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# GeoCapabilities Approach to Climate Change Education: Developing an Epistemic Model for Geographical Thinking

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## ABSTRACT

Multiple perspectives on geographical thinking are lacking in the teaching of climate change in school geography. This study establishes an epistemic model through a co-construction design to support geography teachers' curriculum making with respect to climate change. We developed the preliminary model with four main geographical perspectives, including natural scientific, humanistic, social scientific, and posthuman perspectives, by drawing on studies in academic geography. Based on interviews with nine geography education researchers who have been involved in the GeoCapabilities project, we examined the educational potentials of multiple geographical perspectives in developing student's capabilities to react to climate change.

## KEYWORDS

Geographical thinking; climate change; epistemic model; GeoCapabilities



## Introduction

As climate change has become a pressing global environmental crisis, school education is increasingly focusing on how best to transmit relevant knowledge to the next generation in a way that encourages young people to engage with the issue. However, recent research has shown that young people's understanding of climate change may be deficient (Rousell and Cutter-Mackenzie-Knowles 2020) and thus ineffectively affect their attitudes and behaviors (Stoeth and Carter 2022). Possible reasons concern the narrowness of climate change education as well as teachers' insufficient understanding of the issue, both of which relate climate change mainly to the natural sciences (Cantell et al. 2019). To unpack the complexity of the issue and evoke learners' values and actions, researchers are increasingly emphasizing the need to include insights from the social sciences and humanities as part of a cross-disciplinary approach to climate change education (Siegener and Stapert 2020; Sund and Gericke 2020). Given that school geography is one of the main channels to teach climate change, this article calls for an appreciation of the multi-perspective capacity of geographical thinking to provide students with a more comprehensive understanding of climate change.

Geography is a field of study with a specific focus on human-environmental relationships that uniquely straddles the divide between the natural, human, and social sciences, thus offering the possibility to provide a more holistic approach to understanding climate change (Taylor and O'Keefe 2021). For this reason, the teaching of climate change is often associated with geography education in many countries (e.g., Singapore, see Chang and Pascua 2017a; Finland, see Tani 2022). However, scholars have argued that

teachers do not have enough awareness of many possible geographical perspectives, causing them to mainly highlight climate change as a physical geographical term (Cantell et al. 2019; Waldron et al. 2019). Furthermore, despite receiving more attention, pre- and in-service teachers can still misunderstand the natural scientific processes of climate change (Papadimitriou 2004; Ratinen, Viiri, and Lehesvuori 2013). Due to the crucial role played by teachers as curriculum makers, their understanding of climate change impacts their potential to develop students' capabilities to think critically about the changing human-environmental relationship and assume a greater sense of environmental and global responsibility (Lambert, Solem, and Tani 2015). Therefore, it is important to enhance teachers' geographical thinking to better support their curriculum making (Mitchell et al. 2022).

Developing teachers' geographical thinking not only includes helping them make sense of geographical thinking, but also includes knowing how geographical thinking can contribute to young people's development. Many recent efforts have focused on supporting geography teaching by emphasizing a conceptual understanding of geographical topics (e.g., Jankell, Sandahl, and Örbring 2021; Maude 2022; Mitchell 2022). However, little research attention has been paid to the multiple geographical perspectives that underpin and shape a comprehensive understanding of various geographical concepts and issues. To fill this research gap and discuss teachers' curriculum making in relation to the specific topic of climate change, the main aims of this study are twofold: first, unpacking the multiple perspectives of geographical thinking on climate change through developing an epistemic model; and second, exploring the educational

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potential of the geographical perspectives by gaining insights from the experts involved in the GeoCapabilities project (Lambert, Solem, and Tani 2015).

In the following section, we begin with a literature review of multi-perspective geographical thinking, the ideas informing the GeoCapabilities approach, and prior studies on climate change as a topic of focus in geography education. We then establish a preliminary model for thinking about climate change geographically *via* four main geographical perspectives, by drawing on studies on the human-environmental relationship in the field of academic geography. After introducing the co-construction design used to develop the model, we discuss the interviews conducted with researchers for examining the model. In addition to explaining the contributions of multi-perspective geographical thinking to the development of young people's capabilities in responding to climate change, this study supports geography teachers in curriculum making by providing an epistemic model for presenting a holistic geographical approach.

