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Research Article

Addressing Global Warming Issues In Schools Through Curriculum Integration

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Abstract

Global warming is gradually shifting weather patterns, causing sea levels to rise, and increasing the frequency of extreme weather events. To effectively mitigate its effects and adapt to the changing climate, it is imperative to have a thorough understanding of global warming and its impacts. Thus, the purpose of this study is to use curriculum integration to address global warming issues in schools. It takes educational cues from Finland, Japan, South Africa, and New Zealand about how to teach about global warming. In order to accomplish the study's goal, a systematic review of the literature was carried out, incorporating and deleting journal articles from databases with broader coverage, including Scopus, WoS, and DOAJ. Thematic analysis was used to examine the data. The comparative study's conclusions show that while South Africa implements climate education policies unevenly, Finland is committed to interdisciplinary teaching, Japan incorporates climate change education into curricula, and New Zealand incorporates climate science across a variety of subjects. It was suggested, based on the findings, that countries create and carry out professional development initiatives to give educators the know-how and abilities needed to instruct students on climate change-related subjects.

Keywords: Curriculum, Education, Global Warming, Integration, Pedagogy

INTRODUCTION

Global warming is a component of climate change which refers specifically to the increase in Earth's average surface temperature. Global warming occurs primarily due to human activities such as burning fossil fuels and deforestation [1]. International debates on global warming issues show that education has a key role to play in responding to the climate crisis. However, current national education policies in South Africa do not provide clear direction about what this means for schools [2]. Global warming and climate change education are global issues that need urgent attention and must be addressed carefully. This could be done by considering thought-out partnerships between government, civil society, environmental agencies, and education institutions [3]. Studies conducted by UNESCO [15] recapitulate the need for collaborative partnership, and further proposed the shifts in mindset starting from policy makers to education institutions. These institutions

should be responsible for integration of local learning and action in education by co-opting values and attitudes [4], aligned to global warming and environmental challenges.

Climate Education for Sustainable Development was identified as a central tenant in helping the public understand and relate to issues. It involves in change of lifestyle to reduce greenhouse emissions and adapt to the changing local conditions. The curriculum is systematically planned, and some of its functions can be adapted to change the behaviour of young people to enable them to gain insight that can assist them in solving societal problems exacerbated by climate change. It is therefore imperative that curriculum and clear educational policies on global warming issues be considered as critical elements that could enhance awareness and interventions in trying to reduce dangers of climate change in societies. The consequences of global warming issues are not far reaching. It poses a challenge to political leaders, policymakers, and leaders within every sector. Addressing issues emanating from global warming is therefore requires an interconnected approach [5]. Since global warming issues has become a global challenge, many countries have committed resources into fighting against it. For instances countries like New Zealand, Finland and Japan have integrated it across their curricula.

According to Ministry for the Environment, and Stats NZ, (2020), many New Zealand schools report that they support student leadership around environment and climate issues [6]. In classrooms, students have opportunities to learn about climate change causes and impacts, as well as personal actions they can take to make a difference. Students have fewer opportunities to engage in collective and systemic actions or learn about career pathways and opportunities in a low-emissions economic future. Bolstad [7] argues that New Zealand's educational policies and strategies currently provide a diffuse framework for responding to climate change, and there is a lack of coherent messaging "from the top" about what could or should be expected of schools. Yet some innovative practices and approaches are visible across the schools.

Zilliacus [8] points out that in Finland, the climate crisis calls for changes in all areas of human life. One such area is the education sector, which needs to be the target of urgent reform to be able to support these crucial changes. International sustainability policies call for transformative changes in worldviews that may inspire new ways of thinking and acting. Worldview transformation means a major change in deep-rooted ways of viewing the world that results in long-lasting changes in individuals' sense of self, perception of relationship to the world, and even their entire way of being. Worldviews interface with perceptions of issues like climate change in ways that are frequently overlooked. The climate crisis demands a re-orientation and transformation of worldviews, a change in which education can play a pivotal role. Therefore, the crises also call for rapid educational policy reforms. A central question is how to make worldview transformation related to sustainability visible in education policy. The general school education curricula in Finland (grades 1-12) express sustainability as a core aim. However, it is debatable whether educational policy such as the Finnish curricula can promote worldview transformation.

In Japan, it is reported that since the 2000s, schools have developed diverse approaches to environmental education, reflecting the characteristics of each region. Environmental education has been primarily implemented in Life-Environmental Studies classes and during the Period for Integrated Studies, in response to the guiding principles of the Teacher's Guide for Environmental Education. However, other subjects have not been considered for the integration of climate change and environmental education [9]. It is reported that although some schools are carrying out advanced educational activities, based on these national policies, many schools are not making sufficient progress regarding environmental education.

