

IMPLEMENTATION OF TEACHER DEVELOPMENT PROGRAM FOR INTEGRATING CLIMATE CHANGE EDUCATION: NATURAL SCIENCES TEACHERS VIEW

Kayode OLAWUMI¹, Mzuyanda Percival MAVUSO², Xolani KHALO³, Babalwa KAFU-QUVANE⁴, Busiswa MZILIKAZI⁵

^{1,2,3,4,5}University of Fort Hare, South Africa

Corresponding author: Kayode OLAWUMI

E-mail: kayode.olawumi1969@gmail.com

Volume: 4

Number: 3

Page: 788 - 798

Article History:

Received: 2022-10-20

Revised: 2022-12-13

Accepted: 2023-01-17

Abstract:

The devastating effect of climate change (CC) on the environment worldwide has been a worrisome phenomenon. The effort by the government and other stakeholders to integrate climate change education (CCE) into the school curriculum in South Africa has not yielded the desired result because of the lack of teacher professional training programs for teaching CCE in the classroom. Using the pedagogical content knowledge (PCK) theory as lenses, this qualitative study investigated the implementation of the in-service teacher development programs and their role in enhancing the integration of CCE in Natural Sciences lessons. Five secondary schools out of twenty schools that participated in the in-service teacher training program conducted by one higher education institution (HEI) were purposely selected. Data for this study were generated through one-on-one semi-structured interviews with four participating Natural Sciences teachers at the selected schools. The data showed that implementing in-service teacher development programs helped Natural Sciences teachers integrate CCE into their lessons. The data also revealed that Natural Sciences teachers' content and pedagogical content knowledge on CC was lacking; thus, they were not adequately integrating CCE in their lessons. The study concludes that the teacher training programs are responsible for teacher improved the pedagogical practice of Natural Sciences teachers in the classroom and the integration of CCE. Therefore, the paper recommends that teacher professional development programs on CCE for Natural Sciences teachers be organized continuously.

Keywords: Pedagogical Content Knowledge, Climate Change Education, Pedagogical Practice, Professional Development Program, Secondary School.

Cite this as: OLAWUMI, K., MAVUSO, M.P., KHALO, X., KAFU-QUVANE, B. & MZILIKAZI, B. (2023). "Implementation Of Teacher Development Program For Integrating Climate Change Education: Natural Sciences Teachers View." *International Journal of Environmental, Sustainability, and Social Sciences*, 4 (3), 788 - 798.



INTRODUCTION

Over the years, the effect of CC on the environment worldwide has been alarming (Celik, 2020). Government and other organizations passionate about the environment are at different fora organized debates to find a lasting solution to the problem. Meetings and conferences were held by the head of government all over the world, politicians, educationists, environmentalists, and other professionals that are key to the implementation of policies on climate change to find solutions to the problems in a way that will make our environment suitable for habitation (Shields, 2019; Apollo & Mbah, 2021). The United Nations has identified education as one of the channels through which learners can be sensitized on the concept of climate change, the need to protect our environment from the havoc that can put it in danger, and how to adapt to the problem of CC

(Vigneswaran, Leelamani, Divya & Divya 2017). In response to this and the need to address the problem of CC, the South African government implemented the integration of CCE into the school curriculum across school subjects (Bush & Glover, 2016). This effort was targeted to educate learners on the havoc of climate change and measures that can be taken to mitigate and adapt to the problem. Molthan-Hill, Blaj-Ward, Mbah, and Ledley (2022) believe that this initiative by the South African government to integrate CCE into the school curriculum across subjects has yet to yield the desired result. Teachers responsible for teaching the subject need more content knowledge of CC, adaptation, and mitigation. However, for Natural Sciences teachers to effectively teach CCE in their classroom, they are expected to have a good mastery of the content knowledge of critical concepts like climate change, adaptation, mitigation, and pedagogical skills that will enable them to implement curriculum-aligned and locally relevant CCE.

The importance of professional development of teachers teaching CCE is critical to implementing curriculum-aligned and locally relevant CCE in the classroom (Shea, Mouza & Drewes 2016). Despite the critical role of professional development of teachers in the development of Natural Sciences teacher capacity to implement curriculum-aligned and locally relevant CCE, little effort has been made at improving understanding and preparedness to address CC in terms of research and development (Monroe, Plate, Oxarart, Bowers, & Chaves, 2019).