## Literature review

### ***Geographical thinking on climate change: The potential of multiple perspectives***

Geography offers a powerful way of thinking about the world, derived from its integrated approach, broad theme of study, and rich conceptual understanding (Morgan 2013). In bridging between natural, human, and social sciences, geography studies the relationship between people and the environment, which has been central to the history of geographical thought despite the paradigm shifts and different schools of thought that have emerged over the years (Cresswell 2013). The integrated nature of geographical thinking enriches possibilities to understand such key concepts as *space*, *place*, *scale*, and *environment* (Morgan 2013). For instance, Freeman and Morgan (2014) have argued that a proper balance of natural scientific (focus on spatial and objective aspects with a positivist approach), humanistic (focus on individual, personal, subjective aspects), and social scientific (focus on socio-political processes) perspectives can offer teachers a better way to inform students about the concept of *place*. Likewise, various epistemological perspectives can shape a holistic understanding among students of the *human-environmental relationship* as a key concept as well as a core component of geography (Holt-Jensen 2018). Apart from the three basic perspectives, another emerging stream of thought—the posthuman perspective—has made a productive contribution to current geographical studies by challenging and shifting the previous anthropocentric perspectives to a focus on more-than-human agency in thinking about the human-environmental relationship (Falcon 2023; Greenhough 2014; Miele and Bear 2022).

The synthesis of diverse perspectives places geography fruitfully at the center of human-environmental issues, in particular climate change (Taylor and O'Keefe 2021). In addition to seeing climate change as in physical geography, geographers connect climate change with social processes and cultural meanings across different scales (Finn 2021).

The various ways of geographical thinking can provide teachers with abundant resources to instruct students about climate change, which is an important topic in school geography. However, in light of the knowledge transformation from academic discipline to school subject (Deng 2021), it is necessary to know what kinds of geographical perspectives can best be adapted to school teaching in a way that matches educational purposes, which serves as the starting point for this study. It should be acknowledged that definitions vary greatly regarding educational aims in different contexts. In this study, we do not try to downplay the differences and propose a universal scheme of incorporating certain types of geographical perspectives into school teaching. Instead, we discuss the educational potential of plural geographical perspectives, which can shed light on what knowledge to select and present to students when school geography teachers engage in curriculum making on the topic of climate change.

### ***GeoCapabilities approach: Unpacking the educational contribution of geographical thinking through teachers' curriculum making***

In focusing on climate change as an issue in geography education, we apply the ideas of GeoCapabilities, which is an approach used to explore the contribution that geography education offers for young people's development. Applying Amartya Sen and Martha Nussbaum's educational capabilities framework (Nussbaum 2013; Nussbaum and Sen 1993), the GeoCapabilities approach focuses on the educational outcomes that young people can be and do in order to live and thrive in the future (Lambert, Solem, and Tani 2015; Mitchell 2022). Furthermore, the GeoCapabilities approach, which is also informed by Michael Young and Johan Muller's theory of powerful knowledge (Young 2009; Young and Muller 2014), emphasizes the significant role of geographical knowledge in the development of human capabilities. Based on a social realist approach to knowledge, its proponents argue that the disciplinary knowledge produced and validated by specialized communities is powerful because of its very characteristics (striving for objectivity, reliability, fallibility, and testability) as well as the intellectual power offered to students (Maude 2016). The international GeoCapabilities project has brought together an array of research convincingly demonstrating that geographical knowledge and geographical thinking are powerful tools for developing young people's capabilities, such as their ability to think about themselves in the world, about the changing relationship human beings have with the environment, and about assuming a sense of environmental and global responsibility (e.g., Béneker and van der Vaart 2020; Lambert and Solem 2017; Lambert, Solem, and Tani 2015; Maude 2016). These capabilities are inextricably connected with how to live a good life within the context of climate change, developed through thinking about climate change geographically (Mitchell 2022).