In South Africa, recent years, environmental issues have dominated the global conversation. This has necessitated the inclusion of environmental content in educational curricula [10]. The National curriculum and assessment policy statement (CAPS) document in South Africa has incorporated Environments Education (EE) topics in some subject areas of the basic education system. With the curriculum development process in South Africa, particularly in the Curriculum and Assessment Policy Statement (CAPS), evidence of EE can be seen in the natural sciences, social sciences, and life skills subjects [11]. Thus, it is worrying to note that in South African curriculum there are no specific stand-alone subjects on environmental education, but rather an integrated component having a stand-alone subject could have a more complex focus on climate change issues.

Moreover, it can be established that South Africa's National Curriculum and Assessment Policy Statement (CAPS) includes environmental education (EE) topics in natural sciences, social sciences, and life skills, but lacks a dedicated subject for a comprehensive focus on climate change. Similarly, Japan primarily implements environmental education in Life-Environmental Studies and the Period for Integrated Studies, with limited integration in other subjects [12]. In contrast, New Zealand encourages student leadership in environmental issues but lacks consistent school-wide approaches due to a diffuse framework and incoherent policy direction (Ministry for the Environment & Stats NZ). Finland's national curriculum emphasizes sustainability, but the effectiveness of educational policies in promoting a transformative worldview on sustainability remains debatable [8]. Therefore, addressing these gaps and drawing lessons from the experiences of Japan, New Zealand, and Finland, South Africa can enhance its educational framework to better equip students with the knowledge and skills needed to tackle global warming and climate change.

Objectives

1. To explore educational policies of New Zealand, Finland Japan and South Africa in terms of addressing global warming.

2. To establish pedagogical strategies for addressing global warming issues in schools through curriculum transaction.

THEORETICAL FRAMEWORK

One of the most significant goals of teaching is to promote the critical thinking capability of students and thus, to create good citizens for a just society. The critical pedagogy was identified as an ideal theory to underpin this research project. The literature shows that critical pedagogy has its origin in the tradition of critical theory of the Frankfurt School and the work of the Brazilian, Uddin [13] states that critical pedagogy is a transformation-based approach to education. Hence, this theory was found relevant for this research paper in the sense that people could be transformed through education that alerts them on environmental issues that could assist in avoiding global warming. Critical pedagogy's major tenets are that education should go beyond transfer of knowledge but should also contribute on training people to help them develop critical consciousness, which leads to transformation of the individual and society at large.

Furthermore, Aliakbari and Faraji [14] state that through curriculum the students are expected to act in a way that enables them to transform their societies which is best achieved through emancipatory education. Thus, integration of global warming issues into school curriculum could be the solution to curb the escalation of climate change and global warming in our societies. These scholars further posit that through problem posing education and questioning the problematic issues in learners' lives, force them to think critically and develop a critical consciousness which help them to improve their life conditions and to take necessary actions to build a more just and equitable society. It is an undeniable fact that issues of global warming have been confirmed to be escalating because of unacceptable practices by individuals, which include pollution among others [15].

METHODOLOGY

To answer the research questions in this study, a Systematic Literature Review (SLR) will be used. The research will employ a tripartite protocol that was adapted from Mpuangnan and Ntombela [16], comprising three stages: preparation, execution, and documentation.

i. Planning Phase: In this first stage, the research questions are developed, and a review protocol is painstakingly crafted.
ii. The Conducting Phase: This stage is devoted to finding pertinent research materials, carrying out a strict study selection procedure, and carefully evaluating the caliber of the chosen studies.
iii. Reporting Phase: The last stage is devoted to summarizing the review's conclusions.

Planning Phase

In addition to creating a review protocol and research questions, the author has defined search terms pertaining to global warming-related concerns. These search phrases involve "global warming issues," "global warming issues in South Africa," "global warming issues

in New Zealand," "global warming issues in Finland," along with "global warming issues in Japan." Using search terms like "appropriate teaching methods," "teacher approaches to global warming," and "learners' approach to global warming," the second category focuses on pedagogical strategies for addressing issues related to global warming. In addition, the researcher has chosen the search engines for the literature search with great care, choosing Scopus, Web of Science (WoS), the Directory of Open Access Journals (DOAJ), and the International Bibliography of the Web of Sciences (WoS), covering the years 2000–2024. Based on the extensive coverage of academic literature, as demonstrated by earlier research, this choice was made [16,17].

Conducting Phase

About 52 articles were initially reviewed and included during the writing phase. Nevertheless, 17 articles were eliminated after it was discovered that they were duplicates. After that, the author went through the remaining papers and assessed how well the abstract and title of each piece related to the study's research questions. The journals' quality was also taken into account. A final set of 24 articles was left for in-depth analysis after an additional 11 articles were rejected as a result of this screening process.

