the STATKON Unit at the university. Additionally, the draft instrument was reviewed by two experts in science education and one in educational technology to ensure its content validity. Based on expert recommendations, the items were refined for clarity, alignment, and construct coherence.

Before the questionnaire was administered to the participants, it was piloted on 30 non-participating teachers to validate the items' comprehensiveness and clarity. Cronbach's alpha measurement was used to measure the internal consistency of the constructs, and the lowest Cronbach measurement was .899 among the constructs (Cronbach, 1951). This means that all the constructs were reliable, and all the items in the questionnaire consistently measured the same underlying construct.

The EFA was performed to measure the constructs of the questionnaire, namely, teachers' perceptions, teachers' perceived affordances, teachers' use of IWBs, and teachers' perceived challenges in integrating IWBs to integrate IK. The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity were used to assess whether the dataset was appropriate for factor analysis. This is because it was crucial to determine whether the data were suitable for this method before performing factor analysis.

The results showed a KMO value of .848, suggesting that the sample is "great" for conducting factor analysis, meaning that the correlations between pairs of variables can be explained by other variables, which is essential for a meaningful factor extraction. Bartlett's Test of Sphericity assesses whether the correlation matrix is an identity matrix, indicating a significant chi-square value (4141.135) and a significance level of less than.001, In simpler terms, the significant result indicates that the correlations in the data are sufficiently strong to justify the use of factor analysis. A summary of the exploratory analysis and the results of the construct's reliability are presented in Table 2.

Table 2: Summary of exploratory factor analysis and construct's reliability of results

Factors	Factor loadings	Eigenvalues	Variance explained (%)	Cronbach's Alpha Coefficient
Factor 1: Teachers' Perceptions				
Using IWB to integrate IK enhances learners' understanding of cellular respiration.	.752	8.464	32.555	.919
Integrating IK through IWBs improves learners' engagement with the topic of cellular respiration.	.729			
I believe that integrating IK using IWBs aligns with the cultural diversity of my learners.	.617			
I encourage learner participation in creating or sharing IK content for IWB presentations on cellular respiration.	.682			
I believe that using IWBs to integrate IK enhances my effectiveness as a Life Sciences teacher when teaching cellular respiration.	.752			
Adequate support and resources are available for me to integrate IK using IWBs effectively.	.554			
Factor 2: Teachers perceived affordances.				
IWBs allow for dynamic and interactive presentation of IK related to cellular respiration.	.833	.635	2.442	.971
IWBs enable meaningful integration of IK when teaching cellular respiration.	.835			
IWBs enable real-time updates and modifications to IK content during classroom discussions on cellular respiration.	.855			
IWBs support the exploration of diverse perspectives and cultural interpretations of cellular respiration concepts through IK.	0.839			
IWBs provide opportunities for collaborative learning experiences centered around Indigenous knowledge in cellular respiration lessons.	.807			
Learners show improved comprehension of	.804			

cellular respiration concepts when IWBs are used to integrate IK.				
Integrating multimedia elements (e.g., videos, images) to showcase IK promotes cultural diversity/inclusion in the classroom.	.810			
Factor 3: Teachers' use of IWBs				
I regularly integrate IK into my lessons using IWBs when teaching cellular respiration.	.499	.103	.398	.946
I find it easy to integrate IK into my teaching using IWBs.	.524			
I actively seek out IK resources to integrate into my IWB presentations for cellular respiration lessons.	.472			
I encourage learner participation in creating or sharing IK content for IWB presentations on cellular respiration.	.441			
I use other ICT tools to create IK-related content for IWB presentations.	.455			
I use multimedia (visual and auditory) on an interactive whiteboard to present Indigenous Knowledge in my classrooms.	.488			
I use various applications like CDs, word-processed documents, spreadsheets, and PowerPoint presentations to present Indigenous Knowledge content.	.457			
Factor 4: Teachers perceived challenges				
Technical difficulties with IWB hardware or software hinder the smooth integration of IK in cellular respiration lessons.	.609	.254	.979	.899
Limited access to relevant IK resources poses a challenge to effectively integrating them into IWB presentations for cellular respiration.	.682			
The lack of interest from the learners toward IK discourages me from integrating IK through IWBs when teaching cellular respiration lessons.	.528			
Time constraints during lesson planning and preparation limit the extent to which IK can be integrated into IWB presentations for cellular respiration.	.675			
Lack of training or professional development opportunities on effectively integrating IK using IWBs hinders successful integration of IK through IWBs in cellular respiration teaching.	.685			
The School Management Team (SMT) at my school actively promotes the integration of IK, particularly using IWBs in classrooms.	.665			