Students' access to the powers of geographical thinking relies on the professional practices adopted by geography teachers, who are regarded as curriculum makers in the GeoCapabilities approach (Lambert, Solem, and Tani 2015). With teacher's agency highlighted, teachers are encouraged to

make their own critical decisions about what and how to teach based on their specialized geography knowledge and knowing their students' needs. Therefore, engaging with the discipline of geography becomes a central task in teachers' professional development and constitutes a core component of their teaching (Mitchell et al. 2022). Evidence indicates that teachers' curriculum making benefits notably from their collaboration with academic geographers, who help teachers update their knowledge and think geographically (Mitchell and Béneker 2022). However, a lack of support from the academic community is still a crucial problem in bridging the gap between academic geography and school geography (He, Tani, and Yang 2022), mainly due to the epistemic difficulty of engaging with sophisticated disciplinary knowledge and the practical barriers to successfully organizing such collaborative efforts (Hill and Jones 2010). Therefore, in addition to informing teachers about recent trends in academic geography as a means of broadening their professional horizons, it is necessary to provide teachers with a scaffold for more easily accessing academic geography and supporting their choice of what to include when engaging in curriculum making. In this regard, we propose an epistemic model for presenting the main perspectives for thinking about climate change geographically, which might also serve as an applicable tool for understanding various geographical concepts and issues in a holistic geographical manner.

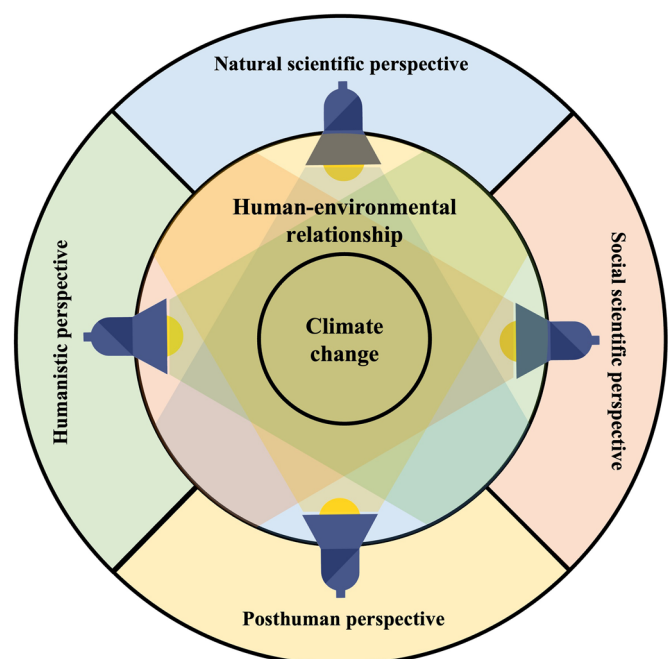
### ***Climate change education in school geography: Insufficient engagement in geographical thinking***

Climate change education often takes place within the geography curriculum in many countries, focusing especially on geography's relational understanding of the natural and social dimensions of climate change (Dawson et al. 2022). The content of climate change in school geography often involves studying its causes and impacts as well as solutions to the resulting problems, characterized by a disciplinary analysis of the interactions between humans and the environment (Chang 2014; Dawson et al. 2022). Despite the strong emphasis on an interdisciplinary approach, it might be questioned whether the multiple perspectives of geographical thinking are adequately recognized and presented in teaching. For instance, some contexts focus on teaching about climate change solely within the context of physical geography, approaching the issue from a natural scientific standpoint (Cantell et al. 2019). While this approach is essential for fostering students' science literacy and dispelling misconceptions related to climate change (Chang and Pascua 2017b; McCaffrey and Buhr 2008; Ratinen 2016), the integral human or social dimension necessary for comprehending this complex human-environmental issue often receives insufficient attention in teaching (Waldron et al. 2019). Likewise, teachers might also fail to address the emerging posthuman understanding in contemporary geography. To present a more holistic geographical approach to understanding and teaching about climate change, this study develops an epistemic model grounded in disciplinary thinking and explores its educational potential.

### ***The preliminary epistemic model***

A review of the existing literature revealed multiple perspectives on geographical thinking, each of which might help students understand complex issues and develop their capabilities. We propose an epistemic model for supporting teachers' curriculum making. Drawing on contemporary geographical studies on the human-environmental relationship, we highlight four perspectives important for understanding climate change, namely natural scientific, humanistic, social scientific, and posthuman perspectives, which constitute the preliminary model (see Figure 1). Drawing on Freeman and Morgan (2014) three-lamp model for comprehending the concept of *place*, this epistemic model also employs a metaphor suggesting that the four perspectives are like lamps that could help illuminate a more holistic geographical thinking. Table 1 illustrates how each lens makes it possible to understand the human-environmental relationship and, in turn, sheds light on climate change in different ways.

