

# Teachers' Professional Competencies in Climate Change Education: A Systematic Review

Julia Ellinghoven<sup>a</sup>, Monika Martin<sup>b</sup>, Hendrik Lohse-Bossenz<sup>a</sup>, Marisa Holzapfel<sup>a</sup>, Andrea Westphal<sup>a</sup>

<sup>a</sup>Universität Greifswald, <sup>b</sup>Pädagogische Hochschule Freiburg

UNIVERSITÄT GREIFSWALD  
Wissen lockt. Seit 1456



## Introduction

Tackling climate change is one of the most pressing challenges faced by societies worldwide. Climate change education (CCE) is therefore of great importance and should be integrated into schools. CCE offers the potential to enlighten future generations about climate change, develop climate literacy skills and promote climate friendly behavior (Khalidi & Ramsey, 2021). The quality and effectiveness of teaching depend on the teachers' competencies (Kunter et al., 2013). In the context of climate change education, it is crucial to specify these skills and examine their effectiveness. The research landscape of CCE is criticized for a lack of connection to established frameworks in educational research (Gräsel et al., 2013). In order to fill this gap, this study aims to map the constructs addressed in CCE research on the COACTIV framework. The study therefore addresses the following research questions:

- RQ1: Which professional characteristics of teachers as conceptualized in the COACTIV have been investigated in the climate change education literature?  
 RQ2: How can intervention programs promote these characteristics?  
 RQ3: To what extent are these professional characteristics associated with instructional quality in climate change education and with student learning outcomes?

## Method

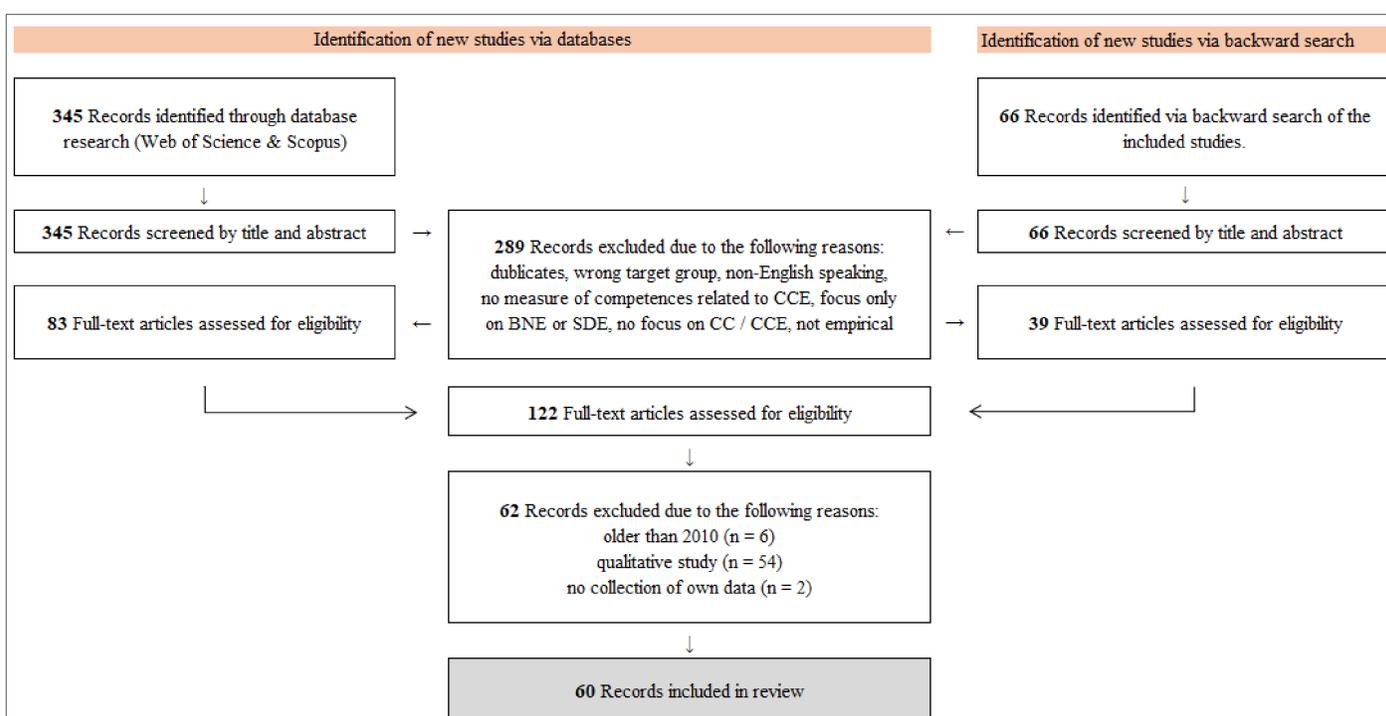


Figure 1: PRISMA chart: search and inclusion overview.

