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# Envisioning educational pathways for climate change competencies: Insights from a Delphi study

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## ABSTRACT

The purpose of this Delphi study was to gather insights on climate change education from a 35-member expert panel for a description of an education system that would best develop climate change competency. The initial round of inquiry was a questionnaire designed to highlight the panelists' diverse knowledge and empirical experiences. The second round suggested a description of the relevant competency and an education system. The third and final round sought confirmation over the system description. The chosen method brought ample insight into climate change education and on some key emerging tensions. Differing approaches according to education levels were suggested to focus on actionable understanding of climate change at lower levels, and then develop into a more complex competency at higher levels of education. The implications of the study address teachers, planners, and policymakers of the education system from primary to secondary, and higher to continuing education.

## KEYWORDS

Climate change education; sustainability education system; Delphi-study

## Introduction

Global changes, induced by certain human activities, are threatening planetary well-being, and likely the very survival of various vital ecosystems (Steffen et al., 2015). The ongoing climate change, and the polycrisis at large, challenge us to seek and develop solutions for mitigation and adaptation (Homer-Dixon et al., 2021) throughout the web of life—predominantly at the outputs of various human processes (Purvis et al., 2019). To generate these urgently needed changes, education has been—as throughout the history of human development (Darder et al., 2023) also in this turning of an epoch—one of our most relevant strategies (Lotz-Sisitka et al., 2015). Formal education at various levels has been active in responding to this need (Monroe et al., 2019) through various approaches, from focusing on climate solutions enactment (Molthan-Hill et al., 2019) to bridging the acknowledged capabilities gaps for sustainability (Wynes & Nicholas, 2017) and nurturing the kind of competency that is expected to bring about the necessary solutions (Salovaara et al., 2020).

Sustainability education (SE) and climate change education (CCE) in general have become a major focus of academic research (e.g., Aikens et al., 2016; Reid, 2019) as well as of pedagogical and methodological developments (e.g., Leal Filho et al., 2021; Lehtonen et al., 2019; Mochizuki & Bryan, 2015). Along these foci, CCE has been addressed, for example, through its key contents (Stevenson et al., 2017); its major aims (Bangay & Blum, 2010); its pedagogical challenges and distinctiveness (Molthan-Hill et al., 2019); its utilization at various educational levels (Nepraš et al., 2022) and disciplines (Eilam, 2022); and

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by its hoped-for societal impacts (O'Neill et al., 2020). It is well acknowledged that CCE is needed in both climate change-specific education (Park et al., 2020), e.g., a specialist program, and as a theme in any form of education (Molthan-Hill et al., 2022), e.g., climate change as a topic embedded within other primary education subjects.

As climate change is a dynamic and systemic issue, education on it also presents complex issues in implementation. For example, the response to the ongoing polycrisis through education ought to be truly transformative; through its aims and ways to generate transformative outcomes (Jickling, 2013), the education processes, institutions and societal tendency at large are also thought functional when they are stable and predictable. Moreover, CCE and sustainability education are almost universally thought to respond to a specific competency need (e.g., Frisk & Larson, 2011), while it has also been acknowledged that educating sustainability through a certain practicable image can also risk becoming a self-fulfilling prophecy (Wals, 2011). As a recent review of numerous CCE strategies suggests (Monroe et al., 2019), the aforementioned contrasts also present practical challenges, for example in requiring teachers to handle both the factual and persuasive aspects of education even at the risk of excess advocacy (Qablan et al., 2011) or being able to engage the students in potentially transformative deep learning (Warburton, 2003). However, besides the sustainability *problematique* which is yet emerging, educated systemic perceptions on it are still developing and can be presumed to produce the kind of transformation that could be unforeseeable with current mindsets (Salovaara et al., 2021).