Different ontologies and epistemologies relating to humans, the environment, and their relationship with the four perspectives shape distinct understandings of climate change. The four perspectives on the human-environmental relationship are embedded in the paradigm shifts of modern geographical thought, from de-humanized to anthropocentric and currently anti-anthropocentric. Despite the different theoretical underpinnings and critical arguments, all four geographical perspectives have their own values and serve as tools for geographers to understand the diversity and complexity of the world (Cresswell 2013). The tensions between the different perspectives lead to the question of whether and how they can benefit the geography taught in schools and enhance the epistemic quality of climate change education. To examine the educational



**Figure 1.** The preliminary epistemic model for thinking about climate change geographically (source: the authors).



**Table 1.** Understanding climate change from different geographical perspectives.

Geographical perspectives	Understanding human-environmental relationship (sample views on climate change)
Natural scientific perspective	Both physical and human elements are regarded as objects that can be observed and measured by scientific methods, aiding in problem-solving. (e.g., mitigating climate change by reducing greenhouse gases)
Humanistic perspective	Focusing on individual experience and human subjectivity—how people attach their own meanings to the environment. (e.g., reflecting on the human condition and values based on responses to climate change)
Social scientific perspective	Focusing on social justice issues from the standpoint of different individuals, groups, and societies, especially in terms of different identities based on socio-economic background, gender, race, age, and body abilities, to name a few, in their relationship with the environment. (e.g., criticizing social justice issues among different people in climate policymaking)
Posthuman perspective	Challenging the separation between humans and the environment; engaging with the materiality and agency of non-human entities; tracing relations in the environment network. (e.g., seeing climate change as a hybrid and more-than-climate assemblage where humans and non-humans are mutually implicated in, constitutive of, and vulnerable to climate change; extending care to more-than-human strangers, such as multispecies, in cataclysmic times; adapting and learning to be affected by an unruly planet)

potentials of the four geographical perspectives and improve the preliminary model, we conducted a co-construction study design, which is introduced in the following section.

## Methods

### Study design: Co-construction of an epistemic model

In alignment with the main idea underpinning the GeoCapabilities approach, which aims to unravel the educational potential of disciplinary thinking in school geography teaching, we establish and adhere to a four-step co-construction design to develop the epistemic model for thinking climate change geographically:

- Step 1: Developing the preliminary model by thinking geographically**  
 Draw upon academic insights regarding the human-environmental relationship within the geography discipline to establish the preliminary epistemic model. This is a disciplinary-oriented preliminary model that represents the geographical understanding of climate change.
- Step 2: Interviews with experts in the GeoCapabilities perspective**  
 Conduct interviews with geography education researchers who subscribe to the GeoCapabilities viewpoint and collect their views on important geographical thinking for students to better understand climate change in an open manner.
- Step 3: Interaction with experts to reflect on the preliminary model**  
 Present the preliminary model to the interviewees. Reflect on their geographical thinking in the preliminary model. Discuss the similarities and differences between their original opinions and the preliminary model.
- Step 4: Examining the educational potential of the reflected model**  
 Anticipate the capabilities that can be developed through shared geographical thinking about climate change in the reflected model, which balances disciplinary and educational perspectives.

### Data collection

To examine the educational potential of the geographical perspectives based on the GeoCapabilities approach, we conducted semi-structured, in-depth interviews with nine academic experts involved in different phases of the GeoCapabilities project. Two of the experts were school-based researchers and the others were university-based researchers. The recruited interviewees were from different countries: Australia, China, Czechia, Finland, the Netherlands, Sweden, the UK, and the USA. The international nature of the data collection was compatible with the aim of the project: to communicate the purposes of school geography internationally (Lambert, Solem, and Tani 2015). As geography education researchers, the participants were able to provide rich understandings of both the geography discipline and school geography in their own contexts.

