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Understanding of Natural Sciences Teachers on Addressing Climate Change Concepts in the Curriculum: Evidence from Fundisa for Change Keep It Cool Climate Change Project

Busiswa Mzilikazi[1*]
Xolani Khalo[2]
Ntombi Caga[3]

AFFILIATIONS

[1,2&3]Department of Science, Mathematics and Environmental Studies, University of Fort Hare, Alice, South Africa.

CORRESPONDENCE

Email: xkhalo@ufh.ac.za*

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Abstract: Climate change is one of the most pressing international concerns of the twenty-first century. Globally, it affects economies, societies, and the environment. It is imperative that all sectors, including the education sector, embrace climate change mitigation measures. A qualitative case study was conducted to investigate teachers' experiences with integrating climate change concepts into the teaching of natural sciences at the Senior Phase in the Amathole West Education District. Permission to conduct the study was sought from the Department of Education and the institution for ethical considerations. Empirical data were collected through one-on-one semi-structured interviews with five natural sciences teachers from five selected secondary schools in the Amathole West Education District. One participant withdrew after data collection, and her data had to be discarded. The second generation of Cultural Historical Activity Theory (CHAT) was used as the theoretical framework. The thematic data analysis technique was employed to analyse the collected data. Key issues highlighted included teachers' content knowledge regarding climate change in natural sciences, a lack of training, and insufficient clear guidelines on integrating climate change topics. The study recommends regular teacher capacitation workshops on integrating climate change into their natural sciences teaching. Furthermore, it suggests the organisation of webinars to discuss issues related to climate change integration into the teaching of natural sciences, as well as encouraging teachers to collaborate with climate scientists to improve their pedagogical content knowledge.

Keywords: Climate change, collaboration, curriculum, mitigation, natural sciences.

1. Introduction

Climate change is one of the most pressing global challenges of the 21st century, with profound implications for the environment, economies, and societies worldwide (Intergovernmental Panel on Climate Change [IPCC], 2021). In this context, education is pivotal in equipping future generations with the knowledge and skills to mitigate and adapt to these changes. Integrating climate change into the natural sciences curriculum is crucial for fostering an informed and engaged citizenry capable of addressing the multifaceted impacts of climate change (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2015). UNESCO also highlighted the importance of incorporating climate change education into the natural sciences to meet the Sustainable Development Goals (SDGs), particularly SDG 13 (Climate Action) and SDG 4 (Quality Education). The document provides a framework for teachers to align their teaching with global sustainability objectives, fostering awareness, attitudes, and behaviours that support sustainable development.

According to Olawumi et al. (2023), the efforts of the government and other stakeholders to integrate climate change into the South African school curriculum have not yielded the desired results due to the lack of professional training programs for teachers addressing climate change in the classroom. Herein lies the significance of CHAT in this study, which analyses the confusion between the curriculum planners and the implementers, namely the teachers.

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In South Africa, learners study natural sciences in the Intermediate Phase (Grade 4 to Grade 6) and the Senior Phase (Grade 7 to Grade 9). The natural sciences curriculum at the Senior Phase level lays the foundation for further studies in three specific science disciplines: life sciences, physical sciences, earth sciences, and agricultural sciences (Department of Basic Education [DBE], 2011). Furthermore, natural sciences prepare learners for active participation in a democratic society that values human rights and promotes responsibility towards the environment. The Curriculum and Assessment Policy Statement (CAPS) document for natural sciences highlights one of its aims: to produce learners who are "… critically showing responsibility towards the environment" (DBE, Natural Sciences CAPS document, 2011, p. 5). This curriculum is designed to facilitate children's acquisition and application of knowledge and skills in ways that resonate with their personal experiences. In this context, it emphasises the importance of understanding the local context while remaining attuned to global challenges, including climate change.

Despite the previously mentioned curriculum goals, many teachers overlook the integration of climate change into their teaching resources (Mavuso et al., 2022). Climate change is widely acknowledged as one of the most pressing global challenges of our time. Furthermore, learners need to be thoroughly educated about its causes, effects, and possible solutions. However, integrating this knowledge into educational systems continues to pose a significant challenge (ibid.). While the South African Curriculum and Assessment Policy Statement (CAPS) stipulates that environmental issues such as climate change should be integrated into all subjects, teachers, who are the driving force behind any curricular innovation, are frequently disregarded and do not receive adequate training (Bantwini & Letseka, 2016; Mandikonza & Kavai, 2023; Ndaba & Fru, 2024). This creates a significant gap between the planned curriculum and its implementation (Ngcoza & Southwood, 2015). The analysis of this gap in this study has found the CHAT theory to be pertinent. The study aims to contribute to the limited empirical data exploring how natural sciences teachers currently understand the integration of climate change into their curriculum, particularly in specific regions or contexts, such as the Amathole West District in the Eastern Cape province. Additionally, the study seeks to provide documented data that addresses the unique challenges and opportunities related to integrating climate change into the curriculum in rural or underserved areas, which may not be well documented.