As shown in Table 2, the reliability of the constructs identified in the EFA was strong, with all four factors showing high internal consistency, as measured by Cronbach's Alpha. Factor 1 (teachers' perceptions) and Factor 3 (teachers' use of IWBs) had excellent reliability, with Cronbach's Alpha coefficients of .919 and .946, respectively. Factor 2 (teachers' perceived affordances) had an exceptionally high reliability of .971, indicating near-perfect internal consistency. Factor 4 (teachers perceived challenges) also demonstrated good reliability, with Cronbach’s Alpha of .899. These values confirm that the items within each construct consistently measure the same underlying concept, making the analysis reliable and valid.

3.5 Ethical considerations

The research sought and obtained ethical clearance from the faculty’s research ethics committee from the institution where the researchers worked, and an ethical clearance certificate was obtained (certificate number Sem1-2024-084). A letter was obtained from the Gauteng Department of Education granting permission to conduct research in schools. The teachers provided informed consent before participating in the study. In addition, participants were informed of their right to withdraw from the study at any time without providing reasons for the researchers.

4. Research findings

The results are presented in six sections: Life Sciences teachers’ perceptions of using IWBs to integrate IK, Life Sciences teachers' perceived affordances of using IWBs to integrate IK, Life Sciences teachers’ use of IWBs to integrate, and Life Sciences teachers' perceived challenges of using IWBs to integrate IK. The EFA results are also presented. The following section presents the results of Life Sciences teachers’ perceptions of using IWBs to integrate IK, as shown in Table 3. The results are presented as frequencies, means, and standard deviations.

Table 3: Life Sciences teachers' perceptions about using IWBS to integrate IK

Items	Agree/ Strongly agree (%)	Neutral (%)	Disagree/ Strongly disagree (%)	Mean	*SD*
Using IWB to integrate IK enhances learners' understanding of cellular respiration.	90.2	6.5	3.3	4.08	.668
Integrating IK through IWBs improves learners' engagement with the topic of cellular respiration.	91.5	5.2	3.3	4.08	.648
I believe that integrating IK using IWBs aligns with the cultural diversity of my learners.	87.6	8.5	3.9	4.03	.688
I encourage learner participation in creating or sharing IK content for IWB presentations on cellular respiration.	87.0	6.5	6.5	3.99	.769

I believe that using IWBs to integrate IK enhances my effectiveness as a Life Sciences teacher when teaching cellular respiration.	88.9	7.2	3.9	4.04	.677
Adequate support and resources are available for me to integrate IK using IWBs effectively.	8.5	8.5	83.0	3.88	.910
Averages	**75.61**	**7.07**	**17.31**	**4.02**	**.73**

As shown in Table 3, 90.2% of Life Sciences teachers agreed that integrating IK with IWBs enhances learners' comprehension of cellular respiration by simplifying abstract concepts through familiar contexts. In comparison, only 3.3% disagreed, possibly due to differing beliefs about IK in science teaching. Similarly, 91.5% indicated that IWBs boost learner engagement by enabling interactive participation and incorporating community-shared IK, although 5.2% remained neutral, likely due to unfamiliarity with leveraging these tools effectively. Additionally, 87.6% believed that this integration enhances cultural relevance, acknowledging the importance of reflecting learners' diverse backgrounds. However, some variability in responses may stem from limited exposure to all cultural contexts. Furthermore, 88.9% felt that IWBs improved their teaching effectiveness by fostering engagement and comprehension through multimedia and interactive features, contributing to better classroom management and teaching satisfaction.