The integration of CCE on a subject-by-subject basis into the CAPS document is a welcome development by stakeholders in environmental education. However, more effort must be made to implement a professional teachers' program that will develop the capacity of teachers teaching CCE (Thenga, Goldschagg, Ferguson & Mandikonza 2020). It has been reported that teachers teaching CCE had inadequate content knowledge of CC, mitigation, and adaptation (ibid). Also, teachers needed to improve the pedagogical skill required for teaching CCE in the classroom (Raath & Hay, 2016) since CCE is a new knowledge area that was not part of their pre-service training (Patton, Parker & Tannehill, 2015). Hence, these skills can be acquired through continuous teacher professional development. More research needs to be done to provide appropriate strategies for Natural Sciences teachers to teach CCE in their classrooms (Shea, Mouza & Drewes 2016).

This gap is expected to be filled by the KIC-CCE project targeted at conducting continuous teacher professional development for selected teachers, developing and providing CCE materials for secondary schools' teachers and school leaders, and developing innovative curriculum-aligned CCE change projects involving teachers, students, and communities. The KIC-CCE initiative is a collaborative project between the Department of Basic Education (DBE), the Department of Forestry and Fisheries (DEFF), Higher Education Institutions (HEIs) that provide teacher education training, and four governmental organizations (NGOs) with experience in supporting in-service training for secondary school teachers in education for sustainable development such as Fundisa for change, GreenMatters, WESSA, and VVOB (Makute, 2021).

The nature of climate change. Different authors' definitions have been advanced to find a suitable definition for the concept of CC. The study of CC by scientists predated the industrial revolution when the world began to bring technology to production (IPCC, 2013), which was recently introduced into the school curriculum when the havoc on the environment and human existence became unbearable. The introduction of climate change education into classroom teaching is a welcome development. It has the potential to influence the behavior of learners with their environment and how they perceive the world around them (Wise, 2010).

Different authors have attempted to define CCE, given its devastating effect on the environment worldwide. In defining the climate, McKeown and Hopkins (2010), White, Wolf & Johnson-Maynard (2022) state that the climate part obviously falls under the umbrella of the

natural sciences and has traditionally been taught in geography (e.g., climatology) and earth science (e.g., meteorology). In an attempt to give an acceptable definition of CCE, the intergovernmental panel on climate change (IPCC, 2015) describes CC as noticeable and variable changes that occur in the environment over a long period. These changes are because human activities are detrimental to the environment and capable of causing havoc to human and animal lives. Anderson (2010) viewed CCE as an education that allowed people to act in a way that would positively impact their environment. It involves activities that will inculcate in the learner's positive attitudes, like lifestyles and economic and social activities that will reduce excessive production of greenhouse gases (ibid). Ferguson (2019) believed that CC is a complete alteration of the atmosphere's composition due to human activities that are detrimental to the environment. The practical CC knowledge does not preexist but instead develops in response to local issues and the questions generated by context-specific problems requiring "research" approaches that are context-sensitive. It is also consistent with the contextualized nature of the practicum periods in which students participate, as it provides a localized context with its issues and problems (McKeown & Hopkins, 2010).

Mitigating the effect of CC is an apparent reality we must learn to accept through our socio-economic relationship with our environment (Mochizuki & Bryan, 2015). It indicates that citizens should be informed of the concepts of CC and its effect on the environment for a sustainable environment. Governments at all levels should be at the forefront of creating awareness by integrating CCE into the school curriculum, from primary schools to higher learning institutions (Stevenson, Nicholls & Whitehouse, 2017). Anyanwu, Le Grange, and Beets (2015) are of the view that since CC is a global challenge that affects the entire world in which, governments all over the world have demonstrated a willingness to address it through various initiatives that will create awareness by integrating it into the school curriculum, effort should be made to ensure that teacher development programs are embedded into the school curricula at all level to develop strategies that will equip teachers to deal with the CCE in the classroom

In the view of Stevenson, Nicholls and Whitehouse (2017), CCE involves preparing young people for a rapidly changing, uncertain, risky, and possibly destructive future created by human activities. They expressed this view further that the goal of CCE is hinged on preparing learners for an uncertain future by helping them gain knowledge, skills, dispositions, and values that will enable them to deal with future challenges that may come their way in their environment. (ibid) further reveal that this can only be realized when a professional development program for CCE pre-service and in-service teachers provides them with content and pedagogical content knowledge needed for teaching and learning climate change education.