CCE is a practice that ought to be adopted throughout the education system (Reimers, 2021): from primary to upper and continuing education, as well as within general and specialist—and practical and theoretical—education. Thus, in our view, many questions concerning CCE from a whole education system perspective, remain unanswered. What kind of competency should CCE focus on? Aside from the ample academic work on the topic (e.g., Anderson, 2010; Beck, 2012; Kerry et al., 2012; Steffensen, 2020), what should be taught at what point along the path one goes through from primary to secondary education and further on? Apart from educating people on known facts of CC and strategies of sustainability as a response to CC needs, how are the facts presented in a way that is unbiased but action-evoking (Bleazby et al., 2022; Tryggvason et al., 2023) while being managed in a permissive and reflective manner (Aasen, 2017; Bolsen & Shapiro, 2018)? Such concerns are crucial to the principles of sustainability. And what kind of education system would best deliver such competency? In addition to the various theoretical elaborations on how CCE is to be implemented within different educational contexts (e.g., Kumar et al., 2023; McCright et al., 2013; Vincent & Focht, 2011; Wehrmeyer & Chenoweth, 2006), how do the different perceived functions of the system align?

To examine the aforementioned questions, we conducted a Delphi-method study (Geist, 2010) with an expert panel consisting of various stakeholders of CCE and the education system. This panel included high school and university students, teachers, education and climate researchers and outside-academia professionals working with climate change, representing how and where climate change expertise is practiced, and also those potentially taking part in continuous education. The study collected and discussed numerous views on climate change competency and the educational system concerning it, by asking the panelists: *What do you consider to be the most relevant climate change competency, and in your view, what kind of an education system would best teach it?* In addition to the panelists' views, which we expected to broadly reflect the common viewpoints of the research and practice fields, we were also interested in exploring the tensions and synergies emerging from the various perspectives—particularly when considering CCE to take place on very different levels and contexts of education.

## Theoretical background

This study began by considering various aspects of CCE, some of which also present the above-mentioned knowledge gaps, such as those related to the aims and means of education. Primarily, we conceptualized CCE as a strategy aimed at creating societies that are competent at climate change mitigation and adaptation (Stevenson et al., 2017). However, such a definition leads to multiple interpretations and thus also questions such as those on the subject matter and its focus, like the various issues to be adapted to or mitigated (Borde et al., 2022); on the teaching context, like the various levels and fields of education (Mochizuki & Bryan, 2015); and on the aims of the education, like generating normativity to orient the learners toward intended actions (Öhman, 2007).

Among the numerous academic explorations of SE and CCE, conceptualizations of competency and specific *competencies* have been often the focus, with competency in general coming more from the point of view of educational structuration; programs, and teaching with competency as its guiding aim and a framing of assessment (Johnstone & Soares, 2014), and specific *competencies* as schemes of certain knowledge, abilities and values operationalized at and attained through education (Rieckmann, 2012). The former has perhaps received less attention lately as competence-based education has become a standard in higher education (Anderson-Levitt & Gardinier, 2023), although there are elaborations and critical thoughts on the tensions between what is taught and assessed and their relation, in typical cases, to a recognized need for and conceptualization of a specific capability. For example, in SE, such reciprocity between what is learned and practiced can be seen as being problematic, as our overview of sustainability issues is still emerging and yet has to be taught for immediate actions to resolve those issues (Wals, 2011), which can lead to the practice of sustainability being based on an incomplete or irrelevant understanding. Such worries relate to the formerly mentioned approach to competency in SE and CCE, with certain predetermined and packaged capabilities that the education is intended to lead to Evans (2019).

Especially in SE research, key competencies (Rieckmann, 2018) have been a significant focus for conceptualizing the kind of expertise and professionalism that sustainability work is thought to require. In CCE and SE, competency in more general terms can sometimes be addressed as environmental literacy (Rowe, 2022), referring to one's firm awareness and some level of action-readiness for environmental issues, or to such thematic enlightenment as considering them to lead to somewhat universal environmental agency throughout societies (Salovaara et al., 2021). Competencies in SE and CCE have had a wealth of varying litanies and frameworks defining capabilities, from being able to intervene in the current unsustainable status quo (Perez Salgado et al., 2018) to being versed in systematic, strategic, temporal, interpersonal and normative thinking and doing (Brundiens et al., 2021), and addressed in practical terms, for example, from the capabilities of professional climate change practitioners (Siponen et al., 2024) to how the competencies could be operationalized in education (e.g., Wiek et al. 2015). While most of the former examples contextualize SE and CCE within different forms of higher education—be it bachelor's or master's level—CCE is evidently acknowledged as a topic of teaching that is best to start at earliest convenience (Nepraš et al., 2022), while SE is a recognized need among the currently employed labor force through continuing education (Schreiber-Barsch & Mauch, 2019). In our view, such an approach exemplifies the versatility of CCE, suggesting that at one end it should lead to high-level professional competence and at the other, elementary, end that it should focus on basic awareness building.