1.1. Climate change in the teaching of natural sciences

Integrating climate change into teaching can empower learners to become environmentally conscious citizens. Plutzer et al. (2018), echoed by Olawumi et al. (2023), argue that the goal of climate change education is to prepare learners for an uncertain future by helping them gain the knowledge, skills, dispositions, and values needed to tackle future environmental challenges. Teachers who successfully incorporate climate change into their curriculum may witness increased engagement and activism among learners regarding environmental issues. This integration is important because it allows learners to understand better what is happening around them. For example, it enables them to connect climate change to environmental disasters (North American Association for Environmental Education [NAAEE], 2004). Anderson (2012) discussed the role of climate change education in fostering pro-environmental attitudes and behaviours. The study shows that when learners are taught about the scientific basis of climate change, along with its social, economic, and ethical dimensions, they are more likely to engage in actions that contribute to mitigation and adaptation. To enhance learners' comprehension of complex systems, Shepardson et al. (2014) undertook a study highlighting the significance of integrating climate change into science teaching. This study reveals that when learners are educated about climate change, they develop better causal reasoning skills and environmental literacy. Understanding the interconnectedness of ecosystems, human actions, and climate systems is essential for cultivating responsible and informed citizens. Similarly, Monroe et al. (2019) argued that incorporating climate change into the natural sciences

equips learners with critical thinking and problem-solving skills, empowering them to make informed decisions regarding mitigation and adaptation.

In the South African Senior Phase curriculum for schools (DBE, 2011), the topic of the Atmosphere in Grade 9, under the knowledge strand Planet Earth and Beyond, which is taught in Term 4, addresses climate change concepts. This section comprises rising sea levels, food shortages, and mass extinctions. Learning about this topic helps learners develop scientific process skills, such as investigative skills, which are essential for generating knowledge related to the impact of global warming in their everyday lives (DBE, 2011). CAPS contains a wealth of material necessary to comprehend climate change; however, a clear connection is often not made between the subject matter and its relation to climate change. For instance, the concepts of density and temperature as presented in Grade 8 Term 2's particle model of matter offer essential content knowledge for understanding the ocean's thermohaline circulation, which in turn affects climate. The topic of ecosystem conservation in Grade 8 might also encompass the idea of climate change, discussing how human actions, such as burning fossil fuels, contribute to atmospheric pollution—one of the factors driving global warming. Unit 6 in Grade 7, under the topic of properties of matter, addresses car pollution, which significantly contributes to climate change and results in greenhouse gases in the atmosphere. Figure 1.1 presented below provides an overview of the topics related to climate change that can be explored within the natural sciences in the Senior Phase.

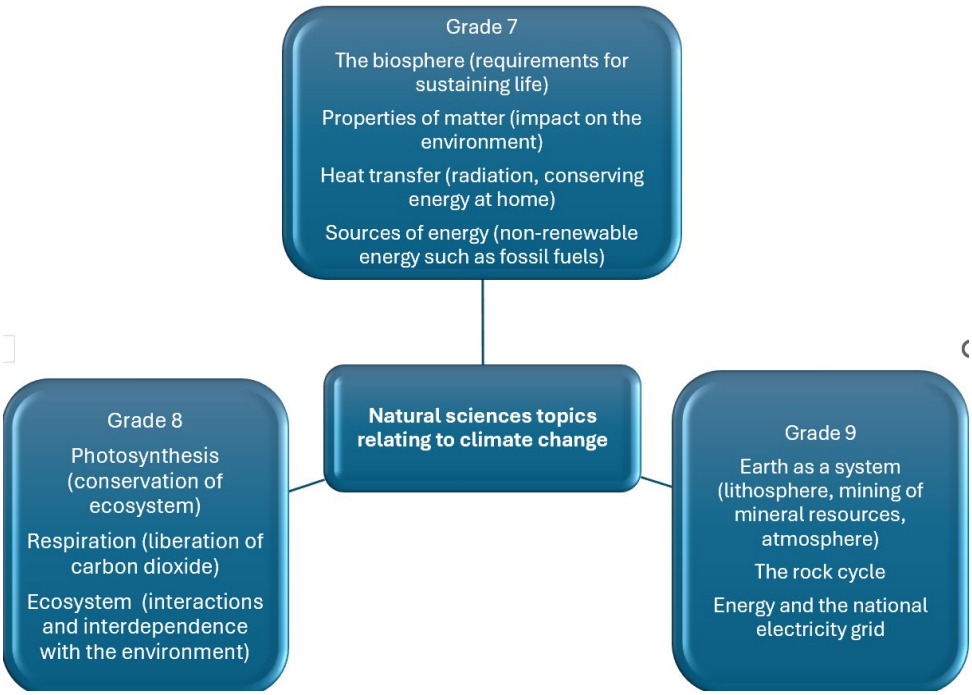

Figure 1: *Summary of topics related to climate change in the CAPS senior phase in natural sciences*

1.2 Teaching strategies relevant to the teaching of topics related to climate change

Teachers are the critical and pivotal engine for learners' educational achievement, and their knowledge system is essential for the effectiveness of education (Lee et al., 2012). Many scholars attest that experiential, inquiry-based, or constructivist approaches have proven effective for science and environmental education (Jacobson et al., 2015; Kezang, 2018; Larison, 2022; Serafín et al., 2015). According to Monroe et al. (2019), role-plays and simulations mimic reality and are often used in environmental education materials to engage learners in understanding different perspectives,

project potential future scenarios, and increase interest and enjoyment in learning. Therefore, visual imagery is important in capturing learners' interest and reaching wider audiences. Park and Park (2020) emphasise that effective education for climate change should include a full range of successful teaching methods, such as field trips, flipped classrooms, simulations, worksheets, data collection, role plays, and community action projects.