Climate change education and the need for teacher professional development program.

CCE is a new study area that came into the limelight because of the global changes causing havoc to the environment worldwide (Bodansky, Brunnée, & Rajamani, 2017). Researchers believed that teachers teaching CCE lack appropriate strategies to teach the subject in their classrooms since these strategies were not included in their pre-service training (Cebesoy, 2019; Competence, 2019). It is mainly due to the newness of CCE as a new knowledge area of study that is still fully integrated into the school curriculum at all levels of education. In South Africa, CCE has been integrated into the school curriculum subject by subject and taught in all subject areas (Vogel, Schwaibold, & Misser, 2015; Ndzimbomvu, Rampedi, & Kemp, 2021). However, there is a need to support teachers teaching CCE by providing teachers with a professional development program that will adequately equip them in classroom teaching. The dimension of CC keeps changing; therefore, efforts should be intensified to examine the implementation of the teacher development program to meet these changes.

Researchers are of the view that teachers are not integrating CCE in their classrooms Thenga et al., (2020), and learners are having difficulties learning CC because teachers were not adequately prepared due to inadequate professional development programs to cope with the requirement for effective teaching of the concept (Shea et al., 2016). (ibid) further reiterated that despite the importance of professional teacher development support for science teachers in capacitating them to teach the subject in their classroom, little or nothing had been published to date on teacher professional development approaches that teachers can use to teach CC in the classroom. Shea et al. (2016) are of the view that much research work has not been done in the area of CC teacher professional development; they suggested design of professional development into three core groups: (i) scientific content teachers are required to know; (ii) good scientific and pedagogical practices (i.e., what teachers need in order teach the content) and (iii) utilizing local examples in the environment that are familiar to the learners.

The role of the teacher in the CCE classroom is enormous. Teachers are expected to have a good mastery of the CC concept to deliver in the classroom effectively. Inadequate understanding and knowledge of the CCE concepts have been responsible for teachers' poor delivery of the subject in the classroom (Karami, Shobeiri & Jafari, 2017). In South Africa, it is still being determined if teachers adequately acquired the relevant knowledge and pedagogical skills required for teaching CC in the teacher development program. To answer this question, Anyanwu and Le Grange (2017) conducted a study that examined teachers' variables on the CC literacy of Geography teachers. The findings from the study reveal that characteristics such as age, gender, teaching experience, and teaching grade significantly influence the CC literacy of geography teachers. The study, however, recommended continuing teacher professional development to develop the capacity of Geography teachers to teach CCE in secondary schools adequately. The study also indicates that pre-service teachers need more knowledge and understanding of basic environmental concepts and their relevance to their teaching in the classroom (Guyen & Sulun, 2017). Teachers' inadequate knowledge of CC topics can pose a challenge to them while teaching in the classroom. The environment is not static and keeps changing, so the knowledge to be acquired by teachers also changes, meaning that what is true about the environment today may not be true tomorrow. Hence, Natural Sciences teachers are not adequately supported with a teacher professional development program that will assist them in integrating CCE into their teaching. They lack appropriate strategies that will enhance their knowledge of content and pedagogical content knowledge in the classroom, which this study intends to investigate.

Based on Shulman's (1986) Model of Pedagogical Reasoning, the expert and novice are compared. According to this model, teachers prepare for lessons by consulting the following sources: content knowledge, pedagogical content knowledge, curriculum knowledge, general pedagogical knowledge, knowledge of goals and purposes, knowledge of learners, and knowledge of educational contexts, settings, and governance. According to Shulman, three sources of understanding make the process of instructional reasoning and action possible. To make a subject topic "teachable," the model explains how a teacher must change their knowledge of it. The many knowledge sources are tapped during this transformation process, with pedagogical content knowledge being the most significant. The teacher differs from the subject matter expert in that they possess different knowledge and comprehension of their field. Learners' knowledge, general pedagogical knowledge, and pedagogical content knowledge are all foundations upon which pedagogical content knowledge is constructed (Gudmundsdottir & Shulman, 2006). The theory is suitable for the study in that it assists in explaining the effect of teachers' continuous professional development on pedagogical practice that will enhance

curriculum-aligned and locally relevant CCE in their classrooms. The theory stipulates that teachers must know the content and pedagogical content knowledge to integrate climate change education into their teaching.