Despite these positive perceptions, 83.0% of teachers cited limited access to resources, training, and professional development as significant barriers, reflecting disparities in school resources and leadership priorities. The 8.5% neutral responses may also indicate the absence of IWBs in some schools, underscoring the need to address these challenges to fully leverage IWBs in promoting culturally relevant and engaging science education in the future.

The following section presents the results of Life Science teachers' perceptions of the affordances of using IWBs to integrate IK, as shown in Table 4. The results are presented as frequencies, means, and standard deviations.

Table 4: Life Sciences teachers' perceived affordances of using IWBs to integrate IK

Items	**Agree/ Strongly agree (%)**	**Neutral (%)**	**Disagree/Strongly disagree (%)**	**Mean**	***SD***
IWBs allow for dynamic and interactive presentation of IK related to cellular respiration.	89.5	9.8	0.7	4.10	.575
IWBs enable meaningful integration of IK when teaching cellular respiration.	92.8	6.5	0.7	4.14	.539
IWBs enable real-time updates and modifications to IK content during classroom discussions on	91.5	7.8	0.7	4.13	.558

cellular respiration.					
IWBs support the exploration of diverse perspectives and cultural interpretations of cellular respiration concepts through IK.	90.2	8.5	1.3	4.08	.573
IWBs provide opportunities for collaborative learning experiences centred around Indigenous knowledge in cellular respiration lessons.	90.8	8.5	0.7	4.11	.557
Learners show improved comprehension of cellular respiration concepts when IWBs are used to integrate IK.	67.3	9.8	22.9	3.22	1.237
Integrating multimedia elements (e.g., videos, images) to showcase IK promotes cultural diversity/inclusion in the classroom.	90.9	7.8	1.3	4.12	.584
Averages	**87.57**	**8.39**	**4.04**	**3.99**	**.66**

Table 3 highlights Life Sciences teachers' perceptions of IWBs for integrating IK. A substantial 89.5% agreed that IWBs deliver dynamic, interactive lessons that engage learners, with a low standard deviation (0.575), indicating consensus. Additionally, 92.8% believed IWBs enabled meaningful IK integration, using multimedia-like videos to contextualize cellular respiration, although 0.7% raised concerns about potential misconceptions. IWBs' flexibility to adapt lessons based on feedback was endorsed by 91.5%, aligning with social constructivism.

Furthermore, 90.2% agreed that IWBs foster multicultural learning by valuing diverse cultural backgrounds, while 90.8% emphasized their role in promoting collaboration on IK, reflecting the Ubuntu principle. However, only 67.3% agreed that IWBs improve comprehension of cellular respiration, with 22.9% citing challenges in aligning IK with Western science-based assessments. Despite this, 90.9% supported IWBs for promoting cultural diversity and inclusion through multimedia, emphasizing their potential to cater to diverse knowledge and learning styles. Neutral responses, ranging from 8.5% to 9.8%, likely reflect teachers' unfamiliarity with IK or limited IWB experience. The findings underscore IWBs' potential to make classrooms inclusive and engaging. However, it highlights the need to address IK integration and assessment alignment challenges.

Life Sciences teachers were asked about their use of IWBs to integrate IK, and the findings are presented in Table 5.