This study employed a multi-stage approach to identify and summarize the competencies of pre-service and in-service teachers in the field of climate change education (CCE) that have been examined in the research literature. After a comprehensive search in Web of Science and Scopus (2025), a hybrid AI (Notebook-LM) and manual screening process was performed. We included empirical studies that focused explicitly on CCE, examined teachers' competencies, used a quantitative design, were published from 2010 onwards, and were written in English. First, a prompt was developed and refined using a test dataset of 25 papers, after which the AI initially coded all study abstracts in two runs. In cases where AI yielded divergent results across the two runs, a third round of human coding was performed by one of the co-authors (Cohen's  $\kappa = 0.790$ ). If there were differences between the AI and the co-author, a further coding was carried out by another researcher (Cohen's  $\kappa = 0.783$ ).

The procedure was repeated for the backward search. 60 studies met the inclusion criteria and were included in the final analysis. To answer the research questions, Data extraction was conducted systematically using a pre-developed data extraction form. A deductive-inductive approach was utilized for RQ1 by assigning competencies to the Coactive Model.

## Results & Discussion

Competence dimension	Competence area	Competence facet	Number of studies
Professional Knowledge	content knowledge	content knowledge on CC	35
	pedagogical content knowledge	ped. content knowledge on teaching CC	9
Values and Beliefs	subjective theories, beliefs, attitudes and values	subjective theories, beliefs, attitudes and values toward CC	34
		subjective theories, beliefs, attitudes and values toward teaching CC	12
Motivational orientations	self-efficacy	Climate Change Self-Efficacy	6
		self-efficacy for teaching CC	13
	enthusiasm	enthusiasm for the topic of CC	1
		enthusiasm for teaching CC	0
Self-regulation	resilience	Experiencing and regulating emotions triggered by CC	8
		emotions towards and while teaching CC	1

Table 1. Competence dimension, areas and facets found in the studies included in our review.

### Professional competencies investigated in CCE literature (RQ1)

Most studies examine the content knowledge that is relevant for teaching ( $n = 35$ ), followed by subjective theories, beliefs, attitudes, and values regarding climate change ( $n = 34$ ) as well as self-efficacy for teaching CC ( $n = 13$ ). Emotions related to CCE, enthusiasm for the subject, and enthusiasm for teaching the subject were investigated least frequently.

### Outlook on RQ2 and RQ3

Results addressing RQ2 and RQ3 are not yet finalized. To answer the research questions, the necessary information (e.g., independent and dependent variables, results, etc.) is being extracted from the studies with regard to the questions. So far, it has become apparent that only a few studies examine intervention programs potentially promoting these professional competencies ( $n = 16$ ). Only a small number of studies ( $n = 5$ ) investigate how professional characteristics are related to teaching quality in the field of climate change and to students' learning outcomes.

Our review provides initial indications of competencies that seem to be relevant for effective Climate Change Education (CCE) and situates them within an established teacher competence framework. However, given the still limited number of primary studies, further empirical research is needed to consolidate and refine this emerging profile and to inform teacher education and professional development in a more comprehensive way.

### References

- Gräsel, C., Bormann, I., Schütte, K., Trempler, K. & Fischbach, R. (2013). Outlook on Research in Education for Sustainable Development. *Policy Futures in Education*, 11(2), 115–127. <https://doi.org/10.2304/pfie.2013.11.2.115>  
 Khalidi, R. & Ramsey, J. (2020). A comparison of California and Texas secondary science teachers' perceptions of climate change. *Environmental Education Research*, 27(5), 669–686. <https://doi.org/10.1080/13504622.2020.1838447>  
 Kunter, M., Klusmann, U., Baumert, J., Richter, D., Voss, T. & Hachfeld, A. (2013). Professional competence of teachers: Effects on instructional quality and student development. *Journal Of Educational Psychology*, 105(3), 805–820. <https://doi.org/10.1037/a0032583>