FINDING AND DISCUSSION

The findings of this study were organized into three main themes. The first theme examined South African educational policies on global warming issues. The second theme focused on the educational policies of New Zealand, Finland, and Japan regarding global warming. The third theme addressed pedagogical strategies for tackling global warming issues in schools. Within each major theme, the author identified and illustrated sub-themes using pie charts.

Educational policies of New Zealand, Finland, and Japan regarding global warming

New Zealand

Climate Change as part of Educational Policies: To meet the ever-increasing exigency for imparting climate change literacy amongst students, educational policies in New Zealand are gradually assimilating such learning. Hopkins et al. [18] argue that New Zealand's vulnerability to climate change in terms of being located on the boundary zone for shifting zones due to atmospheric pressure differences requires sophisticated frameworks. Total curriculum frameworks develop climate science in umbrella - thematic approaches that cut across multiple disciplines for an all-around view of the big ideas about climate. The authors assert that well-embedded, multi-disciplinary educational policy is necessary so students can be helped to understand the intricacy of climate change and its social economic implications for Aotearoa New Zealand. This integration is important to build resilience for future generations in addressing climate-induced challenges.

Everth et al. [19] emphasize the importance of developing Climate Literacy in schools, and then goes on to describe a way this could occur by building infrastructure for climate-change This highlights the need for teacher education and to further develop curriculum resources that help participating individuals teach climate change effectively. Educational policies should support continuous professional development for teachers, so they have the confidence to deliver climate education, and it is important that children are questioned on their understanding of these complex yet enlightening issues. They also call for the collaboration of schools, communities and policymakers to build a holistic climate change education community. These types of collaborative efforts help the ED to ensure that educational policies are not only top down, second tier provisions but also educated by those on ground level with experience and insight from educators and students.

Another essential component of New Zealand's educational policies is youth participation in climate discussions and actions. Bright [20] investigates how secondary schools' policies have been impacted by student-led climate strikes, leading them to improve their approaches to climate education. By including student opinions, educational policies become more impactful and relevant while also giving students a sense of agency. Additionally, Arya and Parker [21] emphasize the value of dialogic action in conversations about climate change and support instructional strategies that promote candid communication and critical thinking. These methods help students form knowledgeable opinions and deeply engage them with climate issues.

Research and education about climate change are greatly advanced by higher education institutions. According to Stratford [22], higher education policies must adopt an ecological perspective in order to meet the Anthropocene era's more expansive environmental objectives. This entails reevaluating curricula so that sustainability and climate resilience become essential elements. Similarly, Lomas [23] investigates how New Zealand universities can take the lead in societal change by incorporating climate action into their outreach and daily operations. Higher education policies can foster a generation of leaders prepared to tackle future environmental challenges by integrating climate change education. Education policies on climate change in New Zealand and the number of cited articles are shown in table 1.

Table 1: Education policies on climate change in New Zealand and the number of cited articles

Educational Policy Aspect	Authors Cited	Number of Articles	Percentage
Integration of Climate Change into Curriculum Frameworks	Hopkins et al. [18]	2	22.2%
Development of Climate Literacy and Teacher Education	Everth et al. [19]	1	11.1%
Collaboration among Schools, Communities, and Policymakers	Everth et al. [19]	1	11.1%

Student Participation and Agency in Climate Action	Bright [20], Arya & Parker [21]	2	22.2%
Promotion of Critical Thinking and Dialogic Instructional Strategies	Arya & Parker [21]	1	11.1%
Ecological Perspective and Sustainability in Higher Education	Stratford [22], Lomas [23]	2	22.2%

Finland

Finland's climate change education policies center on incorporating climate education into the framework of sustainable development and worldview transformation. According to Zilliacus and Wolff [8], Finnish education policies seek to integrate climate change education into a larger framework that promotes ethical thinking and global citizenship. By encouraging interdisciplinary instruction, this strategy makes sure that subjects related to climate change are covered outside of science classrooms as well. By doing this, students are able to connect climate issues to a broader ethical and global perspective, gaining an integrated and holistic understanding of sustainability.

Hofman-Bergholm [24] emphasizes that in order to achieve a sustainable future, behavioural and cognitive changes are required. The Finnish educational system has a strong commitment to sustainable development, and its policies promote students' critical thinking and active participation. This commitment is reflected in experiential learning and hands-on activities that connect theoretical knowledge with practical applications. Such methods deepen students' understanding of sustainability and empower them to take responsible actions to address climate change.

Higher education establishments in Finland are also making a big contribution to combating climate change. The ways that Finnish universities are incorporating climate change into their institutional practices and curricula are covered by Konst & Friman [25]. These institutions offer climate change-related specialized courses and research opportunities by integrating sustainability into their core missions. This emphasis pushes students to create creative answers to climate-related problems in addition to improving their knowledge and abilities. Ilieva [26] assesses students' knowledge of black carbon and the Sustainable Development Goals (SDGs) in northern Finland, highlighting the role that higher education plays in advancing sustainable practices and climate literacy.