Table 5: Life Sciences teachers' use of IWBs to integrate IK

Items	Agree/ Strongly agree (%)	Neutral (%)	Disagree/ Strongly disagree (%)	Mean	*SD*
I regularly integrate IK into my lessons using IWBs when teaching cellular respiration.	55.3	2.6	42.1	3.24	1.114
I find it easy to integrate IK into my teaching using IWBs.	48.4	7.2	44.4	3.12	1.155
I actively seek out IK resources to integrate into my IWB presentations for cellular respiration lessons.	36.0	8.5	55.5	2.86	1.112
I encourage learner participation in creating or sharing IK content for IWB presentations on cellular respiration.	35.3	7.2	57.5	2.84	1.150
I use other ICT tools to create IK-related content for the IWB presentation.	37.3	7.8	54.9	2.90	1.154
I use multimedia (visual and auditory) on an interactive whiteboard to present Indigenous Knowledge in my classrooms.	44.5	6.5	49.0	3.08	1.195
I use various applications like CDs, word-processed documents, spreadsheets, and PowerPoint presentations to present Indigenous Knowledge content.	39.9	7.2	52.9	2.93	1.185
Averages	**42.39**	**6.71**	**50.9**	**2.99**	**1.153**

Table 5 reveals that while 55.3% of Life Sciences teachers regularly integrate IK using IWBs, 42.1% do not, reflecting barriers such as insufficient resources, inadequate training, and a lack of familiarity with IK. Only 48.4% of teachers found IWBs easy to use for IK integration, with 44.4% facing access and technological proficiency challenges. A mere 36.0% actively sought IK resources, suggesting limited awareness of resource availability and the importance of preserving IK. Furthermore, only 35.3% of teachers involve learners in creating or sharing IK content, indicating minimal learner participation due to teacher-centered approaches or doubts about learners' contributions to the content.

Similarly, only 37.3% of teachers use ICT tools like YouTube or simulations to create IK-related content, highlighting their reliance on IWBs alone. While 44.5% use multimedia to present IK, nearly half (49.0%) do not fully utilize such resources, likely due to limited access to diverse media sources. Additionally, only 39.9% use applications like PowerPoint to present IK content, suggesting that most teachers miss opportunities to engage learners effectively through various technologies. These findings underscore the need for targeted professional development, access to diverse IK resources, and a shift towards more participatory and resourceful approaches to integrating IK with IWBs. Table 6 presents the results of the Life Sciences participants who perceived challenges of using IWBs to integrate IK.

Table 6: Life Sciences Teachers perceived challenges of using IWBs to integrate IK

Items	Agree/ Strongly agree (%)	Neutral (%)	Disagree/ Strongly disagree (%)	Mean	*SD*
Technical difficulties with IWB hardware or software hinder the smooth integration of IK in cellular respiration lessons.	87.5	5.9	6.6	4.24	.901
Limited access to relevant IK resources poses a challenge to effectively integrating them into IWB presentations for cellular respiration.	89.5	3.9	6.6	4.27	.890
Lack of interest from the learners towards IK discourages me from integrating IK through IWBs when teaching cellular respiration lessons.	58.8	14.4	26.8	3.58	1.321
Time constraints during lesson planning and preparation limit the extent to which IK can be integrated into IWB presentations for cellular respiration.	85.0	6.5	8.5	4.15	1.005
Lack of training or professional development opportunities on effectively integrating IK using IWBs hinders successful integration of IK through IWBs in cellular respiration teaching.	89.6	5.2	5.2	4.27	.883
The School Management Team (SMT) at my school actively promotes the integration of IK, particularly using IWBs in classrooms.	5.9	3.9	90.2	4.29	.871
Averages	**69.38**	**6.05**	**23.9**	**4.16**	**.955**

Table 6 outlines Life Sciences teachers' challenges when using IWBs to integrate IK in teaching cellular respiration. A significant 87.5% of teachers reported that technical difficulties with IWB hardware or software, such as outdated equipment, software glitches, and lack of maintenance, hindered effective IK integration. The absence of technical support further exacerbated these issues during lessons. Additionally, 89.5% of teachers struggle to access appropriate IK resources, largely due to a lack of guidance in the DBE's CAPS document and prescribed textbooks. As a result, only 6.6% of the respondents had relevant IK resources available. Learners' attitudes toward IK integration also presented a challenge, with 58.8% of teachers noting that a lack of interest from learners, particularly in urban areas, limited the effectiveness of IWBs for this purpose.