This paper will focus on implementing the in-service teacher development program and its role in enhancing the integration of climate change education in Natural Sciences lessons. The study will be guided by the following questions: What are the views of Natural Sciences teachers on implementing in-service teacher professional development programs in South Africa? What is the perception of Natural Sciences teachers on integrating climate change education in their lessons? This study aims to establish how the Natural Sciences teachers were before the training program and how the training has enhanced the integration of climate change education in their lessons.

METHODS

The study being a case study design, adopted a qualitative approach. To answer the how and why of the research, case study research entails a thorough assessment of current events in a practical setting. It helps researchers concentrate on the subject (Creswell & Creswell, 2018). Five secondary schools from the Amathole West Education District, based on their geographical locations and proximity to the training provider, were selected for the study. These schools participated in the Keep-It-Cool Climate Change Education (KIC-CCE) training project run by one higher education institution. One Natural Sciences teacher was selected from each school. Four Natural Sciences teachers participated in the one-on-one semi-structured interview conducted by the researchers. The fifth teacher was involved in a labor-related issue and could not continue with the research. Pseudo-names were used for each participating teacher to protect their identity. Participating teachers were adequately informed about the purpose of the research, and they could opt out of the research at any time they wished. The researchers also sought the consent of the participants before the one-on-one semi-structured interview commenced. There was only one post-course interview session for each teacher to determine the level of teacher content and pedagogical knowledge of climate change education after the training program. The consent of the participating Natural Sciences teachers was sought before the interview session and recording of the proceedings. The thematic approach of coding, sorting, and transcribing was used in analyzing information collected from the participants for the study. The Keep-it-cool-Climate-change-education (KIC-CCE) initiative is a collaborative project between the Department of Basic Education (DBE), the Department of Forestry and Fisheries (DEFF), Higher Education Institutions (HEIs) that provide teacher education training, and four governmental organizations (NGOs) with experience in supporting in-service training for secondary school teachers in education for sustainable development.

RESULT AND DISCUSSION

For this research, findings are structured based on four cases that have been identified in the course of the analysis. The analysis includes four identified cases from the data collected from the KIC-CCE project. Four cases from the KIC-CCE data were analyzed to determine the causal mechanism responsible for the change observed in the pedagogical practice of the four Natural Sciences teachers.

Teachers' content and pedagogical knowledge before the training program. Before the training project, Natural Sciences teachers must focus more on teaching CC-related topics. The teachers were not aligning the teaching of CC with Natural Sciences in their lessons. Teacher A

commented: *"I cannot fix CC into Natural Science. I was teaching climate change education as part of natural science.*

The Natural Sciences teacher had a poor attitude toward teaching CC, which resulted in the learners' lack of interest. The teaching in the classroom was not meant to bring about curriculum alignment and locally relevant CCE. Also noted is a need for more material for assessing learners in the classroom. Teacher B noted: *"I did not show interest in CCE before the training. Students were not interested in CCE because they were not exposed to the concept. I did not have enough materials for assessment, and students were not interested in CCE"*.

Natural Sciences teachers interviewed have a challenge of inadequate teaching resources and poor attitudes toward teaching CCE. Natural Sciences teachers attested to the inadequate knowledge and understanding of CC concepts, which resulted in teaching without the proper foundations of CC. The pedagogical practices used by the Natural Sciences teachers were not appropriate for teaching CCE; they could not align the CC content to the subject. Teacher C noted: *"Before the project, I taught CC on the surface. I focused on teaching the content without linking it to the subject. I have a challenge in bringing the curriculum content to the learners' understanding."*

The Natural Sciences teacher needed to gain more knowledge of the CC concept, adequate educational resources, and appropriate teaching methods in the classroom. As a result, they could not link CC to CAPS in their lessons. Teacher D noted: *"I have little knowledge of CC, adaptation, and mitigation before the project... I am not aware that I have to link CAPS to CCE at all times"*.