Additionally, certain areas like energy production and sustainable living are the focus of Finnish educational policies. In order to suggest future directions for bioenergy policies, Halder [27] looks into how students perceive the production of energy from biomass found in forests. Finland hopes to raise a generation of energy-savvy students by teaching them about renewable energy sources and how they affect the environment. In their discussion

of the application of different policy tools to lessen the effects of housing, transportation, and food on the climate, Nissinen et al. [28] demonstrate a thorough approach to sustainability education. Juntunen and Aksela [29] go deeper into the opportunities and difficulties of teaching chemistry for sustainable development, putting forth pedagogical models that are applicable both domestically in Finland and abroad. These initiatives demonstrate Finland's dedication to incorporating climate change education at all educational levels. Education policies on climate change in Finland and the number of cited articles is shown in table 2.

Table 2: Education policies on climate change in Finland and the number of cited articles

Educational Policy Aspect	Authors Cited	Number of Articles	Percentage
Integration of Climate Change into Sustainable Development Framework	Zilliacus & Wolff [8]	1	12.5%
Promotion of Critical Thinking, Active Participation, and Experiential Learning	Hofman-Bergholm [24]	1	12.5%
Role of Higher Education in Advancing Climate Literacy and Sustainable Practices	Konst & Friman [25], Ilieva [26]	2	25.0%
Focus on Energy Production and Sustainable Living	Halder [27], Nissinen et al. [28]	2	25.0%
Chemistry Education for Sustainable Development	Juntunen & Aksela [29]	1	12.5%
Emphasis on Interdisciplinary and Ethical Learning Approaches	Zilliacus & Wolff [8]	1	12.5%

Japan

Governmental initiatives, educational reforms, and international collaborations have all contributed to the evolution of climate change education in Japan. The incorporation of climate change adaptation strategies into urban and community planning is emphasized by Takahashi et al. [30]. Their findings highlight the need for comprehensive curricula, enhanced teacher preparation, and a unified national strategy that addresses both adaptation and mitigation. These components are essential for creating a resilient society that can address the challenges posed by climate change. Lee [31] looks into how partnerships impact the level of global warming awareness among Japanese people. Partnerships between the public, nonprofit, and private sectors are crucial for raising awareness and altering people's behaviour, the study finds. These collaborations have been

crucial for raising public awareness and supporting efforts to mitigate climate change. According to Lee's [31] research, maintaining and strengthening these cooperative initiatives is crucial for fostering public participation and achieving meaningful climate action.

Tanaka [32] offers a thorough examination of the situation of education for sustainable development (ESD) in Japan, both now and in the future. The report notes that although Japan has made strides in promoting ESD, there are still issues to be resolved, including how to incorporate ESD into formal education, create locally relevant content, and guarantee that teachers receive ongoing professional development. In order to achieve sustainable development goals, Tanaka highlights the necessity of an all-encompassing approach to ESD that takes into account the environmental, social, and economic aspects of the issue. She also advocates for increased stakeholder collaboration.

The political facets of the education for sustainable development movement in Japan are discussed by Nomura and Abe [33]. They draw attention to how important national policies and government assistance are to the advancement of ESD. The authors make the case for a more comprehensive strategy that harmonizes learning goals with more expansive social and environmental regulations. This point of view is reinforced by Kameyama [34], who examines how social and environmental policies interact in Japan and how this affects educational initiatives. Collectively, these studies highlight the difficulty of implementing climate change education and the need for cross-sector coordination in order to make significant progress. Table 3 below is a table summarizing the educational policies related to climate change in Japan, based on the provided findings.

Table 3: Education policies on climate change in Japan and the number of cited articles

Educational Policy Aspect	Authors Cited	Number of Articles	Percentage
Incorporation of Climate Change Adaptation Strategies into Urban and Community Planning	Takahashi, Sato, & Hijioka [30]	1	16.7%
Partnerships Between Public, Nonprofit, and Private Sectors to Raise Awareness and Change Behaviour	Lee [31]	1	16.7%
Education for Sustainable Development (ESD) and Incorporation into Formal Education	Tanaka [32]	1	16.7%
Need for Comprehensive ESD Approach Including Environmental, Social, and Economic Aspects	Tanaka [32]	1	16.7%

National Policies and Government Support for Advancing ESD	Nomura & Abe [33], Kameyama [34]	2	33.2%

South African educational policies on global warming issues

Many policies and initiatives targeted at raising student awareness and engagement with climate change are guiding climate change education in South Africa. With a focus on secondary school students, Kutywayo et al. [35] point out that although students exhibit a great deal of concern for climate change, their comprehension and application of this knowledge are frequently lacking. In order to better prepare students for climate action, the study finds a gap between theoretical knowledge and practical skills, and it suggests that more hands-on approaches be incorporated into current educational strategies.