The interviews were guided by two main questions: (1) What kinds of geographical perspectives are important for understanding climate change? (2) What kind of contribution can those geographical perspectives offer for young people to develop their capabilities to react to climate change? The interviews took place and were recorded in Microsoft Teams, lasting from 50 to 90 min. The interview data were automatically transcribed in Teams during recording and subsequently collated by the first author to ensure accuracy in wording for further analysis.

### Data analysis

The data analysis was guided by Braun and Clarke (2006) six phases of thematic analysis: familiarizing oneself with the data; generating initial codes; searching for themes; reviewing the themes; defining and naming themes; and producing reports. To facilitate the different steps involved in co-constructing the epistemic model, we included both inductive (data-driven) and deductive (pre-existing frame-based) analysis. At the beginning of the interviews, participants were asked about the geographical perspectives they deemed important for understanding climate change. Their responses reflected diverse ways of structuring geographical thinking, influenced by their epistemological perspectives. To identify themes from their original responses, we initially applied an inductive approach. Subsequently, we employed a deductive approach to explore which

geographical perspectives, evident in the preliminary model, were valued by the participants, with the preliminary model serving as an analytical framework. The interactive step in the interviews proved beneficial in minimizing misunderstandings between researchers and participants. Additionally, we conducted inductive analysis to generate themes regarding participants' views on the capabilities that can be developed from thinking geographically *via* different perspectives.

## Results

### *The valued aspects of geographical thinking about climate change*

Four main themes were generated based on participants' geographical thinking about climate change before the preliminary model was presented. The geographical perspectives, as the focus of this study, were implicated in their answers (see Table 2).

The first theme focuses on the facts relevant to climate change, such as climate data and climate events related to the natural and social environment. Natural scientific facts concern the changing atmosphere, including warming temperatures and related components. Changes to landscapes and natural disasters were described in some of the interviews. Additionally, some interviewees also mentioned important climate-related social issues, including climate refugees and the difficult intergovernmental negotiations to address climate change.

The second theme, which concerns the natural and social processes of climate change, was spotlighted in most of the interviews. This theme directs attention to a deeper explanation for why climate change is occurring and how climate

change impacts humans and the environment, which involves substantive knowledge of physical and human geography. Most of the interviewees stressed the understanding of the physical processes of greenhouse effects, which scientists regard as the direct reason for human-induced climate change. Adopting a deeper focus, interviewees also emphasized the social reasons and climate justice issues. They generally acknowledged that any effort to assess the responsibilities of different countries needs to account for historical developments and current economic relationships among different nations and not just provide intuitive data about greenhouse gases emission. Additionally, many considered the political economic explanation for climate change, which situates climate change in the grand narrative of capitalist development.

The third theme involves a set of geography concepts. Most interviewees regarded the *human-environmental relationship* as the most important concept for understanding climate change in a geographical way. This suggests a shared understanding that climate change involves a complex interplay of natural processes and societal dynamics, underscoring geography's unique role in "synthesizing and connecting physical systems and human systems" (P3). In addition, they highlighted the notion of *place* because it illustrates the fact that "climate change actually happens in certain places in the world" (P1) and that the effects and solutions vary in different places (P7, P9). Other concepts, such as *space*, *scale* (local and global), and *time* (development or change), were also mentioned as reflecting the spatial and temporal aspects of climate change.

The final theme relates to the solutions and values in terms of reacting to climate change. In pushing past straightforward solutions, such as reducing greenhouse gases through specific actions, the interviewees engaged with

**Table 2.** Interviewees' ideas on geographical thinking about climate change, colored based on authors' analysis (blue: natural scientific perspective; green: humanistic perspective; red: social scientific perspective; yellow: posthuman perspective).

