



CLIMATE EDUCATION: A GRAND CHALLENGE

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Climate change and its mitigation represent a major global challenge, alongside biodiversity loss, global pandemics, and shortages of fresh water and food. It has the power to shape the environment and future; however, policymakers seek to prevent undesirable changes through environmental and education policies. Hinesjeffrey et al. (2013) consider climate education to be a major challenge. For example, the mitigation of climate change requires an understanding of climate change as a multidisciplinary phenomenon that must be considered in addition to the natural sciences, at least from the perspective of the social sciences, engineering, economics and education. This mitigation requires individuals to have a wide range of competences, such as creative and critical thinking and socioemotional skills (Hestness, 2015).

The basic phenomenon in climate education can be described as the slow rise in average temperature across the globe. This slow rise causes various changes in the atmosphere, in the ground, and in the seas, which causes changes in 'average' weather or climate in different areas of the globe. In some areas, dry seasons grow longer and more intense, while in others, rains and storms increase. This is referred to as climate change (IPCC, 2018). The reason for the slow rise in the average temperature globally is the increase in greenhouse gases, such as carbon dioxide and methane. This increase in greenhouse gases is strengthening the greenhouse effect, with the result that the average global temperature is rising slowly. The greenhouse effect itself is important, and without it, plants and animals would die. The increase in greenhouse gases comes mainly from the burning of fossil fuels used to produce energy, as well as other human activities such as logging, agriculture and the production of raw materials such as steel and concrete. Climate education aims to support students in understanding the basic phenomena related to climate change, the reasons or models behind the phenomena and approaches for mitigating climate change.

The teaching of climate change is emphasised in curriculum documents, but it is difficult to teach and learn and not necessarily engaging for young people because of its interdisciplinary, multifaceted, complex—and frankly intimidating—nature. A special challenge is based on the fact that teaching climate change typically aims to influence students' behaviour. Therefore, the teaching and learning of climate change and its mitigation require reformed pedagogical approaches and improvements in teacher education (Hestness et al., 2015).

Stratton et al. (2015) recognised four teacher-related challenges in making progress in teaching and learning climate change. First, in many countries, there is a lack of competent science teachers, especially teachers



who have qualifications in physics. Second, science teachers lack knowledge related to climate change and pedagogical competences, especially in lab conditions and in the teaching and learning of values, ethics and socioscientific issues in the context of teaching climate change. Third, teachers need to participate only a few days per year in professional learning activities, and climate change has been emphasised for a short time in initial science teacher education. Consequently, educating science teachers to teach climate change requires a new paradigm for the preparation of science teachers. It will require a new teacher education curriculum that addresses the social purposes of science education in the context of uncertainty and change.

Several researchers, such as Stratton et al. (2015), have outlined the general characteristics of climate education. Researchers have also suggested specific models for climate education, such as Cantell et al. (2019), who suggested a climate education 'bicycle model'. The model emphasises the importance of the following aspects in climate education: climate-related knowledge, thinking skills, values, identity, worldview, action, motivation, participation, future orientation, hope and other emotions and operational barriers. I introduce the next two climate education-related reviews, which recommend promising learning project types as solutions to climate education.

Rousell et al. (2020) applied a systematic literature review to analyse climate education research from 1993 to 2014. The review indicated that young people's understanding of climate change is generally limited, erroneous and highly influenced by media. Second, pedagogical approaches to climate education appear to be largely ineffective in affecting students' attitudes and behaviour. The review identifies the need for participatory, interdisciplinary, creative and affect-driven approaches to climate education, which are largely missing from the literature. The authors call for new forms of climate education that directly involve young people in responding to the scientific, social, ethical and political complexities of climate change. Project-based learning could be such a new form because it guides students to ask relevant questions related to the complex phenomenon, critically search for information, for example, on the internet according to the questions and then analyse and present this information in a way it can be applied in different situations.

Jorgenson et al. (2019) recommend, based on their systematic review, that environmental educators and researchers work together to develop and adopt innovations that save energy and raw materials. Here, too, project-based learning can serve as a pedagogical frame. In this case, the starting point for working and learning is a challenge or problem, which is addressed by finding ideas, making prototypes and evaluating these ideas and prototypes. The end result of this work, too, is knowledge or a new way of working to solve environmental problems.

In summary, science teachers need to have extensive subject matter and multidisciplinary knowledge related to climate change and pedagogical content to design high-quality climate education that addresses the complex nature of climate change and influence students' attitudes and actions. In practice, teachers should use versatile pedagogical approaches, such as project-based learning, in climate education.

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