Climate change education (CCE) programs in South Africa are assessed by Sibanda and Manik [36], who highlight both their advantages and disadvantages. They discover that although there are several CCE programs in place, unequal resource distribution among schools and inconsistent implementation compromises their efficacy. This observation supports the findings of Kutywayo et al. [35] by showing that student application of climate change knowledge is impacted by differences in educational quality and resources. The authors advocate for a more uniform CCE program in order to guarantee that every student receives an equal and thorough education regarding climate-related issues.

An overview of national policies pertaining to climate change education and education for sustainable development (ESD) is given by Laessøe and Mochizuki [37]. According to their research, despite South Africa's progress in incorporating ESD into educational policies, there are still obstacles in converting these policies into efficient teaching methods. This larger picture emphasizes a discrepancy between carefully thought-out policies and their actual application, supporting Sibanda and Manik's worries regarding the variation in CCE effectiveness amongst schools. The study conducted by Akrofi et al. [38] aims to explore the factors that impact student climate action and pinpoint any knowledge gaps. They discover that although students actively engage in climate-related activities, their comprehension is frequently limited, which hinders their efficacy. The findings of Kutywayo et al. [35] regarding the gap between knowledge and application are supported by this, which also emphasizes the necessity of educational interventions that close these gaps. These interventions can better prepare students for meaningful climate action by emphasizing the development of their understanding and practical skills.

Using North-West University as a case study, Villavicencio Calzadilla et al. [39] investigate climate change communication in higher education. Their study emphasizes how important it is for universities to use research and community involvement to advance climate change education. This viewpoint emphasizes that while foundational education

is important, higher education is also crucial in developing advanced understanding and leadership in climate issues, which complements the findings from primary and secondary education studies. When taken as a whole, these studies highlight the necessity of a coherent approach to climate change education that unifies initiatives at all educational levels and tackles both practical and policy issues. Table 4 is a table summarizing the educational policies related to climate change in South Africa, based on the provided findings.

Table 3: Education policies on climate change in South Africa and the number of cited articles

Educational Policy Aspect	Authors Cited	Number of Articles	Percentage
Gap Between Theoretical Knowledge and Practical Skills in Climate Education	Kutywayo et al. [35]	1	20%
Inconsistent Implementation and Unequal Resource Distribution Among Schools	Sibanda & Manik [36]	1	20%
Challenges in Converting Educational Policies on Climate Change into Effective Teaching Practices	Laessøe & Mochizuki [37]	1	20%
Factors Affecting Student Climate Action and the Need for Bridging Knowledge Gaps	Akrofi, Antwi, & Gumbo [38]	1	20%
Role of Higher Education in Climate Change Communication through Research and Community Engagement	Villavicencio Calzadilla, Mauger, & Du Plessis [39]	1	20%

A cross-country analysis of policies and practices on educational responses to climate change

Table 5 presents a cross-country analysis of policies and practices on educational responses to climate change reveals diverse approaches to integrating climate education into school curricula and broader educational frameworks across New Zealand, Finland, Japan, and South Africa.

Table 5: Summary of educational policies regarding global warming issues across New Zealand, Finland, Japan, and South Africa

Aspect	New Zealand	Finland	Japan	South Africa
Integration of Climate Change	Climate science integrated across various subjects; multidisciplinary approach to understanding climate issues (Hopkins et al. [18]).	Climate change integrated within broader worldview transformation and sustainability education; interdisciplinary teaching (Zilliacus & Wolff [8]).	Climate change education integrated into curricula; focus on adaptation and mitigation strategies (Takahashi et al. [30]).	Climate change education integrated but inconsistent; calls for standardized implementation (Sibanda & Manik, [36]).
Teacher Training and Resources	Emphasis on professional development and resource creation for teachers (Everth et al. [19]).	Encourages hands-on, experiential learning to bridge theory with practice (Hofman-Bergholm [24]).	Need for improved teacher training and comprehensive curricula (Takahashi et al. [30]).	Significant gaps in teacher knowledge and resources; need for enhanced support (Kutywayo et al., [35]).
Student Involvement	Student-led climate strikes influencing school policies; emphasis on student agency (Bright [20]).	Focus on active engagement and critical thinking; experiential learning encourages student participation (Hofman-Bergholm [24]).	Collaborative efforts to raise public awareness, with student involvement in climate actions (Lee [31]).	Students show concern but often lack practical application; need for more hands-on approaches (Kutywayo et al., [35]).
Higher Education	Universities incorporate climate change into curricula and operations; focus on sustainability (Stratford [22]; Lomas, [23]).	Higher education integrates sustainability into core missions and research; specialized courses on climate change (Konst & Friman, [25]).	Higher education contributes through research and community outreach; need for more alignment with ESD goals (Tanaka [32]).	Higher education institutions play a role in advancing climate education but face challenges (Villavicencio Calzadilla et al., [39]).