Time constraints, reported by 85.0% of teachers, add to the difficulty, as integrating IK required careful planning and additional resources. Furthermore, 89.6% of teachers cited insufficient professional development and training, which impacted their confidence in using IWBs effectively. Additionally, 90.2%

expressed concerns that their school's SMT did not prioritize IK integration, often focusing on Western science content instead. These challenges highlighted the need for improved technical support, resource access, training, and institutional support to enhance the integration of IK using IWBs.

5. Discussion

The findings of this study reveal that Life Sciences teachers perceive IWBs as effective tools for integrating IK in teaching cellular respiration. A striking 90.2% of teachers agreed that using IWBs enhanced learners' understanding of this concept. This can be attributed to the multimedia capabilities of IWBs, which simplify abstract and complex concepts by presenting culturally relevant examples like indigenous fermentation processes (Sitsha, 2023). Such practices align with Mihai (2019), who highlighted the potential of IWBs to contextualize learning and make it relatable for learners.

Furthermore, de Beer (2019) argued that integrating IK reduces and enables learners to connect scientific concepts to their everyday experiences. However, a small percentage (3.3%) of teachers disagreed, potentially reflecting their skepticism about IK's scientific validity. Edson and Govender (2021) noted similar reservations, as some teachers perceived IK as anecdotal rather than empirical.

Teachers noted IWBs' impact on learner engagement, with 91.5% affirming that IK integration improved participation during lessons. The interactive features of IWBs, such as highlighting and real-time updates, encouraged active learner involvement. This resonates with the findings of Mokoena et al. (2019), who emphasized the capacity of IWBs to transform classrooms into collaborative spaces where learners can contribute their IK. However, 5.2% of teachers remained neutral on this question, which may reflect a lack of familiarity with the advanced features of IWBs. Ndlovu (2021) pointed out that some teachers might not be fully trained to use these tools effectively, thereby limiting their potential to engage learners.
Most teachers (87.6%) agreed that integrating IK through IWBs aligns with the cultural diversity of their classrooms, suggesting that teachers value the inclusivity fostered by these tools. This aligns with the principles of cognitive justice (Visvanathan, 1997), which advocates for the equal acknowledgment of diverse knowledge systems. Using multimedia to showcase IK respects and validates learners' cultural identities, fostering a sense of belonging. However, 8.5% neutrality suggests that some teachers might struggle to adapt lessons to the cultural dynamics of their classrooms. Cronje et al. (2015) observed that many teachers lack access to IK resources that adequately represent all cultural perspectives, which may limit their confidence in making lessons culturally inclusive.

Despite these positive perceptions, the actual implementation of IWBs to integrate IK reveals significant challenges. Only 55.3% of teachers reported regularly integrating IK into their lessons, indicating a gap between intentions and practice. This finding highlights systemic barriers, such as inadequate professional development and resource availability (Kulcuta et al., 2019). For instance, 89.5% of teachers identified a lack of IK-specific resources as a critical challenge. This aligns with the findings of Cronje et al. (2015), who emphasized that without accessible resources, teachers struggle to integrate IK meaningfully. While advocating for IK integration, the CAPS curriculum provides limited guidance on sourcing and applying IK in teaching. This lack of support creates a disconnect between policy objectives and classroom realities.

Technical issues emerged as a significant barrier, with 87.5% of teachers citing hardware and software malfunctions as hindrances to effective IWB use. These challenges disrupt lesson flow and erode teachers' confidence in technology. Khalo (2020) similarly highlighted that unresolved technical issues often discourage teachers from fully utilizing ICT tools. Additionally, 85% of teachers pointed to time constraints as significant obstacles. Preparing lessons that integrate IK using IWBs requires additional planning, particularly when sourcing relevant materials. These demands, combined with technical difficulties, reduce the feasibility of IK integration in time-pressure teaching environments.