Such a scheme suggests a potential trajectory between elementary primary education to professional higher education—potentially extended to continuing education after, thus envisioning a CCE system of sorts. Such a system would thus nurture knowledge at all levels, which alone is typically both thought to lead to action (Kolenatý et al., 2022) and is well recognized as often also failing to do so (Chaplin & Wyton, 2014). Related to the former dilemma, here too one can see the potential to approach sustainability aims through predefined key issues that get tackled by the educated (Redman & Wiek, 2021) or one could anticipate that it—as an emancipatory environmental education (Huckle, 1993)—would lead to the kind of ingenuity that would bring about yet unforeseeable understandings and solutions to CC. In either case, CCE—and similarly SE—can be seen to aim to change the education system in all its dimensions with a depth and width that correlates to our comprehension of the problems at hand. Thus, we see the theoretical background of this study as encompassing both competency-based education and a more emancipatory plural education.

## Materials and methods

### *The Delphi method and eDelphi tool*

The Delphi method is a technique in which a group of individuals can collaboratively discuss a complex problem (Rowe et al., 1991). There are several ways to implement Delphi methods, but most of them share common characteristics, such as structured phases of communication and discussion, opportunities to revise what has been communicated, and a certain degree of anonymity during discussion (Okoli & Pawlowski, 2004). In educational research, the Delphi method has been used in environmental education, for example, to explore desirable curriculum content (Seo et al., 2020) or what would be the most desirable

outcome of the education (Clark et al., 2020). Thus, for exploring the education system as is and reflecting on the stakeholder's perceptions of the significant CC competencies taught through the system, the Delphi method emerges as a suitable candidate. Delphi, while typically concludes in cohesion (Fish & Busby, 1996); can during its several rounds of research subject participant interaction be easily utilized to evoke and highlight the diversity of the group (e.g., Ho et al., 2018; Kattirtzi & Winskel, 2020). In addition, the Delphi method, per its typical utilization for scenario making (e.g., Calleo & Pilla, 2023; Renzi & Freitas, 2015), seemed relevant for co-creating a vision of an education system that is inherently different from the current one.

The thirty-three invited participants of the Delphi study were selected as a purposive sample group (Powell, 2003) based on their stakeholder status in climate change education (CCE) in the Finnish education system, hence possessing first-hand expertise on the topic. Aiming at a diversity of voices and a wide base of knowledge (Rowe et al., 1991), the expert panel included a heterogeneous group of 33 members, with six researchers on climate change and five on education; five higher education students; five upper secondary school students; five higher education teachers and teaching planners; and seven representatives of climate change experts working in various organizations, such as local governance, NGOs and private companies. A few of the panelists, by their own admission, belonged to more than one expert group (such as being a teacher by training and currently working as a researcher). As the panel was assembled to represent a divergent stakeholder group of the CCE, the panelists were instructed to consider the question and prompts of the study specifically from their empirical point of view, based on their learning and teaching, research, the needs acknowledged in their field, or realizations they considered worthwhile to bring up.