It was also evident during the CCE training program that Natural Sciences teachers need to gain the required pedagogical skills to teach CC. Also noted from our observation is that Natural Sciences teachers needed to have the content knowledge of CC, adaptation, and mitigation. The Natural Sciences teachers reported that they were unable to link the CAPS principles in their lessons. Furthermore, these teachers indicated they needed more educational resources for teaching CC in their classrooms before the training project. It indicated that Natural Sciences teachers viewed the provision of teaching and learning materials as key to incorporating CC in their lessons.

Role of the professional teacher development program in enhancing the integration of CCE in Natural Sciences teaching. The training program was conducted by one educational institution in the Eastern Cape, and educational resources/materials support was received by Natural sciences teachers. The training and the educational materials support were adjudged by the four Natural Science teachers as adequate and have brought about improved performance in the classroom. One teacher C specifically reported that: *"...I have improved my CCE content knowledge through the educational material/resources, improve my CCE lesson plan, teaching method, and lesson planning through the material/resources. The training also assisted me in using examples in the school environment that are relevant to my teaching in the classroom..."* (Teacher C).

Natural Sciences teachers reported that the training program had exposed them to a curriculum-aligned and locally relevant CCE. It was reflected in the reported development of appropriate pedagogical skills responsible for teaching CC effectively in the classroom. Natural Sciences teachers commended the training program received as all-inclusive and enhanced their performance in their classroom. The four Natural Sciences teachers all supported the claim that the project intervention (CCE project) contributed immensely to improving their pedagogical practice in the classroom. The KIC-CCE program and the educational materials were responsible for the change in the teaching and learning of CCE. The success rate of the KIC-CCE training program was adjudged to be very high by the Natural Science teachers. Teacher B noted: *"...I now use more relevant CCE educational material, teach learners to understand real-life climate change issues, help students develop CCA and Mitigation solutions, and integrate CCE better in my Natural Sciences class. My*

students can now apply the CC concept in tackling real-life issues affecting men and women in the school community. Above all, the intervention has helped me to change my teaching strategies in the classroom...." (Teacher D)

Natural Sciences teachers' understanding of CC, adaptation and mitigation had reportedly improved because of the training support program provided by one higher education institution in Eastern Cape. The content and pedagogical knowledge of the Natural Sciences teachers to teach climate change in their classrooms has improved due to the training support program. It is in line with findings from the literature that continuous professional development of Natural Sciences teachers can enhance their content and pedagogical knowledge to teach climate change in their lessons. Teacher C said, *"I received curriculum-aligned and locally relevant CCE training. Now I use local examples in the school environment and community where the school is located to teach my learners in the classroom. This strategy enhances their understanding of CC topics in the geography lessons"*. (Teacher C). Another teacher said: *"I have improved my knowledge of CC, adaptation and mitigation through CC education... my pedagogical practice has also improved after the training workshop"*. (Teacher A).

The researchers also observed from the support visit that the training program had increased the skills of the Natural Sciences teachers in the classroom. It was an indication that the training program is one of the causal mechanisms that were responsible for the improvement in the capacity of the Natural Sciences teachers to teach CCE in the classroom.

Project implementation and teacher enhancement improve pedagogical practice. Findings from the analysis reveal that most of the participating Geography teachers that attended the training program now use more locally relevant and scientific content to teach climate change in their lessons. It emerged from the data analysis that the training program has enhanced the capacity of the Natural Sciences teacher to teach climate change. The participating Natural Sciences teachers reported that the training program had enhanced their capacity to understand and deal with real-life issues about CCE in their school community. The Natural Sciences teachers that attended the training program have improved their capacity to teach CC concepts like mitigation and adaptation. Also emerged from the analysis is that Natural Sciences teachers attend the PLCs meeting, which has assisted them in enhancing their pedagogical practice. Unlike before the training project, the data reveals that Natural Science teaches CC effectively and uses a local environment that learners are familiar with. Another teacher said: *"I participated in the PLCs meeting ... the meeting enhanced my pedagogical knowledge and practice in the CC classroom"*. Teacher C said, *"I have been participating in the PLCs meeting, unlike other school teachers....the PLCs meeting is an effective space and process for improving my pedagogical practice."*