Climate change-related topics should incorporate activities that allow learners to actively engage with concepts, discuss their understanding, practice relevant actions, and explore local examples of climate change impacts (Monroe et al., 2019). Some scholars focus on providing content about climate change through inquiry-based activities. Similar to the constructivist approach, these activities enable learners to develop their knowledge and generate conclusions based on their understanding (Porter et al., 2012).

Scholars such as Olawumi et al. (2023) and Theobald et al. (2015) contend that when learners actively participate in climate change discussions, they develop a conceptual understanding of both local and global examples of climate change. Consequently, the results of their study indicated that learners were more likely to modify their behaviour, more certain that climate change would impact their lives, and more supportive of government action to mitigate climate change. Learners are also believed to be interested in issues relevant to their lives (Nam & Ito,2011). Teachers in various contexts commonly use different strategies to teach topics related to climate change and engage learners. Jacobson et al.(2015), echoed by Karpudewan et al. (2015), assert that employing a variety of learner-centred teaching methods is the most effective approach for teaching climate change-related topics. Furthermore, they highlight the utilisation of experiential, inquiry-based, or constructivist approaches, which have been proven effective for science and environmental education, and are therefore frequently applied to climate change topics (Jacobson et al.,2015). Karpudewan et al. (2015) encourage debates, small group discussions with worksheets, hands-on laboratories, and field trips.

Role-plays and simulations that mimic reality are often employed in environmental education materials to engage learners and stimulate interest and enjoyment in learning (Karpudewan et al., 2015). Vethanayagam and Hemalatha(2010) and Reinfried et al. (2012) assert that the use of visual imagery, animated educational videos, simple drawings, or cartoons are effective strategies for capturing learners' interest. Mutlu and Tokcan(2013) believe that watching documentaries can lead to significant learning gains regarding climate change. Other strategies that can be used to convey content about climate change include inquiry-based activities, such as employing a flipped classroom design with worksheets to guide small group discussions, laboratory investigations, and simulations. This promotes social interaction, whereby learners are expected to work collaboratively, share ideas and observations, and develop new understandings (Theobald et al., 2015).

1.3 Challenges of integrating climate change topics into the teaching of natural sciences

Integrating climate change into the curriculum might be challenging for some teachers due to the geographical area where the school is located, as the local context may influence teachers' perceptions of climate change integration. For instance, teachers in regions more directly affected by climate change (e.g., coastal areas facing rising sea levels) may have a greater sense of urgency in teaching this topic (Hung, 2022).

Furthermore, Olawumi et al. (2023) argue that for natural sciences teachers to teach climate change effectively in their classrooms, they need to have a strong mastery of critical content knowledge, including climate change, adaptation, mitigation, and pedagogical skills. This knowledge will enable them to implement curriculum-aligned and locally relevant content in their teaching. However, many teachers lack the appropriate strategies to enhance their understanding of both content and pedagogical content knowledge. Shea et al. (2016) assert that the implementation of curriculum-

aligned and locally relevant materials, as well as the professional development of teachers, is necessary for effective climate change education.

As noted above, understanding the terminology used in climate change is also a challenge that teachers face when integrating these concepts into their classrooms (Boon, 2016). Language is a vital component of education in South Africa (Joubert, 2010), and English serves as the language of learning and teaching (LoLT), which can sometimes act as a barrier to learning. The level of understanding of climate change concepts, such as mitigation, adaptation, and resilience, is affected by the fact that the LoLT is not the learners' mother tongue.Limited teaching time for the subject also affects the effective integration of climate change in most schools. According to the DBE (2011), the time allocated for natural sciences in the Senior Phase is ten weeks per term, with three hours per week. In Grades 7, 8, and 9, the content is packaged to be completed within 34 weeks. The policy allocates six hours for assessment in terms 1 and 3, while terms 2 and 4 cover eight weeks each, plus two weeks for revision and examinations (DBE, 2011). This implies that the time available for teaching is insufficient. Teachers may feel pressured to cover a broad range of knowledge strands, such as Life and Living, Matter and Materials, Energy and Change, and Planet Earth and Beyond. Consequently, they may find it challenging to dedicate sufficient time to climate change concepts.

Based on the previous discussion, there appear to be contradictions between the planned curriculum and its actual execution for the reasons outlined above (Ngcoza & Southwood, 2015). Most schools' lack of adequate resources hinders the proper integration of climate change into the curriculum. In the CAPS (2011) document, the resources needed for teaching natural sciences are listed for each topic to assist teachers with planning and preparation (Olawumi et al., 2023). CAPS stipulates that in instances where equipment is limited, teachers should be encouraged to improvise or to make use of readily available resources.

Climate change is a complex topic that requires an interdisciplinary approach (Ennes et al., 2021; Mavuso et al., 2022). Many teachers recognise the need for professional development opportunities to enhance their knowledge and teaching strategies related to climate change (Li et al., 2021). Some teachers may find it challenging to teach climate change effectively, especially if they specialise in a particular branch of natural sciences and lack expertise in other relevant fields such as social sciences or environmental policy (McNeal et al., 2017; Eilam, 2022). Patton et al. (2015) argue that these branches were not part of their pre-service training. While the scientific consensus on climate change is strong, societal and political controversies may surround the topic (Ennes et al., 2021). In other words, climate change affects society in different regions unevenly, sometimes leading to the migration of people from affected areas to other regions, potentially causing social and political tensions. Additionally, the environmental impact of climate change can result in economic losses from damage to infrastructure, agriculture, fisheries, and tourism industries.