This study was carried out using a web platform dedicated to running Delphi-method studies; eDelphi (<http://edelphi.org>). The platform provides various Delphi-study tools, of which an anonymous online discussion forum was the most important to this study. The participants were invited *via* an emailed unique invite link, which took them directly to the ongoing part of the study. These emails were sent from the platform, with a message describing the ongoing Delphi phase process, purpose, deadlines, and encouragement to participate. The goal of the first round of eDelphi was to collect the panelists' divergent viewpoints and opinions. As there is a tendency for Delphi studies to suppress viewpoints and opinions not shared by the majority or by the most confident participants (e.g., Bolger et al., 2011), the first Delphi round was conducted as a questionnaire. The first round's prompt also explicitly stated that the goal was to create a divergent description, representing a plurality of different viewpoints, which are needed to address issues of sustainability and climate change systematically (Barrett & Grizzle, 1999). The second and third Delphi rounds were conducted as anonymous online discussions. The first-round input by the panelists, as *inquiry*, was collected and analyzed to formulate a suggestion that was then used as a prompt for the second Delphi round. The second round, as *suggestion*, was then used to collect comments from the panelists and to evoke discussion on emerging tensions within the formulated education system description. The third round, seeking for *confirmation*, took the second-round discussion and formulated a second version of the description. The final version of the description was concluded based on the third-round discussion.

## Results

### Round 1—Ask: Competencies and education of CC

The first Delphi round, as typical of the method, focused on obtaining the expert panel's insights on the research theme. To gather the various perspectives of the individual panelists, the first round was designed as an open-ended questionnaire, where the panelists gave their answers anonymously and directly to the Delphi facilitators *via* the platform. The two questions prompts were:

1. *What are the most important competencies (knowledge-, skill- and value-based capabilities) needed in climate change adaptation and mitigation? and*
2. *How should learning, teaching and the education system (from secondary, tertiary, and continuous education perspectives) change for them to secure the learning of those competencies you mentioned above?*

The first question was founded on the concept of competencies, which, although prevalent in the field of education planning and research, also clearly describes operational capabilities rather than, for example, knowledge alone. In addition, the questions were deliberately formulated to focus on the most important competencies and targeted especially at climate change adaptation and mitigation, aiming to further emphasize the potential diversity of this Delphi round (to be further iterated toward cohesion in the latter phase) and the importance of considering both adaptation and mitigation strategies in climate change activities. The second question was aimed specifically to bring out the divergent perspectives from the panelists' personal points of view to the envisioned education system as a whole. The suggested levels of education, as well as the mentioned aspects of learning and teaching, were aimed to best host the various empirical experiences of the panelists. In addition, while the purpose of this Delphi study was not to create a future scenario *per se*, the study and its introduction to the panelists was predicated on making changes to the current education system.

Panelists' answers were later grouped by the suggested education levels, and further by different individual, organizational and societal/global level notions. Other classes, such as those related to (individual) capabilities, (organizational) processes or (societal) values also emerged within the dimensions. On the individual attributes, the systemic approach—comprising such a description as understanding the interconnectedness, global perspectives, planetary boundaries, and human-nature dilemma in CC—emerged as an important area of competency. Also, competencies related to concrete action, like knowledge utilization and critical reflection, problem-solving and finding creative solutions to the issues were suggested. In addition to these knowledge- and action-oriented competencies, another area related to more psycho-social attributes—such as moral responsibility, emotional intelligence, and empathy, with social and collaboration skills in general—also emerged. The attributes related more to the collective and organizational dimension included contextualizing the knowledge and issues to a specific field of practice, as well as notions of expertise and professionalism in climate change activities. However, considering activism, alternatives and transition movements were also considered meaningful. In general, understanding the overall phenomenon of CC and its implications for individuals and organizations was a highlighted priority.

### **Round 2—Suggest: Discussing the proposal**

From the first-round questionnaire results, encompassing the divergent perspectives on both the most relevant competencies and the envisioned education system, we formulated the following initial description:

#### **Proposal**

Under the education system, we address primary and secondary education, higher education, as well as continuing education, which serves communities and organizations, ultimately benefiting the entire society through the educated individual.

The system educates active citizens, skilled and responsible professionals, and practitioners. It utilizes various forms of teaching, like project- and problem-based learning, which transcend disciplinary boundaries and aim for self-directedness and tangible actions. It conveys a practical and reliable understanding of climate change and the skills to apply what has been learned or to seek new information for CC activities. Agency, critical and reflective approaches, emotional intelligence, and communication are taught, taking into account the learner's individual capacities.

The whole system aims to be aligned with individual lessons, educational programs, and the national curriculum, for example, in activity-oriented education of general knowledge at lower levels, and in a more complex and profession-oriented and subject-specific knowledge at higher education levels. The teaching and curriculum ought to evolve and remain topical in collaboration with various stakeholders.