Themes	Codes
Factual phenomena, data, and events related to climate change	Atmospheric changes (global distribution of rising temperatures and CO <sub>2</sub> ) (P1, P4, P6)
	Changing landscapes and natural disasters related to climate change (e.g., melting glaciers and rising sea level) (P4, P5, P7, P9)
	Vulnerable people (climate refugee / immigrants) because of climate change (P1, P9)
	It is difficult to reach agreements about climate change among different countries based on intergovernmental negotiations (P1, P2, P6)
Explanation of the processes of climate change	Explaining the physical processes of climate change, i.e., increasing levels of greenhouse gas pollution, by learning about physical geography, meteorology, earth system science, and climatology (P1, P2, P3, P4, P6, P7, P9)
	Explaining the social processes underpinning climate justice issues, e.g., different historical responsibilities, political conflicts, and economic relationships among different countries (P1, P2, P3, P4, P6, P7, P8, P9)
	Providing the political economic reasons (capitalism) for climate change (P3)
Relevant geography concepts for understanding climate change	Human-environmental (nature-society) relationship / interactions (P1, P3, P4, P5, P6, P8, P9)
	Place (P1, P3, P6, P7, P8)
	Space (P1, P5, P8)
	Scale (local and global) (P3, P5)
Solutions and values for reacting to climate change	Time and development / change (P5, P9)
	Pay attention to local, indigenous, minority, or ethnic knowledge and experiences with climate change (P3, P7)
	Promoting survival knowledge to react to possible disasters in local areas (P9)
	Addressing climate change requires global collaboration (P1)
	Providing hope that individual agency can make a difference in dealing with climate change (P1, P2, P5)
	Foregrounding the role of individual moral actions and behaviors in mitigating greenhouse gas emissions (e.g., food and transportation choices) (P2, P5)
	Showing care and empathy for the surrounding environment, knowing how other species change and adapt to climate change (P2, P3, P9)
	Discerning the differences between fact, fiction, and opinions about climate change (P3, P6, P7)
	Becoming aware of the social justice issues underlying climate change, e.g., responsibilities and vulnerabilities of various countries (P1, P2)

broader concerns ranging from the individual level to the global level. Some key phrases, such as local knowledge, hope, international collaboration, empathy, discernment, and justice, indicated that participants' main reactions to climate change derived from their geographical thinking. Although many emphasized the regional differences of climate change, as they did with the previous themes, only two interviewees specifically highlighted the values of local knowledge in addressing climate change as well as accounting for young people's local experiences. Similarly, another interviewee valued the need for practical survival knowledge to cope with possible disasters due to climate change on a local scale. Additionally, some interviewees believed that an attitude of hope should be conveyed together with geographical thinking, given that individuals can have positive influences based on a holistic understanding of climate change. This hope should also be based on various actions, values, and moral standpoints that could be promoted, including intergovernmental collaboration, individual agency, caring for the environment and multiple species, exhibiting critical judgment about claims regarding climate change, being aware of climate justice issues, and engaging in political participation.

In sum, participants emphasized knowing the facts, processes, concepts, and solutions and values when thinking about climate change from a geographical standpoint. The four themes echo the threefold arrangement of powerful geographical knowledge proposed by Lambert, Solem, and Tani (2015), which include possessing: a deep descriptive world knowledge (facts); a critical conceptual knowledge that has explanatory power and systematicity, providing a relational understanding of people living on the planet (processes and concepts); and a propensity to think through alternative social, economic, and environmental futures in specific place and locational contexts (solutions and values).

### ***The valued geographical perspectives in the preliminary model***

According to our analysis, the participants' initial responses were dominated by the natural scientific and social scientific perspectives on geographical thinking. They paid exclusive attention to the natural and social scientific perspectives in the themes dealing with facts and explanations for climate change processes, while integrating and extending the geographical perspectives in the theme discussing solutions and values. Their responses did not straightforwardly indicate which specific perspective related to the theme of relevant geography concepts because the understanding of those concepts can involve different perspectives, whereas participants merely provided a general description of these ideas in the interviews.

In the interactive step, when the participants were asked to reflect on their original opinions after given the preliminary model, most of them thought that their original views were included in the model, mainly involving natural scientific, humanistic, and social scientific perspectives, but lacking posthuman perspective. The absent posthuman perspective was due to their lack of familiarity with the relatively fresh approach, which they also acknowledged.