This implies that people may lose their jobs, affecting their families and placing blame on the government. Environmental educators may believe that a fundamental science topic has become political and, therefore, too closely linked to advocacy for classroom teachers to address. At the same time, social change may be seen as central to the mission of environmental education, which presents challenges for educators (McNeal et al., 2017).

Some teachers are reluctant to educate about climate change due to concerns about how parents may react (Martha et al., 2017; Wise, 2010). According to some teachers (Morris et al., 2014; Tyson, 2014), discussing climate change in their community may damage their credibility and efficacy; therefore, they avoid the subject (Bowers et al., 2016; Martha et al., 2017; Sommers, 2014). Furthermore, some teachers feel inadequately equipped with the information and skills needed to teach learners about climate change (Martha et al., 2017; Monroe et al., 2013; Plutzer et al., 2018). This highlights the significance of CHAT in this study to analyse teachers' understanding of integrating climate change into their lessons.

1.4 Overview of Fundisa for Change-Keep It Cool (KIC) climate change project

This study is derived from the Fundisa for Change initiative in partnership with the Keep It Cool (KIC) climate change pilot project, which was managed by five South African universities. The Fundisa for Change programme encourages teachers to 'teach for change'. It aims to strengthen and expand the environmental and sustainability content knowledge specified in the subjects offered in the South African national school curriculum (Grades R–12). The Fundisa for Change programme directly addresses Sustainable Development Goal 4 (SDG 4), which focuses on quality education, and SDG 13, which concentrates on climate action. SDG 4 indicates that including sustainable development in education is necessary for achieving relevant, quality education. Specifically, target 4.7 of SDG 4 requires all governments to:

> By 2030, ensure that all learners acquire the knowledge and skills needed to promote Sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and culture's contribution to sustainable development (United Nations, p.118, 2012).

Helping teachers integrate the concept of climate change into related curricular areas is the aim of Fundisa for Change in partnership with the KIC project. Each university was required to select twenty schools, from which twenty teachers of geography and twenty teachers of natural sciences were trained in integrating climate change into these subjects. The initiative provided one week of training for each of the twenty schools, with one teacher from each school teaching geography and one from natural sciences participating. Following the training, each institution was to choose five schools from among the participants, where interviews would be conducted as a project requirement. VVOB, a non-profit that supports the education sector, provided funding for the initiative. VVOB encourages the growth of local capacity to promote sustainable development throughout Africa. Twenty schools in the Eastern Cape's Amathole West District participated in the project. This study is based on interviews conducted with natural sciences teachers and seeks to investigate: *What are the experiences of natural sciences teachers on integrating climate change concepts into natural sciences teaching?*

1.5 Theoretical framework

This study is underpinned by Cultural Historical Activity Theory (CHAT) (Engeström, 2001), as illustrated in Figure 1.2 below. The key idea of using CHAT in this study is to address contradictions, conflicts, and tensions among individuals. CHAT offers a prism through which to view how people relate to one another, to their cultural surroundings, and to the activities they participate in (Engeström, 2001; Yamagata-Lynch, 2010). CHAT has evolved through four generations of study, according to Engeström and Sannino (2011). The first generation, which emphasised individual effort, was influenced by Vygotsky's work from the 1920s and 1930s. Vygotsky posited that learning is a mediated process aided by social interactions and encounters with artefacts (Yamagata-Lynch, 2010). The second generation of Vygotsky's work was expanded by Leont'ev in 1978. This socio-historical generation focuses on collective activity as the unit of analysis, introducing components such as rules, community, and division of labour. Thus, CHAT emphasises the social and cultural nature of human activity, highlighting how cultural artefacts, tools, and institutions shape individuals' cognition and behaviour. It views human development as a process that occurs through social interactions and participation in culturally mediated activities.The theory was then popularised by Engeström, who wrote extensively on it and developed it further into the second and third generations, and is now working on the fourth generation of CHAT (Engeström, 2015). This study utilised the second generation of CHAT to analyse the data according to the themes that emerged from thematic analysis.

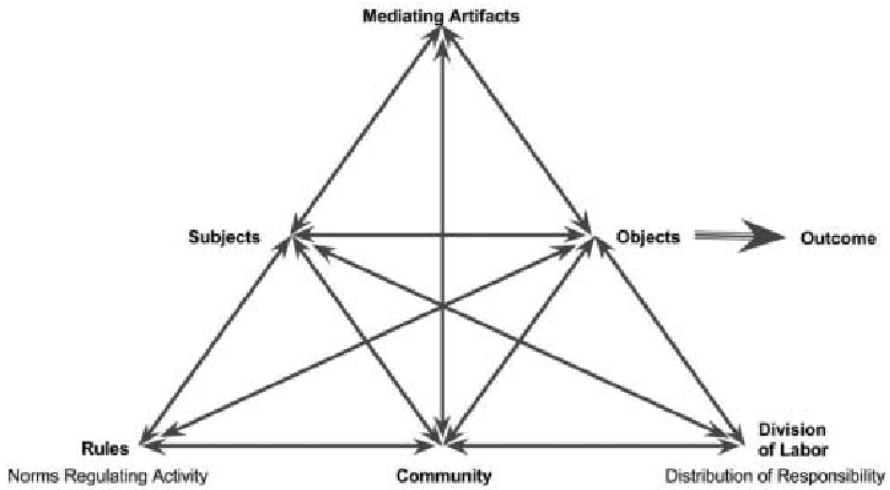

Figure 2: *An illustration of human action in the second generation of CHAT (Engeström, 2001)*