At this stage, the Delphi study transitioned to anonymous online discussion. We asked the participants to read the proposal carefully and to participate in the online discussion. While the main aim

of the second Delphi stage was to suggest and further elaborate on the views of the panelists, we also asked them to comment on selected emerging contentions between some suggested characteristics of the system.

One tension emerged, in our view, between suggesting that *the focus ought to be on basic concepts and practicable education*, while also *fostering systemic understanding of the issues and their susceptibility*. Also, the suggestion stated that *CC ought to be taken as an interdisciplinary topic*, although *interdisciplinarity views and solutions cannot be created without some respective subjects and fields*. Furthermore, it was suggested that *learning should produce rigid expertise based on univocal views of CC and sustainability*, while also remaining *a critical and reflective, constantly evolving*, subject. The discussion occurred in two manners: responding to the suggested discussion topics and commenting on other panelists' responses.

While in the online discussion the panelists predominantly approved of the suggested education system description, notes on aiming for a more concretized and explicit description and suggesting some competency and thematic additions and edits to the wording arose. Critical thinking, emerging from, for example, realizations of the scientific process and its limitations, was mentioned. Systems thinking was suggested as a specific subject. Also, a notion was raised that the described competency appeared knowledge-oriented and as such potentially overlooked, for example, relevant social and emotional capabilities. Ethicality and eco-friendliness were suggested as explicit additions to the value-base of the system and that the interplay between the individual and the educational system ought to be reciprocal.

The suggested tensions led to elaborations on the suggested, and related, themes. While some panelists suggested that there is already a somewhat universal acceptance of CC causes and actions, the notion of univocality caused some uneasiness in others. Such suggestions, that the views should remain plural, and that the views ought to be the outcome of a dialogue—suggesting that education should emerge from discovery and critical views as well. Related to the suggested univocality and rigidity however, it was thought that contentions between attitudes or disciplines, or knowledge in general, were to be expected and accepted.

Another discussion revolved around the operationalization and the change to the suggested system. While the description can appear reformist, to fully embrace the aims and intent of the suggested system some fundamental changes would have to occur, like in learning assessment, and in allocation of resources whether in terms of teachers' working hours or influence or in terms of students' study hours. A suggestion was brought up that collaboration to secure the needed resources could suffice and notions of collaboration and community engagement were suggested as additions.

### **Round 3—Confirm: Describing the education system**

The final Delphi stage aimed to establish the panelists' confirmation of and cohesion on the suggested description of a CC education system. In the online conversation, the description was predominantly accepted and agreed upon as a comprehensive and multiperspective description of the system. However, the panelists made some final additions to it, and some aspects sparked further discussion.

While the individual to social was a dimension already noted in the description, issues were raised regarding capabilities and responsibilities, such as issues between agency and structures in generating changes, but more so over the lack of clarity on whose views or values the education should be based upon. Furthermore, while the description manages to be comprehensive, it can also appear general and ambiguous, for example in lacking examples of the actors relevant to the mentioned collaboration, or suggestions on how to resolve potential contradictions between the teachers' personal values and the values promoted by certain strategies. Regarding values, the very notion of "educating values" was thought to have its ideological risks and potentially contributing negatively to the evident polarization related to these issues. Finally, explicit comments on specific wording and clearer conceptualization of the addressed areas were also made.

Based on the final Delphi stage, as an online discussion, the final version of the description was formulated as follows:

#### ***Education for Climate Change Competency at all levels of education:***

*In this educational system, we include primary, secondary, higher, and continuing education that serves communities and organizations, ultimately benefiting society through the individuals it focuses on. The system recognizes the*

*importance of general climate change competency among citizens and the specific need for professional competencies, aiming to support agency—with an understanding of the structures in which the concrete action and collective challenges of change take place.*