The capacitation of Natural Sciences teachers in terms of developing their content knowledge and pedagogical skill in a way that will bring about curriculum-align and practical locally relevant examples have received limited attention from stakeholders and indeed government. The data collected indicates that the four Natural Sciences teachers have little knowledge of climate change education and lack the required pedagogical skills to help them teach it in their classrooms before the KIC-CCE training project. Another finding from the analysis reveals that Natural Sciences teachers do not take climate change education seriously before the KIC-CCE training project. It indicates that Natural Sciences teachers' attitudes also contributed to their poor performance in the classrooms. The situation before the training project requires urgent attention, which the KIC-CCE training project was designed to address. Also, results from the data analysis show that Natural Sciences teachers that participated in the study do not have professional training that will enable them to teach topics on climate change education in their classrooms. This position aligns with prior literature and the views of Vogel et al. (2015); Ndzimbomvu et al. (2021), which emphasized that teachers need continuous professional development programs to enable them to develop

climate change content knowledge and pedagogical skills to teach the topics in their lessons. However, Thenga et al. (2020) emphasize that to teach climate change education effectively, the Department of Basic Education should, as a matter of priority, implement a periodic CPTD program that will capacitate Natural Sciences teachers to teach climate change in secondary schools in South Africa. It becomes imperative given the findings, which reveal that the majority of the Natural Sciences teachers, after the training, could effectively teach CC concepts like adaptation and mitigation in the Natural Sciences classroom. According to them, they should be part of the pre-service teachers' program in the Universities and for serving teachers continuously. It is essential going by the result of findings that reveal that Natural Sciences teachers need more content knowledge of climate change education before the KIC-CCE project. The KIC-CCE training by one University in the Eastern Cape was utilized by the Natural Sciences teachers responsible for teaching climate change education in the classroom. The training project provided by the KIC-CCE project was responsible for the change observed in the Natural Sciences teachers' knowledge of climate change concepts, as indicated in the result of the findings. This training program and educational resources/materials provided by the KIC-CCE project assisted Natural Sciences teachers in integrating climate change education into their teaching by utilizing locally relevant examples in their communities.

Natural Sciences teachers that participated in the KIC-CCE training project improved their lesson planning technique, content knowledge, and teaching method because of the training and the educational materials/resources support they received from the project. This position aligns with the view Shulman (1996) expressed. According to the theory, teachers prepare for lessons by consulting the following sources: content knowledge, pedagogical content knowledge, curriculum knowledge, general pedagogical knowledge, knowledge of goals and purposes, knowledge of learners, and knowledge of educational contexts, settings, and governance. This theory has opened our understanding to develop pedagogical content knowledge in Natural Sciences teaching. Teachers must prepare for their lessons before going to the classroom. It has made it possible for teachers to integrate climate change education into their teaching in the classroom. Apart from this, teachers can utilize examples relevant to their local environment in their teaching in the classroom. It can only be achieved with the training project organized by one HEI in the Eastern Cape. This assertion also showed that the KIC-CCE training project CPTD provided by one Higher Institution (H.I.) in the Eastern Cape was responsible for the improved pedagogical practice of the Natural Sciences teachers that participated in the training to integrate climate change education in their classrooms. These results from the data analyzed above indicate that implementing the CPTD is an important causal mechanism for teachers' improved teaching practice, particularly in integrating climate change education topics into their Natural Sciences classroom using locally relevant examples in their environment.

CONCLUSION

The findings reveal that Natural Sciences teachers were teaching climate change without recourse to any strategy. Most of these teachers were found to need more content knowledge of climate change concepts and, as such, could not effectively teach the topic in their lessons. Also noted from the findings is the need for more training support for teachers, especially Natural Sciences teachers, in discharging their duties in the classroom. Lack of training has affected these teachers to effectively align the curriculum and use locally relevant and practical examples while teaching climate change education in their lessons. The paper concludes that Natural Sciences teachers needed more content knowledge, lesson planning skills, and teaching methods before the training program, affecting their classroom teaching. It means that the training programs were

responsible for the improved pedagogical practice of Natural Sciences teachers in the classroom. Therefore, the paper recommends that continuous professional teacher development programs on Climate Change Education for Natural Sciences teachers be organized continuously. CCE should also be adequately integrated into the teacher education pre-service programs. HEIs, the Department of Higher Education and Training, and the Department of Basic Education should collaborate to see how to integrate CPTD programs for climate change education into the University curriculum.