The significance of CHAT (Cultural-Historical Activity Theory) in this study lies in its ability to provide a comprehensive framework for exploring teachers' understanding of how to integrate climate change into their teaching methods. CHAT emphasises the interconnectedness of social, cultural, and historical contexts in shaping educational practices. By applying this theoretical lens, the study can delve into the various factors that influence teachers' perspectives and approaches to climate change. Moreover, CHAT encourages a focus on the historical context of education and how past experiences shape current practices. By considering the historical development of environmental education and the evolving discourse around climate change, the study can uncover how teachers' backgrounds and prior training influence their current teaching methods.

The application of CHAT in this study can facilitate a critical analysis of the contradictions and challenges teachers face when attempting to integrate climate change into their teaching. These contradictions may arise from institutional constraints, curriculum limitations, or differing levels of support from school administrations. By identifying these challenges, the study can contribute to the development of targeted professional development programmes and resources that empower teachers to effectively address climate change in their classrooms.

CHAT focuses on activity systems as the primary unit of analysis, which includes, in this study, subjects (teachers), objects or objectives (curriculum goals related to climate change), tools (teaching strategies, resources), rules (curriculum guidelines, educational policies), community (curriculum planners, learners), and division of labour (roles and responsibilities). The activity system in this study is outlined as follows:

- **Subject:** The teachers who are responsible for integrating climate change concepts into their teaching of natural sciences.
- **Object:** The goal or purpose of the activity system. Empowered teachers with better pedagogical strategies for teaching interdisciplinary topics like climate change.
- **Tools/Artifacts:** Mediating tools used in the teaching-learning process**, c**urriculum guidelines and policy documents, textbooks, lesson plans, and multimedia resources, and teacher training programs and workshops on climate change integration.
- **Community:** The stakeholders involved in the activity**, o**ther teachers (peer networks and communities of practice), policymakers and curriculum developers.
- **Rules:** The explicit and implicit norms guiding the activity: National curriculum requirements for natural sciences and educational policies on climate change integration.

- **Division of labour:** The distribution of roles and responsibilities within the system; teachers planned and delivered lessons and assessed students; school leaders provided resources and support, facilitating professional development and policymakers designed and approved curriculum policies.

2. Methodology

This is a qualitative case study based on the interpretivism paradigm. This paper is derived from the data collected for the Fundisa for Change Keep it Cool Climate Change (KIC) project. Twenty natural sciences teachers participated in the project, as discussed in Section 1.4. Five of the twenty schools involved in the teacher capacitation programme were selected for the project's research component after the training. The five teachers were chosen based on their active participation during the training and their willingness to engage in the research. One teacher withdrew during the data collection, resulting in the need to discard the data collected from him, as ethical guidelines allow participants to withdraw from the project at any time. The project was a pilot study focused on developing teachers capacity to integrate climate change into the two selected subjects: natural sciences and geography. In terms of ethical considerations, the institution granted ethical clearance, and permission to conduct the study was sought from the Department of Education. The participants also provided their consent. The study aimed to address the following research question: *What are the experiences of natural sciences teachers regarding the integration of climate change concepts into natural sciences teaching?*

One-on-one interviews were conducted with each participant using open-ended semi-structured questions. During these interviews, the researchers took notes in addition to voice recordings to ensure that no essential data was missed. The thematic data analysis technique was employed, and several themes emerged from the collected data. The researchers then used notes and recordings to sort related data and group them according to themes (Kumar, 2012). The recordings and notes were carefully transcribed through coding to enable the researchers to match the data with the established themes (Bryman, 2016; Creswell & Creswell, 2017; Mpofu & Maphalala, 2020).

3. Presentation and Analysis of Data

Data analysis followed an inductive approach, adding value to the researchers' intent to explore the experiences of natural sciences teachers in integrating climate change into natural sciences teaching, and themes were generated.

3.1 Teachers' experience on the integration of climate change in the natural science curriculum

Teachers were given the opportunity to share their experiences of integrating climate change concepts into the teaching of natural sciences in the senior phase through a set of questions. During the interviews, they were asked specifically about their experiences with this integration. The following are the responses from the participants:

> *T1: "We must teach climate change because it broadens learners' knowledge about environmental issues and equips them with skills in planning, conducting investigations, and solving problems but I do not see how I can talk about climate change in natural sciences"*
> *T2: "It is important if our learners can understand climate change challenges and can be of great help in our community. For example, they can assist in community gardens, etc.". But I have never talked about climate change in my teaching".*

> *T3: "Climate change is a hot topic, we hear about it on television and radio, and learners need to learn about it" In topics such as biodiversity in grade 8, I can talk about climate change, but I have never touched it, I only teach what is in the textbook".*
> *T4: "Learners must be equipped about climate-related issues. I only teach about fossil fuels without taking into consideration that the topic relates to the issues of climate".*
> *T3 added:" It is important that we integrate climate change so that our learners can be able to link climate change issues they are learning about with what is happening in real life."*

The responses provided by participants T1, T3, and T4 highlight a notable conflict concerning the depth and breadth of content knowledge related to climate change integration. While teachers are aware of the various aspects of climate change that could be integrated into the curriculum, they often choose to sidestep the topic. This avoidance stems primarily from the lack of a clear and structured framework that outlines how to effectively implement climate change in their teaching practices.