*In primary education, the aims are to provide a basic understanding of the causes of climate change and the immediate actions one could take to tackle the issues, and to guide learners to seek further information to address related issues. For vocational, secondary, and continuing education and diverse learners' needs, the educational system focuses on providing field-specific and practical climate change competency relevant to their context. Climate change is addressed as a cross-disciplinary phenomenon, but through contextual perspectives. Also in higher education, the phenomenon, its problems, and potential solutions can be approached as integrated into specific disciplines, or they can be taken as a free-standing systemic topic.*

*The education has a scientific basis and is knowledge- and content-oriented, problem-based, and project-based learning are utilized to nurture an understanding of the general significance and importance of the climate crisis to one's personal and professional life, for example in working on the topic. Various skills such as complex knowledge acquisition and creation, critical thinking, and argumentation, as well as emotional intelligence and communication skills, will lead to concrete action, both autonomous and communal.*

*The diverse values and worldviews related to the topic are addressed in teaching by acknowledging the potential differences between various actors, disciplines, and sectors, and by striving to reconcile conflicts with inclusivity, and ensuring that a receptive yet actionable understanding of the significance, causes, and potential actions of climate change is attained.*

*Such education empowers individuals to adapt to or to take concrete mitigating actions for climate change without compromising the actors' capacity to do so in considering the responsibility and resources of students, learners, teachers, researchers, and other stakeholders of the education system. The necessary conditions, knowledge and human resources for the system are ensured through collaborative efforts, with shared responsibility and based on jointly agreed values and plans.*

## Discussion

The focus of our study remained on defining the CCE system with diverse stakeholder perspectives, rather than, for example, finding more concrete directions on the actualization of the drafted description—which is also our future research interest. However, exploring the possible implications of the suggested description—with reflections to existing research—brings us to present relevant suggestions to different levels of education: while basic education aims to teach CC through its universally agreed and actionable aspects, vocational education aims to teach field-specific competency that is applicable in given contexts and academic education teaches a more abstract and theoretical comprehension of CC and sustainability (broadly generalizing). Thus, considering CC and sustainability education as an entire system that is expected to bring about the necessitated sustainability changes appears to suggest that its effect comes through at least three different manners, perhaps regardless of the level of education in question. Firstly, through outcome-based education that focuses on practicable knowledge and skills that focus for example on the technical enactment of sustainability (Wynes & Nicholas, 2017). Secondly, through a more emancipatory education that aims to nurture the kind of expertise that could lead to ingenious solutions for sustainability that are beyond the current scope of known solutions but still within the acknowledged and emerging problematique of sustainability (Mochizuki & Bryan, 2015). And finally, through an educated epistemological and cultural shift that could be schematized to transform our very understanding of sustainability and its relation to the intent of human processes (Salovaara et al., 2021).

While this might seem apparent, considering the vastness and depth of research and practice related to CC and sustainability education, we see potential implications from this framing to the education system as a whole. On the one hand, there is a developmental trajectory along the recommended foci of the education based on the level on which it takes place: from basic and practicable, to more complex and abstract yet potentially transformative education. On the other hand, there is also a reciprocal trajectory between the problematique and human definition, comprehension, and practices, in teaching skills to enact the known strategies, developing competency to further elaborate on the very strategies and ultimately nurturing a mindset that is not only transformative but transformed. While constructing

a detailed plan for the trajectory can get counterproductively complex, our efforts point toward acknowledging this potential trajectory and how through it the hoped-for sustainability impacts can be achieved without complicating the subject at lower levels of education or losing relevance at higher levels. In a manner, CCE could indeed be seen as various other topics (e.g., math) that, while can have a uniquely intricate and abstract ends, can also be adopted in simple practices as well.

Discussion on the roles of knowledge and values in such an education system brought forth tensions between urgency of action and indoctrination. With the rise of post-truth and the polarization of public debate (e.g., Aasen, 2017; Bolsen & Shapiro, 2018), the discussion on how to mitigate climate change is sometimes shifted toward questioning the existence of anthropogenic climate change and whether or not any effort should be made to mitigate it (Tryggvason et al., 2023). Although, controversy about the existence of anthropogenic climate change is political and social—not scientific—as there is a well-documented scientific consensus on its causes and mechanisms (Bleazby et al., 2022). However, as climate change is a highly politicized issue, it is not surprising that CCE has faced charges of indoctrination (Bleazby et al., 2022). Thus, it should be acknowledged that indoctrination should not be a concern when teaching about the reasons and mechanisms of anthropogenic climate change, but rather it concerns the goals related to fostering the values, attitudes, and behavior of students. This type of tension between urgency of action and fear of indoctrination is summarized well by Wals:

*“On the one hand, there is a deep concern about the state of the planet and a sense of urgency that demands a break with existing un-sustainable systems, lifestyles and routines, while on the other there is a conviction that it is wrong to persuade, influence or even educate people towards pre- and expert-determined ways of thinking and acting.”* (2010, p. 150).