Another key finding is that 58.8% of teachers reported low learner interest in IK as a discouraging factor for teaching it. This reflects broader societal attitudes, particularly in urban areas like Gauteng, where Western practices often overshadow indigenous traditions. Ndlovu-Gatsheni and Msila (2021) argue that the perception of IK as primitive or outdated contributes to its marginalization in education. However, this lack of interest is not universal, as 26.6% of teachers noted that their learners responded positively to IK-based lessons. This variation suggests that learner attitudes may be influenced by the manner in which IK is presented and integrated into the curriculum.

Institutional challenges further exacerbate these issues. A total of 90.2% of teachers reported inadequate support from school management teams for integrating IK using IWBs. This lack of prioritization may stem from an emphasis on accessible content, which often excludes IK in favor of Western science. Ngcobo (2020) highlighted a similar issue, noting that institutional support is critical for fostering culturally inclusive teaching practices. Without systemic backing, teachers face additional hurdles in aligning their pedagogical approaches with CAPS objectives.

6. Limitations, implications, and recommendations of the study

The findings of this study have important implications for the integration of IK in Life Sciences education using interactive IWBs. The results suggest that IWBs have the potential to be culturally responsive tools that can enhance teacher engagement with IK content. However, realizing this potential requires systemic reforms, including the provision of culturally relevant teaching resources, improved infrastructure, and targeted teacher professional development. Institutional support and policy alignment are critical for translating the aspirations of IK integration into meaningful classroom practices. Addressing these factors could enable IWBs to foster inclusive and contextually relevant learning environments that better reflect learners' diverse knowledge systems.

The design of this study presents some limitations that temper the interpretation and generalizability of its findings. The exclusive reliance on quantitative data from Life Sciences teachers, without triangulation through qualitative methods or the inclusion of other stakeholders such as learners and curriculum advisors, restricts the depth of understanding of the complexities of IK integration and contextual challenges.

Furthermore, the absence of inferential statistical analysis limits insights into the relationship between teachers' perceptions and their actual classroom practices. The lack of comparison or control groups prevents causal inferences about whether the observed benefits derive from IWBs, IK content, or their combination. Additionally, focusing solely on Gauteng Province limits the applicability of the findings to other regions, while excluding learner perspectives risks an incomplete portrayal of the intervention's impact on learner engagement and outcomes.

Future research should adopt mixed methods designs to capture richer, more nuanced data from multiple stakeholders, including learners and school management. Incorporating qualitative tools, such as interviews and classroom observations, would provide deeper contextual insights into how IWBs are used to integrate IK, and the barriers teachers face. It is also essential to include inferential statistical techniques, such as correlation or regression analyses, to examine the predictors and dynamics of technology adoption and IK integration into classrooms. Expanding the geographic scope beyond Gauteng and including diverse educational settings will enhance the generalizability of the findings. Finally, employing comparison groups or experimental designs could clarify causal effects and strengthen the evidence of the pedagogical value of IWBs for IK integration.

7. Conclusion

This study reveals that Life Sciences teachers perceive IWBs as valuable tools for integrating IK into the teaching of cellular respiration. Teachers view IWBs as valuable tools for simplifying abstract concepts and connecting scientific ideas to culturally relevant examples, fostering learner engagement and inclusivity. The integration of IK aligns with the principles of culturally responsive teaching and supports the broader goals of curriculum transformation to decolonize education. However, significant barriers hinder the full realization of IWBs' potential in the classroom.

Despite positive perceptions, challenges such as inadequate professional development, limited access to IK-specific resources, and technical difficulties with IWB functionality impede meaningful integration. Institutional factors, including insufficient support from school management and time constraints during lesson preparation, exacerbate these challenges. These systemic issues create a gap between policy objectives advocating for IK integration and the practical realities that teachers face. Additionally, the lack of explicit guidance within CAPS on sourcing and incorporating IK leaves teachers without the tools necessary for effective implementation.

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