Policy and Implementation	Collaborative efforts between schools, communities, and policymakers; ongoing improvements in policy implementation (Everth et al. [19]).	Strong commitment to sustainable development and practical applications; policies support integrated learning (Zilliacus & Wolff [8]).	Emphasis on national strategy and policy integration; challenges in aligning educational objectives with environmental goals (Nomura & Abe [33]).	Policies exist but implementation is inconsistent; need for more effective and equitable strategies (Sibanda & Manik [36]).

It can be seen from table 5 that every nation uses a different approach to address climate change in its educational systems. In New Zealand, a multidisciplinary approach integrates climate science into a range of subjects to give students a comprehensive understanding of climate issues [18]. Finland adopts a more comprehensive approach by integrating climate change into a framework of education about sustainability and worldview transformation. This multidisciplinary approach fosters a holistic viewpoint by integrating climate-related issues into a broader framework of sustainable development [8]. Japan incorporates climate change into its curricula, emphasizing mitigation and adaptation tactics in particular to give students real-world experience in dealing with climate-related issues [30]. Although there is climate change education in South Africa, there are considerable differences in how it is integrated. To guarantee consistent and successful climate education throughout schools, a standardized approach is being called for [36].

Another important component of these educational policies is the emphasis on resources and training for teachers. To support effective climate education, New Zealand places a high priority on professional development and the creation of resources for teachers. As a result of this emphasis, teachers will be better equipped to teach climate science and related subjects [19]. In order to help teachers engage students in meaningful ways, experiential learning—which links theoretical knowledge with practical application—is prioritized in Finland [24]. Japan recognizes that in order to enhance the delivery of climate education, more thorough curricula and improved teacher preparation are required. This emphasizes how important it is to provide educators with more resources and support [30]. South Africa faces considerable gaps in teacher knowledge and resources, indicating a need for substantial improvements in training and support to enhance climate education effectiveness [36].

The degree to which students in these nations are involved in climate change initiatives also varies. The climate strikes spearheaded by students in New Zealand have had a substantial impact on school policies, emphasizing the importance of student agency and engagement in climate issues [20]. Through experiential learning, Finland promotes critical

thinking and active student participation in climate-related activities [24]. Although there is a need for more practical application of climate education within schools, students in Japan are actively involved in public awareness raising and climate action participation [31]. Although there are frequently few opportunities for real-world application, South African students express concern about climate issues. To effectively engage students in addressing climate challenges, more hands-on approaches are required [36].

In these nations, universities are vital to the advancement of climate change education. With a focus on sustainability, New Zealand's universities incorporate climate change into their operating procedures and curricula. Through instruction and institutional actions, this integration helps students comprehend and address environmental challenges [22, 23]. According to Konst and Friman [32], Finnish higher education institutions integrate sustainability into their core missions and research, providing specialized courses on climate change as a means of advancing knowledge and solutions. Research and community outreach are two ways that Japan's higher education sector contributes, but more alignment with the goals of Education for Sustainable Development (ESD) is required to maximize the impact of climate education [32]. Higher education institutions in South Africa are engaged in climate education, but they face obstacles, especially when it comes to putting good plans into practice and coordinating their efforts with more general climate objectives [39].

The execution of policies pertaining to climate change education exposes unique national strategies and obstacles. To improve climate education policies, New Zealand policymakers, communities, and schools are working together. The goal of ongoing development is to maximize the efficacy and execution of policy [19]. Finland's policies that encourage integrated learning and real-world applications of climate education demonstrate a strong commitment to sustainable development [8]. Although there are still difficulties in coordinating national strategies with environmental goals, Japan focuses on integrating them with educational objectives. This suggests that policies pertaining to education and the environment need to be more coherent [33]. South Africa has existing policies on climate change education, but their implementation is uneven. There is a need for more effective and equitable strategies to ensure consistent and impactful climate education across the country [36].

Educational policies regarding global warming issues across New Zealand, Finland, Japan, and South Africa

Educational policies tackling global warming differ widely across countries like New Zealand, Finland, Japan, and South Africa. The policies in each of countries have a unique path to weave climate education into their learning systems. In New Zealand, climate science is spread across different subjects to give students a well-rounded understanding of climate issues [18]. This way, students can learn the science behind climate change and also understand its social, economic, and environmental impacts. Finland takes a different

approach by embedding climate education into a broader conversation about sustainability and transforming worldviews [8]. This holistic method encourages students to think deeply about their role in sustainable development. On the other hand, Japan is all about practicality. Their curriculum emphasizes real-world applications, such as mitigation and adaptation strategies, which help students get hands-on experience with climate challenges [30]. In South Africa, the approach to climate education varies significantly across regions and schools, highlighting a need for a more standardized and unified strategy to ensure everyone gets consistent and effective climate education [36].