As educators might not be willing to move beyond teaching facts about climate change—in fear of indoctrination—a challenge to move toward comprehensive CCE emerges. Within the scope of this study, our view corresponds with, for example, Qablan et al. (2011) in suggesting that a more action-oriented approach could suffice in most cases; focus on what could be achieved and finding the shared values (Wals, 2010), equally and somewhat universally, from the outcomes seems like the most sensible way to advance. Schematically, one could also deduce that exercising a thorough systemic approach to these topics would likely lead to the kind of critical and reflective paths called for without approaching them necessarily from a values-point of view. To continue, whether the aim is to allocate time and funding for training teachers and updating curriculums of respective fields, or about how to facilitate teacher-parent meetings for mapping out the different yet shareable values under which the subject could be approached in actionable ways, or the task is about organizing co-creative education policy workshops that would address the topic on a national level—once again our belief is that the initial step is to recognize the necessity to plan the plural trajectory (Öhman, 2007), which could lead to better outcomes than simply hoping for the needed alignment to happen somewhat organically.

Based on the descriptions of competencies as well as the following discussion, we also recognized a tension between general cross-disciplinary competencies and more contextual and specialized field-specific competencies. As the most impactful changes often happen in specialized fields, it is crucial that solutions for CC adaptation and mitigation should be integrated into specific disciplines and industries. Thus, there is a need to define what CC competencies are within each field as well as within the educational and professional structures of that field. At the same time, CC mitigation and adaptation are wicked problems, which demand reconciliation of different points of views, tying together know-how from several fields, as well as merging various values and attitudes. Therefore, there is a need for cross-disciplinary perspectives, which can contribute to building such transversal competencies. The way in which stakeholders were balancing between the more knowledge-oriented CCE and the openly ideological action-oriented CCE can be seen in how the final description points out that CCE should be “knowledge- and content-oriented”, and at the same time it should empower students to take “concrete autonomous and communal action”. Although content-based shallow approaches and process-based participatory deep learning are sometimes seen as opposite ends of a spectrum (e.g., Warburton, 2003), in the competency-based visions for education both approaches can contribute to students’ ability and willingness to influence the status quo by taking purposive actions now or in the future (e.g., Wals, 2010).

In the final description, CC competency was described as a framework for holistic understanding and action including “receptive yet actionable understanding of the significance, causes and potential actions of climate change” as well as “complex knowledge acquisition and creation, critical thinking and argumentation, as well as emotional intelligence and communication skills.” The competencies emerged from this study predominantly echo the existing research on CC expertise (e.g., Siponen et al., 2024) and sustainability competency (e.g., Brundiers et al., 2021)—that have too been well schematized in educational practice for example by Wiek et al. (2015). They point out, for example, an issue in teaching the key competencies is that students ought to be at a fairly similar level of existing competency to the topic—which a more coordinated whole-educational system trajectory would actualize. While CCE is—in our study too—recognized to be highly interdisciplinary, the details to how this ought to be maneuvered, in for example, curriculum design or teacher training, was not specifically talked among the panelists—perhaps specifically because the interdisciplinary nature is somewhat expected and accepted. However, the trajectory along which the topic was envisioned to deepen or broaden could be taken as a rough scheme. At the earlier stages of education, likely in relation to both teacher education and curriculum, climate change and sustainability appear as a topic which get addressed in different primary subjects: whether talking about fossil fuels and carbon stock in science, or environmental and economic immigration in history, or exercising elemental ecocriticism in arts. Thus suggesting that the higher education stages then take upon introducing the subject in its systemic and field-specific nature: drawing bridges between the phenomena, their causes and how in the respective contexts this trajectory could be curbed toward more positive futures. In this vein, for example, Salovaara et al. (2020) analyzed from sustainability science programme curriculums, that majority of the topics acknowledged important to sustainability competencies can be—or are—by nature embedded, contextualized and/or latent to other topics: i.e., systems thinking is less often taught in its respective course but is present and exercised often at other courses.