This situation raises important questions about the role of teachers in addressing pressing environmental issues. The dialogue among the participants indicates that discussions surrounding environmental matters, including climate change, are heavily influenced by the individual judgments and interpretations of teachers. Without a standardised approach or guidelines, teachers may feel uncertain about how to approach the topic, leading to inconsistencies in how climate change is taught across different classrooms and schools.

Ultimately, the hesitance to address climate change in the classroom not only limits learners' exposure to vital knowledge but also perpetuates a cycle of inaction regarding environmental education. It underscores the need for comprehensive frameworks and professional development opportunities that empower teachers to confidently integrate climate change into their teaching, fostering a more informed and engaged learner body capable of addressing the environmental challenges of the future.

> *T2 added: "It is important, but the challenge is that teachers need to be trained on how to integrate it into their teaching. We were not contacted before including this climate change in the curriculum, and now we are expected to implement it".*

However, as highlighted by T2, it is evident that teachers responsible for implementing the CAPS curriculum, which emphasises the importance of environmental awareness, are not receiving adequate training and support to effectively address these issues within the curriculum. Addressing climate change within our educational framework is crucial for fostering a generation that is aware of and equipped to tackle one of the most pressing issues of our time. The challenge lies in the necessity for teachers to receive adequate training on how to effectively integrate climate change topics into their teaching. This integration is not merely about adding a few lessons on environmental issues; it requires a comprehensive understanding of the complexities of climate change, its impacts on various ecosystems, economies, and communities, as well as the social and political dimensions that accompany it.

Before the inclusion of climate change in the curriculum, teachers were not consulted or involved in the decision-making process. This lack of consultation has left many teachers feeling unprepared and overwhelmed by the expectation to implement these new topics in their classrooms. Without proper training and resources, teachers seem to be struggling to convey the urgency and importance of climate change to their learners, potentially leading to a superficial understanding of the subject. One of the general objectives outlined in the National Curriculum Statement (NCS) for Grades R–12 is to equip learners with the ability to "utilise science and technology effectively and critically, demonstrating a sense of responsibility towards the environment and the well-being of others" (Department of Basic Education 2011, p. 5). This objective, as articulated in the South African national

curriculum, emphasises integrating environmental issues into disciplines such as natural sciences. Furthermore, it underscores the commitment to preparing youth to assume responsibility for their actions and the welfare of future generations, which is a fundamental principle of Education for Sustainable Development (Burmeister et al., 2012). Teachers responsible for executing the curriculum often find themselves inadequately prepared to tackle environmental issues within it. While the natural sciences curriculum includes relevant topics, teachers frequently lack the necessary pedagogical skills to effectively address environmental challenges, such as climate change. Furthermore, there appears to be insufficient communication between curriculum developers and those who implement it.

> *T1 further stated: "My challenge is to integrate this content because we have limited time to teach natural sciences at the Senior Phase. I think we also need to be capacitated as teachers, too'.*

From the discussion above, the limited time allocated for teaching natural sciences poses a significant challenge for teachers aiming to integrate essential topics related to climate change into their curricula. Given the growing urgency of climate issues, learners must understand the scientific principles underlying climate change, its impact on ecosystems, and the socio-economic implications it entails. However, the constrained time frame often leads to a rush through the content, leaving little room for in-depth exploration of contemporary issues like climate change.

Moreover, the complexity of climate science requires a multidisciplinary approach, integrating knowledge from biology, chemistry, physics, and earth sciences. Achieving this integration can be difficult within a restricted schedule, as teachers may feel pressured to cover a predetermined syllabus that prioritises standardised testing and core content over emerging global challenges.

> '*… our specializations are not on environmental education and science education.*"T3 remarked.

As a result, learners may miss out on critical discussions about sustainability, renewable energy, and the role of human activity in climate change, which are vital for fostering informed and responsible future citizens.

Additionally, the limited instructional time can hinder opportunities for hands-on learning experiences, such as experiments, field studies, and project-based learning, which are essential for engaging learners and deepening their understanding of climate-related topics. Without these experiential learning opportunities, teachers may struggle to connect theoretical knowledge with real-world applications, diminishing their ability to critically analyse and address climate issues. The restricted time allocated for natural sciences not only limits the breadth of content that can be covered but also poses a barrier to equipping learners with the knowledge and skills necessary to confront the pressing challenges of climate change. To effectively address this issue, educational institutions may need to reevaluate their curricula, prioritise interdisciplinary approaches, and advocate for increased instructional time dedicated to environmental education.

Furthermore, teachers lack adequate training in the integration of environmental issues or have limited access to sufficient resources to effectively incorporate these topics into their teaching (Martha et al., 2017; Monroe et al., 2013). This can lead to a lack of confidence and preparedness to address environmental issues in the classroom. Another noted contradiction is that teachers do not see the direct relevance of environmental issues to the specific natural sciences topics they are teaching, leading them to prioritise other content that they perceive as more important or directly aligned with assessment requirements.