One major focus of these policies is on supporting teachers. New Zealand, for example, places a big emphasis on teacher training and resources to ensure that educators are well-prepared to teach climate science effectively [19]. This support helps teachers feel confident and capable of engaging students on complex climate issues. Finland emphasizes experiential learning for teachers, which ties theoretical knowledge to practical application and helps them make climate education more meaningful and engaging for students [24]. Japan acknowledges there are gaps in this area, pointing out the need for more robust curricula and better teacher preparation to enhance the delivery of climate education [30]. Meanwhile, in South Africa, there are significant shortfalls in teacher knowledge and resources, indicating a real need for improved training and support to boost the quality of climate education [35].

How students engage with climate change varies from country to country too. In New Zealand, student-led climate strikes have had a noticeable impact on school policies, underlining the power of student involvement in climate issues [20]. Finland encourages students to think critically and get actively involved in climate-related activities through hands-on learning [24]. In Japan, while there is room for more practical climate education within schools, students are already quite active in raising public awareness and participating in climate action [31]. South African students also show a keen interest in climate issues but often lack opportunities for real-world engagement, suggesting a need for more interactive approaches to get them more involved [35].

Universities in these countries are crucial players in advancing climate change education. In New Zealand, universities incorporate sustainability into their operations and curricula, helping students grasp environmental challenges through both learning and institutional practices [22, 23]. Finnish higher education institutions go further by embedding sustainability into their missions and research, offering specialized courses on climate change to drive knowledge and solutions [25]. Japan's universities contribute to climate education through research and community outreach, but there's a need to better align with Education for Sustainable Development (ESD) goals to have a bigger impact [32]. South Africa's universities are also involved but face challenges, particularly in effectively implementing plans and aligning efforts with broader climate goals [39].

When it comes to policy implementation, each country faces unique challenges. In New Zealand, there is ongoing collaboration between policymakers, communities, and schools

to keep improving climate education policies and make them as effective as possible [19]. Finland is committed to sustainable development through policies that encourage integrated learning and real-world applications of climate education [8]. Japan, however, faces difficulties in aligning its educational and environmental strategies, suggesting the need for more coherent policies [33]. South Africa has policies in place, but their implementation is uneven, indicating a need for more equitable and effective strategies to ensure all students benefit from impactful climate education [36].

Pedagogical strategies for managing global warming issues in schools

By incorporating experiential learning opportunities into the curriculum, pedagogical strategies allow students to interact with global warming issues firsthand. These real-world encounters help students better understand and feel more connected to the subject matter by making the abstract ideas of climate science more relatable and tangible. The importance of empirical science education in improving climate change literacy is emphasized by Kumar et al. [40]. Students can interact directly with data and evidence when scientific experiments and observations are incorporated into the curriculum, which helps them comprehend the concrete effects of climate change on a deeper level. This method not only improves understanding but also fosters a sense of intimacy with the material. Favier et al. [41] state that improving pedagogical content knowledge about climate change should be a top priority for teacher training programs. This entails giving aspiring teachers the abilities and information required to explain intricate ideas in climate science and their ramifications. Teachers who are more proficient in this area can provide students with more accurate and interesting lessons on climate issues.

Tauritz [42] investigates methods for instructing students on how to deal with ambiguous information regarding sustainability issues. When faced with conflicting or incomplete information regarding climate change, students can navigate and make wise decisions by honing their critical thinking and problem-solving abilities. Promoting inquiry-based learning and having conversations about uncertainty with students aids in their development of resilience and adaptability. Hung [43] is in favour of an all-encompassing strategy for climate education that incorporates doing, knowing, and being. This entails fusing academic understanding with real-world application, as well as encouraging accountability and a sense of personal connection to climate issues. By implementing projects that motivate students to take part in neighbourhood environmental initiatives, schools can help students apply what they have learned to real-world situations.

The significance of teaching students about the wider social ramifications of climate change and equipping them to address future climate challenges is emphasized by Sabino [44] and Schreiner et al. [45]. Through incorporating social justice into environmental education and addressing the ways in which various communities are disproportionately impacted by climate change, students can gain a comprehensive understanding of climate

challenges. Students gain a sense of agency and environmental responsibility when they are involved in projects that let them suggest and test solutions for climate-related issues.

The significance of teaching about the global aspects of climate change is emphasized by Hicks and Holden [46]. This entails assisting students in realizing how interrelated all global systems are as well as our shared responsibility for addressing climate-related issues. By using case studies, encouraging international collaborations, and facilitating cross-cultural discussions, educators can help students gain a broader understanding of climate change. Tang [47] provides a case study on climate change education in China, highlighting the beneficial effects of this subject on students' attitudes and beliefs. Topics related to climate change are introduced to postsecondary students, providing them with the knowledge and abilities needed to comprehend and deal with these problems in the workplace. This method emphasizes how crucial it is for students to receive ongoing education on climate change throughout their academic careers.