REFERENCES

- Anderson, A. (2010). Combating climate change through quality education. Retrieved from <https://www.brookings.edu/research/combating-climate-change-through-quality-education/>
- Anyanwu, R., Le Grange, L., & Beets, P. (2015). Climate change science: The literacy of geography teachers in the Western Cape Province, South Africa. *South African Journal of Education*, 35(3), 1-9. <https://doi.org/10.15700/saje.v35n3a1102>
- Apollo, A., & Mbah, M. F. (2021). Challenges and opportunities for climate change education (CCE) in East Africa: A critical review. *Climate*, 9(6), 93. <https://doi.org/10.3390/cli9060093>
- Bodansky, D., Brunnée, J., & Rajamani, L. (2017). *International climate change law*. Oxford University Press.
- Bush, T., & Glover, D. (2016). School leadership and management in South Africa: Findings from a systematic literature review. *International Journal of Educational Management*, 30(7), 1257-1272. <https://doi.org/10.1108/IJEM-05-2015-0080>
- Cebesoy, Ü. B. (2019). Pre-service teachers' opinions about a two-day climate change education workshop. *International Research in Geographical and Environmental Education*, 28(3), 211-227. <https://doi.org/10.1080/10382046.2019.1589506>
- Celik, S. (2020). The effects of climate change on human behaviors. In A. Menafoglio & D. A. Lazzari (Eds.), *Environment, climate, plant and vegetation growth* (pp. 577-589). Springer. https://doi.org/10.1007/978-3-030-14384-5_33
- Chang, R. (2016). Climate change education in the K-12 curriculum: Methods and assessment. *Journal of Environmental Studies and Sciences*, 6(2), 205-212.
- Competente, R. J. T. (2019). Pre-service teachers' inclusion of climate change education. *International Journal of Evaluation and Research in Education*, 8(1), 119-126. <https://doi.org/10.11591/ijere.v8i1.14695>
- Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage.
- Ferguson, T. (2019). Climate change education for sustainable development. In W. Leal Filho (Ed.), *Encyclopedia of sustainability in higher education* (pp. 1-10). Springer. https://doi.org/10.1007/978-3-319-63951-2_130-1
- Garrow, E. E., & McNamara, K. E. (2016). Climate change education: Student media coverage of an emerging environmental issue. *Applied Environmental Education & Communication*, 15(3), 173-182.
- Gudmundsdottir, S., & Shulman, L. (1987). Pedagogical content knowledge in social studies. *Scandinavian Journal of Educational Research*, 31(2), 59-70. <https://doi.org/10.1080/0031383870310201>
- Güven, G., & Sulun, Y. (2017). Pre-service teachers' knowledge and awareness about renewable energy. *Renewable and Sustainable Energy Reviews*, 80, 663-668. <https://doi.org/10.1016/j.rser.2017.05.250>