Moreover, integrating climate change should not be a one-size-fits-all approach. Different regions and communities experience climate change in unique ways, and teachers need to be equipped with

the tools to tailor their teaching to reflect local contexts and challenges. This requires ongoing professional development, access to up-to-date research, and collaboration with experts in the field. In addition, it is essential to foster a supportive environment where teachers can share best practices, resources, and strategies for teaching climate change effectively. This collaborative approach can help build confidence among teachers and ensure that they feel empowered to engage their learners in meaningful discussions about climate action and sustainability.

Addressing climate change in education is not just about the content; it is about creating a culture of awareness, responsibility, and action. By investing in teacher training and support, the Department of Education can ensure that teachers are not only prepared to integrate climate change but are also inspired to motivate their learners to become proactive stewards of the planet. However, from the discussions, there seems to be a manifestation of the tension between roles and responsibilities in the division of labour according to CHAT. Figure 1.3 below shows the contradiction between the subject (teachers) and the rules (CAPS document).

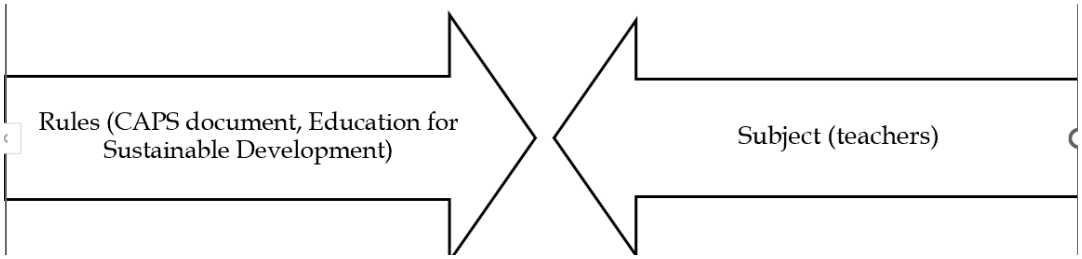

Figure 3: *Contradictions between the rules and the subject*

3.2 Resources and instructional tools

T1 commented, "In the CAPS document concerning the instruction of energy sources, it is essential for students to engage with readings and images related to both non-renewable and renewable energy to foster their understanding of climate change. However, due to a scarcity of resources, I am compelled to utilise the materials at my disposal, which occasionally limits the depth of learning regarding climate change".

From the comment highlighted by T1, the CAPS document outlines that the teaching approach to energy sources emphasises that learners should actively engage with a variety of readings and visual materials covering both non-renewable and renewable energy sources. This engagement is crucial for developing a comprehensive understanding of climate change and its implications for the environment and society. By exploring diverse perspectives and information, learners can better grasp the complexities of energy production, consumption, and the resulting impact on our planet. However, there is a significant challenge due to a scarcity of resources available for teaching this important topic.

> *'The limited materials at my disposal often restrict the depth and breadth of learning experiences I can provide for my learners'. T1 continued.*

While teachers strive to create an enriching educational environment, the lack of diverse and high-quality resources can hinder learners' ability to fully explore the nuances of climate change, including the critical differences between renewable and non-renewable energy sources. This situation necessitates a creative approach to teaching, as educators must make the most of the materials available while seeking out supplementary resources whenever possible. This discussion is supported by a study conducted by Anderson et al. (2020), which stated that barriers such as a lack of resources, insufficient teacher training, and the challenges of aligning climate change concepts with standardised curricula persist. Moreover, this conflict reflects a broader issue within the educational system, where the integration of critical contemporary issues into the curriculum is often

impeded by a lack of resources, training, and support. As a result, important topics like climate change may be relegated to the background, depriving learners of the opportunity to engage with and understand the complexities of these global challenges.

It is also noted that some schools experience understaffing, which results in teachers being assigned subjects outside their areas of expertise and leaves them unsure of their ability to teach specific subjects due to content gaps.

> *…the current staffing levels at my school are insufficient, resulting in teachers being assigned to teach subjects outside their areas of expertise, which adversely impacts the quality of teaching.* T4 remarked.

School staffing often leads to teachers being frequently assigned to teach subjects that fall outside their areas of expertise. This misalignment between teachers' qualifications and the subjects they are required to teach can have significant negative consequences for the quality of education provided to learners. Teachers who are not adequately trained or experienced in a particular subject may struggle to deliver the curriculum effectively, hindering learners' understanding and engagement with the material. Moreover, this lack of specialised instruction can result in gaps in learners' knowledge and skills, as they may not receive the depth of understanding that comes from being taught by someone who is well-versed in the subject matter (Eilam, 2022).

The Post-Provisioning Model (PPM) is a formula-based framework designed to guide the allocation of teachers to public schools based on the number of enrolled learners (Department of Basic Education, 2013). This system aims to ensure that schools are staffed in a manner that reflects their learner populations, ostensibly promoting equitable access to education. However, the PPM model is not without its challenges and limitations. One significant drawback of the PPM is its reliance solely on enrolment figures, which can lead to an oversimplified view of the staffing needs of a school. By focusing primarily on the number of learners, the PPM overlooks the diverse range of subjects that schools offer. Each subject area often requires specialised knowledge and skills, and the demand for teachers can vary widely depending on the curriculum and the specific needs of the learner body. For instance, a school may have a high number of learners enrolled in advanced science courses, yet the PPM may not allocate enough qualified science teachers to meet this demand, leading to imbalances in subject-specific staffing.