The online eDelphi tool used in this study allowed the facilitators to collect the variety of panelists’ viewpoints without suppressing opinions not shared by the most confident participants (Bolger et al., 2011). This was especially important for the goals of the first Delphi round. In the second and third rounds, discussion between participants was encouraged by providing the option to comment on posts by other participants, although participation rate and activity varied between the rounds. As the eDelphi tool ensured anonymity, the participants could focus on what was being said, instead of who was saying it. Compared to face-to-face interaction, the online format might have reduced the amount and spontaneity of interaction between participants (Jordan, 2022). During the Delphi process as well as during the analysis presented in the results section, the researchers sought to remain impartial throughout each round of analysis and summarized interpretations of them. The validity of these interpretations was increased by having conversations between the facilitators as well as providing the participants opportunities to comment on the summaries provided by the facilitators between rounds—as typical of the method. As described in the methodology section, the goal of this study was to include a diversity of voices and perspectives (e.g., students, teachers, and experts on relevant research fields) on the Delphi study expert panel. Despite this, the number of participants and viewpoints was still limited. However, while another approach, such as the use of stakeholder surveys, could provide a wider range of opinions, the Delphi method seemed justifiable for the specific aim of exploring differing perspectives on the topic, which were later brought to cohesion. For future research needs, we suggest that a more detailed review of the currently employed CC and sustainability education strategies contrasted with the results of this study would be a relevant starting point. Another potentially groundbreaking study could take a longitudinal view on the impact of CC and sustainability education on students who are exposed to the topics throughout their elementary to higher education to further elaborate on the hypothesized trajectories in this study.

## Conclusion

The aim of this Delphi study was to shed light on the most relevant competencies in climate change education, and to conceptualize an education system to best teach them. The insights discovered by this

study came from an expert panel of diverse stakeholders, first representing the diverse views of education system participants from students to teachers, and planners to researchers, with the aim of getting them to cohere to one agreed-upon description of the climate change education system. For these aims, the Delphi method, the platform used to run the study, the chosen panelists and the presented prompts yielded relevant insights.

Through the expert panelists, we were able to distinguish the different foci and aims for CCE in primary, secondary and higher education; stemming from lower levels' actionable foundations of CC to the secondary and vocational educations needs for industry and context-specific utilization of CCE and to the (though not exclusive to) continuing and/or higher education where CC can be addressed by its exceedingly complex nature, also as a free-standing discipline—as a trajectory of complexity of sorts. The suggested CC competency was constructed to entail knowledge-oriented abilities, emotional capacities, and value-based views. The implications of such a description, predominantly as suggested changes to the education system, would require further collaboration between such stakeholders as teachers, planners, researchers, students and parents to, for example, allocate the needed resources to actualize the change and for acknowledging the joint values under which various actions can be aligned. Such collaboration could, for instance, aim at aligning cross-educational level curricula to have more comparable cohorts of students moving from one level to the next in the educational trajectory.

It was suggested that CC, and the sustainability thereof, ought to be addressed univocally and unambiguously by its causes, effects and needed mitigation and adaptation action. However, such homogenous perspectives also raised concerns on ideological issues, such as the risk of shallow sustainability comprehension and implementation by focusing on actionable education, or the risk of indoctrination with aims of educating certain world-views, or the risk of furthering societal polarization with such a potentially hegemonic education—which we, finally, suggest to be best managed by approaching the issues in an critically systemic manner, and by not only allowing, but to actively inviting differing plural value-viewpoints to be engaged in the process.

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## Ethical statement

This study was performed under ethical guidelines from the University of Helsinki. However, explicit review by ethical research board for this study was not mandatory.

## Disclosure statement

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