It is clear that improving teacher preparation to explain difficult ideas, cultivating critical thinking abilities to handle ambiguous information, and increasing climate change literacy through practical scientific experiments are effective pedagogical approaches for addressing global warming in the classroom. Bringing together academic understanding with real-world application promotes accountability and a sense of connection to climate issues. Students gain the confidence to take on challenges through projects when they address the social implications of climate change. Instructing students on the worldwide aspects of climate change aids in their comprehension of interdependent systems and shared accountability. Students' views and attitudes are positively impacted by ongoing education about climate change, from early childhood education through postsecondary education, better equipping them for challenges ahead. Table 6 summarizes the pedagogical strategies for managing global warming issues in schools.

Table 6: pedagogical strategies for managing global warming issues in schools

Experiential Learning Opportunities	Authors Cited	Number of Articles	Percentage
Experiential Learning Opportunities	Hung (2022), Kumar et al. (2023)	2	15.4%
Empirical Science Education to Improve Climate Literacy	Kumar et al. (2023)	1	7.7%
Improving Pedagogical Content Knowledge for Teachers	Favier et al. (2021)	1	7.7%
Teaching Strategies to Handle Ambiguous Information and Critical Thinking	Tauritz (2019)	1	7.7%

Holistic Approach to Climate Education (Doing, Knowing, and Being)	Hung (2022)	1	7.7%
Integrating Social Justice into Climate Education and Addressing Disproportionate Impacts	Sabino (2024), Schreiner et al. (2005)	2	15.4%
Global Aspects of Climate Change Education	Hicks and Holden (2007)	1	7.7%
Case Study on Climate Change Education and Positive Impact on Student Attitudes	Tang (2023)	1	7.7%
Ongoing Climate Change Education Throughout Educational Careers	Tang (2023), Sabino (2024)	2	15.4%
Promoting Inquiry-Based Learning to Develop Resilience and Adaptability	Tauritz (2019)	1	7.7%

RECOMMENDATIONS

Based on the findings, the following recommendations can be made.

1. Governments should create and implement professional development initiatives to give educators the know-how and abilities they need to teach about climate change to students.

2. It is imperative that national curricula incorporate topics related to climate change into a variety of subjects and grade levels.

3. To obtain in-depth understanding, future research should examine teachers' viewpoints on climate change education, including their experiences, difficulties, and needs. Qualitative techniques like focus groups and interviews should be used to collect this data.

CONCLUSION

The examination of climate change education policies in South Africa, Finland, Japan, and New Zealand demonstrates different approaches and difficulties in incorporating climate education. Using a multidisciplinary approach, New Zealand integrates climate science into a range of subjects to provide a comprehensive understanding. Finland integrates climate-related topics into a wider context by concentrating on worldview transformation and sustainability education. Japan places a strong emphasis on mitigation and adaptation tactics, offering useful knowledge for dealing with climate-related issues. However, there is a lot of variation in South Africa's approach to integrating climate

education, which emphasizes the necessity for a standardized method to guarantee efficacy and consistency.

Resources and training for teachers are essential in these nations. In order to support effective climate education and make sure educators are well-prepared, New Zealand places a high priority on professional development and resource creation. Finland encourages experiential learning, tying together theoretical understanding and real-world application to effectively engage students. Japan understands that in order to improve the delivery of climate education, better teacher preparation programs and extensive curricula are required. There are significant gaps in South Africa's teacher resources and knowledge, which calls for enhanced training and assistance. The degree of student participation in climate initiatives varies; while Japan and South Africa require more practical applications, New Zealand and Finland exhibit strong student agency and participation. Higher education institutions play a vital role in integrating sustainability and climate change into core missions, curricula, and research, although challenges remain in aligning educational efforts with broader climate goals, particularly in South Africa.

Furthermore, it can be discovered that effective teacher preparation for conveying difficult ideas, the development of critical thinking abilities to handle ambiguous information, and the improvement of climate change literacy through practical scientific experiments are all examples of pedagogical strategies for addressing global warming in schools. Bringing together academic understanding with real-world application promotes accountability and a sense of connection to climate issues. Students gain the confidence to take on challenges through projects when they address the social implications of climate change. Instructing students on the worldwide aspects of climate change aids in their comprehension of interdependent systems and shared accountability. Students' views and attitudes are positively impacted by ongoing education about climate change, from early childhood education through postsecondary education, better equipping them for challenges ahead.

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CONFLICT OF INTERESTS

There is no conflict of interest associated with this study.

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