Nevertheless, after the authors' explanation, the participants then provided more insights and clearly saw the educational potential of the approach. Seven of the interviewees commented that the ideas from posthuman perspective are interesting and important complement to their original thinking and to school geography with respect to understanding climate change, given that it could help young people realize and problematize the predominant human-centered mindset in the human-environmental relationship and rethink the agency and rights of non-humans (e.g., P9). A mismatch can be found between participants' assertions and the authors' identifications (see Table 2) in terms of the humanistic perspective. This mismatch can be explained, as elicited in the interactions, by the fact that some participants misconceived humanistic perspective as human geography which is one of the sub-disciplines focusing on the broad influence of humans. After gaining a shared understanding of the geographical perspectives involved in the preliminary model, the interaction ended up with the participants' appreciation for the model and acknowledging the significant roles played by diverse geographical perspectives in helping young people understand climate change. In other words, the perspectives included in the preliminary epistemic model were examined by the participating geography education researchers.

### ***Geographical perspectives and capabilities development***

From the perspective of the GeoCapabilities approach, the participants highlighted how geography education contributes to young people's capabilities to think, to be, to do, and to live in the world, which guided them to consider the educational potential of the epistemic model. There were two nuanced ways of response: three of them tried to unpack the potential of each perspective and came up with specific capabilities at addressing climate change (P1, P2, P4), while the others preferred to talk about the generic capabilities that students develop if equipped with all the geographical perspectives.

The first type of participants provided nuanced insights into how each perspective contributes to students' understanding of climate change. The natural scientific perspective can equip young people with necessary scientific knowledge and data capacities to understand and articulate the intricacies of climate change, including phenomena like the greenhouse effect and other pertinent data, such as rising temperature, ice melting, changing sea level, and precipitation (P2). This geographic lens further facilitates the transforming of abstract climate data into tangible experiences by immersing students in real-world locations through a spatial perspective (P1, P4). For instance, the approach enables students to witness the natural hazards due to climate change in real places, such as the disappearance of islands due to rising sea levels (P1). In this sense, young people can develop a deeper understanding of the environmental challenges posed by climate change. The humanistic perspective fosters young people's awareness of individual agency, empowering them to recognize their capacity for having positive or negative influences on the world. For example, students may put their eco-friendly values into practice, such as choosing

trains over planes or buses over cars (P2). The social scientific perspective encourages deep reflection on the political and social justice dimensions of climate change. Students could engage in analyzing policies, participate in debates on environmental justice, or advocate for sustainable practices in their communities (P1, P2, P4). Despite its novelty to the participants, the posthuman perspective has the potential to evoke empathy in young minds for the more-than-human lives affected by climate change, such as caring about the survival and adaptation of other species in the changing environment (P2).

The other interviewees believed that employing the four perspectives in geographical thinking leads to two generic outcomes, oriented more toward students' ultimate development and capable of being transformed into capabilities for reacting to climate change. The first generic outcome is critical thinking. When tackling complex issues like climate change through diverse geographical perspectives, students encounter a variety of voices and viewpoints, fostering an awareness of the multitude of interests involved. Instead of passively absorbing information in school textbooks or on social media, students armed with multiple perspectives can independently assess and analyze existing ideas. For instance, they may critically evaluate the extensive amount of information about climate change by questioning the sources, objectivity, and potential representation of specific interest (P3, P6, P7). Additionally, they can holistically analyze climate change questions, such as connecting the rise in CO<sub>2</sub> levels to natural scientific knowledge about the atmosphere, social scientific concerns regarding conflicts of interest between countries over fossil resources, and environmental values from a humanistic perspective (P8). Corresponding to the first outcome, the second one relates to the freedom and agency of young people, aligning with the educational goal in the GeoCapabilities approach. This freedom and agency encompass not only the ability to think critically but also to take action, live in a way that aligns with their values, and express their thoughts about, knowledge of, and understanding of the issues. For instance, the interviewees expressed an appreciation for students actively engaging in climate policy making, making their voices heard, and proposing solutions (P3).

## Discussion

It is intriguing that the geography education researchers participating in this study gave differing amounts of attention to each perspective in the epistemic model, even though they valued all perspectives' roles. They privileged the natural and social scientific perspectives over the other two in their geographical thinking about climate change. This finding is in line with a study by Hall and Moore-Cherry (2022), which found that the applied (mainly natural scientific) and critical (mainly social scientific) perspectives are valued in geography education with respect to informing students to best serve society and act against structures of injustice. Since there is a commonly oversimplified binary of applied and critical perspectives in geography, it was reasonable to assume the less attention paid to the humanistic and

posthuman perspectives, which constitute the "shades" or "overlaps" between the applied-critical division (Hall and Moore-Cherry, 2022: 2). This uneven attention to the geographical perspectives could not be limited just to teach climate change but common in the arena of geography education generally. Despite rare efforts by some to focus on cultural geographies and explore how humanistic and post-human perspectives can contribute to the way powerful knowledge is formulated in higher education (Waight 2021), this study calls for a further exploration of these two infrequent perspectives at the school level.