As a result of this oversight, teachers may find themselves facing excessive workloads. In schools where the PPM does not accurately reflect the subject distribution, teachers may be assigned to teach multiple subjects or manage larger class sizes than they can effectively handle. This can lead to burnout and job dissatisfaction as teachers struggle to meet the diverse needs of their learners while also maintaining their professional standards. Moreover, the PPM can inadvertently place teachers in positions where they are teaching subjects for which they lack proper training or expertise. For example, a teacher trained in languages may be required to teach a science class due to staffing shortages, which can compromise the quality of education that learners receive. This misalignment between teacher qualifications and subject assignments can hinder learner outcomes and diminish the overall effectiveness of the educational system.

4. Discussion of Findings

For this research, the findings and discussion are structured based on the research question the study intends to answer and the themes identified in the analysis. All the participants' responses indicated that they understand how important climate change is to learners, supporting Mavuso et al. (2022) assertion that teachers also recognise the importance of integrating climate change into their curriculum. The reality is that, based on the teachers' experiences, the three hours per week allocated for the teaching of natural sciences in the Senior Phase is insufficient (DBE, 2011), as teachers are

expected to cover a broad range of knowledge strands that natural sciences encompass without the addition of climate change content.

The teachers' understanding of the subject content is clearly explained by the Cultural Historical Activity Theory (CHAT), which serves as the lens of this study when asserting tension, contradictions, and misalignment between the implementers and the planners of the curriculum. McNeal et al. (2017) and Eilam (2022) argue that inadequate content knowledge in the teaching of climate change may be caused by the fact that some teachers specialise in a particular branch of natural sciences and lack expertise in other relevant fields, such as environmental science/climate change or environmental policy.

The learner-centred approach encourages learners to participate in activities and ask questions in class. Karpudewan et al. (2015) promote other learning methods, such as debates, small group discussions with worksheets, hands-on labs, and field trips when integrating climate change. Teachers are encouraged to use visual imagery, animated educational videos, or simple drawings or cartoons to capture learners' interest and promote their participation in climate change lessons (Vethanayagam & Hemalatha, 2010; Reinfried et al., 2012). Similarly, Karpudewan et al. (2015) suggest using role-plays and simulations to cater to the needs of introverted learners. The lecture method does not promote social interaction. Theobald et al. (2015) contend that learners are expected to work together, share ideas and observations, and arrive at new understandings.

The participants raised the issue of learners being unable to speak in front of their peers, even when asked, fearing they would be laughed at by others. They indicated that such learners struggle with sentence construction when voicing their opinions or responding to questions. The issue of language as a barrier to learning is viewed by Joubert (2010) as a vital component of education in South Africa, where, in selected schools, English is the language of learning and teaching (LoLT). Joubert asserts that the concepts used in climate change content, such as mitigation and adaptation, are what learners struggle to understand, mainly because the language is not their mother tongue. The responses also revealed that although the district office provides some of the materials listed in the natural sciences CAPS document, the schools do not supply the outstanding materials, resulting in teachers having to teach without them.

5. Conclusion

The integration of climate change into the senior-phase natural sciences curriculum is not just a beneficial addition; it is a vital measure for cultivating environmental consciousness among learners, encouraging sustainable practices, and equipping them to face the future challenges associated with climate change. As the world grapples with the escalating impacts of climate change, it becomes increasingly important for educational institutions to prepare learners to understand and address these pressing issues. By embedding climate change topics within the natural sciences framework, teachers can facilitate learners' comprehension of the scientific concepts underlying climate change, including its origins, mechanisms, and far-reaching effects on the environment. This integration allows learners to connect theoretical knowledge with real-world applications, fostering a deeper understanding of how climate change manifests in their everyday experiences.

Moreover, the integration of climate change can inspire learners to become proactive agents of change within their communities. By understanding the science behind climate change, learners can engage in informed discussions, advocate for sustainable policies, and participate in initiatives aimed at mitigating environmental degradation. This empowerment is crucial, as the younger generation will inherit the consequences of today's environmental decisions and will need to navigate a world increasingly affected by climate-related challenges.

However, research indicates that the integration of climate change content into teaching practices poses significant difficulties. One of the primary challenges is that many teachers are not actively

engaged in the curriculum review processes, which can lead to a disconnect between educational goals and the realities of classroom instruction. Additionally, a lack of sufficient training and professional development opportunities for teachers can hinder their ability to effectively implement climate change topics in their lessons. Without the necessary support and resources, teachers may feel ill-equipped to tackle such complex and multifaceted issues, resulting in a missed opportunity to inspire and educate learners about climate change.

To address these challenges, educational authorities need to prioritise the professional development of teachers, ensuring they have access to the latest research, resources, and pedagogical strategies related to climate change education. Collaborative efforts between teachers, curriculum developers, and environmental experts can also enhance the relevance and effectiveness of climate change content in the curriculum. By fostering a supportive environment for teachers, we can create a more robust educational framework that not only informs learners about climate change but also inspires them to act for a sustainable future.

While the Post-Provisioning Model (PPM) provides a structured approach to teacher allocation based on learner enrolment, it falls short of addressing the complexities of subject diversity and teacher qualifications. To enhance the effectiveness of teacher distribution in public schools, it may be necessary to adopt a more nuanced framework that considers not only the number of learners but also the specific subject needs and the qualifications of teachers. This would help ensure that teachers are not only adequately supported but also positioned to deliver high-quality teaching across all subject areas. Further research can be conducted with learners.

6. Declarations

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