- Intergovernmental Panel on Climate Change [IPCC]. (2013). Climate change 2013: The physical science basis. In T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, & P.M. Midgley (Eds.), Contribution of working group I to the fifth assessment report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom, and New York, NY: Cambridge University Press. <http://www.climatechange2013.org/report/fullreport/>
- IPCC. (2013). Climate change 2013: The physical science basis. In T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (Eds.), Contribution of working group I to the fifth assessment report of the intergovernmental panel on climate change. Cambridge, United Kingdom, and New York, NY: Cambridge University Press. Retrieved from <http://www.climatechange2013.org/report/fullreport/>
- IPCC. (2015). Future work of the IPCC: Consideration of the recommendations by the task group on the Future Work of the IPCC. Geneva.
- Karami, S., Shobeiri, S. M., & Jafari, H. (2017). Assessment of knowledge, attitudes, and practices (KAP) towards climate change education (CCE) among lower secondary teachers in Tehran, Iran. *International Journal of Climate Change Strategies and Management*, 9(5), 628-647. <https://doi.org/10.1108/IJCCSM-12-2015-0196>
- McKeown, R., & Hopkins, C. (2010). Rethinking climate change education. *Green Teacher*, (89), pp. 17-21.
- Mochizuki, Y., & Bryan, A. (2015). Climate change education in the context of education for sustainable development: Rationale and principles. *Journal of Education for Sustainable Development*, 9(1), 77-90. <https://doi.org/10.1177/0973408215571512>
- Molthan-Hill, P., Blaj-Ward, L., Mbah, M. F., & Ledley, T. S. (2022). Climate change education at universities: Relevance and strategies for every discipline. In W. Leal Filho, L. Brandli, P. Castro, & A. Borges de Lima (Eds.), *Handbook of climate change mitigation and adaptation* (pp. 3395-3457). Springer International Publishing. https://doi.org/10.1007/978-3-030-78106-3_198
- Monroe, M. C., Plate, R. R., Oxarart, A., Bowers, A., & Chaves, W. A. (2019). Identifying effective climate change education strategies: A systematic review of the research. *Environmental Education Research*, 25(6), 791-812. <https://doi.org/10.1080/13504622.2018.1443798>
- Ndzimbomvu, N. T., Rampedi, I. T., & Kemp, M. E. (2021). Learning environmental issues from a secondary school curriculum: The case of learners in Mamelodi Township, South Africa. *Sustainability*, 13(16), 9149. <https://doi.org/10.3390/su13169149>
- Patton, K., Parker, M., & Tannehill, D. (2015). Helping teachers help themselves: Professional development that makes a difference. *NASSP Bulletin*, 99(1), 26-42. <https://doi.org/10.1177/0192636515605769>
- Patton, K., Parker, M., & Tannehill, D. (2015). Helping teachers help themselves: Professional development that makes a difference. *NASSP Bulletin*, 99(1), 26-42.
- Raath, S., & Hay, A. (2016). Self-efficacy: A South African case study on teachers' commitment to integrating climate change resilience into their teaching practices. *Cogent Education*, 3(1), 1264698.
- Shea, N. A., Mouza, C., & Drewes, A. (2016). Climate change professional development: Design, implementation, and initial outcomes on teacher learning, practice, and student beliefs. *Journal of Science Teacher Education*. 27(3), 235-258.

- Shields, R. (2019). The sustainability of international higher education: Student mobility and global climate change. *Journal of Cleaner Production*, pp. 217, 594–602. <https://doi.org/10.1016/j.jclepro.2019.01.117>
- Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4-14. <https://doi.org/10.3102/0013189X015002004>
- Stevenson, R. B., Nicholls, J., & Whitehouse, H. (2017). What is climate change education? Springer, pp. 67–71. https://doi.org/10.1007/978-3-319-56020-2_11
- Talcott, F., & Scholz, V. (2015). Methodology guide to process tracing for Christian Aid. The International Non-Governmental Training and Research Centre.
- Thenga, M., Goldschagg, P., Ferguson, R., & Mandikonza, C. (2020). Teacher professional development and geography teachers' pedagogical practices for climate change education. *Southern African Journal of Environmental Education*, 36. <https://doi.org/10.4314/sajee.v36i1.9>
- Vigneswaran, S., Leelamani, A., Divya, S., & Divya, K. (2017). Communicating climate change importance through an interactive multimedia framework for promoting education and effective public awareness of climate change. *International Journal of Applied Environmental Sciences*, 12(3), 409–420. <https://doi.org/10.14500/ijae.v12.3.16855>
- Vogel, C., Schwaibold, U., & Misser, S. (2015). Teaching and learning for climate change – The role of teacher materials and curriculum design in South Africa. *Southern African Journal of Environmental Education*, 31, 78-97. eISSN:2411-5959.
- White, P. T., Wolf, K. J., & Johnson-Maynard, J. (2022). Changes in teacher attitudes relating to climate science. *Natural Sciences Education*, 51(2), e20086. <https://doi.org/10.4195/nse2021.07.0086>
- Wise, S. B. (2010). Climate change in the classroom: Patterns, motivations, and barriers to instruction among Colorado science teachers. *Journal of Geoscience Education*, pp. 58, 297–309. <https://doi.org/10.5408/1.3533616>