Another interesting finding from the interviews in this study is that geographical perspectives, though important, are often not specified in discussions on geographical thinking. To our knowledge, as well as evidenced by this study, geographical thinking is often related to broad and inclusive geographical concepts, such as *place*, *space*, *scale*, and *human-environmental relations* (Fögele 2017; Lambert and Morgan 2010; Maude 2022), which account for teaching in practice (Jankell, Sandahl, and Örbring 2021). Indeed, while it is important to provide students with a conceptual understanding of geography, it is also crucial to notice that different perspectives fundamentally shape various understandings of geographical concepts. This applies not just to the *human-environmental relationship* articulated in this study but also other key concepts as well, like *space* and *place* (Hubbard and Kitchin 2011). By neglecting the underlying perspectives, teachers run the risk confining students to a narrow understanding of concepts and their application to specific issues, such as climate change. This study underscores a challenge in geography education in terms of keeping pace with the evolving nature of the discipline. The examined epistemic model offers potential support to geography teachers as a scaffold for understanding geographical thought, reflecting on their pedagogic practices, and applying them to discussions about *human-environmental relationship*, climate change, and other relevant topics. However, it is important to note that the epistemic model is by no means exhaustive, but rather could be developed further for specific educational purposes. The development of the epistemic model through a co-construction design will also inspire exploration of geographical thinking with respect to topics beyond just climate change and concepts extending beyond the *human-environmental relationship*.

Finally, the limitations of this study warrant mentioning. First, the articulation of the four geographical perspectives in the epistemic model is mainly based on our review of the existing English literature, which might exclude knowledge from other sources in different languages. The reason that the participants expressed general appreciation for the model is probably that they have been deeply engaged with the English-based research, whether from the standpoint of academic geography or school geography. Considering the ongoing de-colonizing discourse in academic geography as well as the climate change studies (Radcliffe 2022; Johnson, Parsons, and Fisher 2022), the outcome of this study, that is, the four-perspective model, should be treated with criticality. However, we recommend repeating the co-construction steps to examine and improve the model in accordance with the



study design discussed in this paper. The co-constructors need not be exclusively geography education researchers, but may also include other experts involved in geography education, such as geographers, geography teachers, and geography learners in schools and elsewhere. The second limitation is that this study has not delved into the practical implementation and validation of the proposed model in a classroom setting, leaving room for further exploration and application. To address this gap, we propose several tangible strategies for integrating the model into educational practices: organizing professional development workshops for geography teachers to familiarize them with the model; encouraging teachers to engage in the co-construction and refinement of the model; collaborating with teachers to integrate the model into the existing teaching framework by generating teaching recourses; and collecting feedback from both teachers and students after classroom implementation and addressing the possible challenges. We argue that, with these proposed strategies, the most important and main contribution of this study is that it provides support for the choices made by teachers in the classroom. This is especially crucial given the premise of the GeoCapabilities project that teachers, as curriculum makers, are expected to make critical decisions based on their knowledge of the discipline and the students.

## Conclusion

This study has examined the contributions of the multiple perspectives in geographical thinking to climate change education and develops an epistemic model for understanding climate change from geographical perspectives. This model extends the epistemic scope of current climate change education in school geography and responds to calls for a more holistic understanding of the complex issue. In addition to the predominantly natural scientific perspectives in pedagogical practice, the humanistic, social scientific, and posthuman perspectives on the human-environmental relationship also play valuable roles in helping young people understand climate change and develop their capabilities for addressing it. Introducing the plural geographical perspectives in a school setting is significant not only because each perspective has particular value related to climate change, but also because they empower young people to think critically and realize their freedom for long-term development as knowledge agents.




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There is no conflict of interest in this article from any of the authors.

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