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Barriers and Enablers of Interdisciplinary Climate Education: Insights From Secondary Teachers

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Abstract

Teachers are at the front line of climate change education (CCE), working to integrate its complex environmental, social and ethical dimensions into their classroom practice. Yet little is known about the barriers to and enablers of implementing interdisciplinarity within CCE. This study investigates Finnish secondary school teachers' perspectives on interdisciplinary CCE, examining how their practices are shaped by access to resources, training and institutional support. Drawing on the ecological model of teacher agency, we conduct a mixed-methods analysis from a national survey of 243 teachers. The findings reveal a strong commitment to locally relevant and ethically informed CCE, as well as an increased interest in activities in outdoor environments, research-based resources and drama-based resources. On the other hand, an increased disinclination to introducing new content and resources highlights the persistence of structural, epistemological, and ideological barriers. Teachers report relying heavily on self-directed learning and growing interdisciplinary fatigue due to fragmented support systems. These dynamics reveal a need for academic-school collaborations that move beyond top-down implementation and towards the creation of accessible, adaptable knowledge. This study contributes to emerging debates about how to foster critical interdisciplinarity in CCE by centring the voices and agency of educators.

Keywords: agency; climate change education; curriculum integration; environmental education; interdisciplinarity; secondary teachers

Introduction

“We should be talking about the change that is happening now. In addition, the topic is viewed too globally in our society in general. It should be looked at more closely, so that it becomes more concrete. Another challenge is how this is force-fed into everything, leaving no creative space for the teacher to incorporate it appropriately into teaching, making it a constraint for everyone. Which is the most common reason for failure to create a clear and relevant approach to the subject.” (T 554)

Climate change is an interdisciplinary subject, with its impacts extending across environmental, social, economic and political domains. As emphasised in the latest IPCC report (IPCC AR6,), enhancing climate change literacy is a critical social policy objective, as it equips

individuals and institutions with the knowledge and skills necessary to implement adaptation and mitigation measures. Climate change education (CCE)¹ plays a central role in this process, fostering an understanding of climate impacts and actions needed to change the course of events. However, while increasing knowledge is essential, one of the key questions in CCE is to consider what knowledge drives meaningful climate action, who is involved and how they are involved in knowledge production (Rousell & Cutter-Mackenzie-Knowles, 2019; Yli-Panula *et al.*, 2022; Hakkarainen *et al.*, 2024). In this light, many countries are increasingly prioritising CCE as part of their broader sustainability agendas. The Nordic region has set ambitious goals to become the most sustainable and integrated region in the world, in part by strengthening the relationship between education, research and innovation (Nordic Council of Ministers, 2020). Finland offers a particularly relevant case to research, with an education strategy for 2030 that includes learning for sustainability at pre-primary, primary and secondary education levels, focusing on an action-oriented and holistic approach (European Commission, 2024).

Despite the importance of interdisciplinary climate education, teaching climate change through an interdisciplinary framework is confronted by multiple barriers, including subject compartmentalisation, and institutional and time constraints (Czerniak & Johnson, 2014; Hammond, Fargher & Walshe 2024). Traditionally, CCE has been heavily associated with STEM subjects (science, technology, engineering and mathematics), particularly biology and geography (Monroe, Plate, Oxarart, Bowers & Chaves 2017; Cantell, Tolppanen, Aarnio-Linnanvuori & Lehtonen 2019; Sund & Gericke, 2020), often reducing it to a scientific or environmental discourse rather than integrating the socio-political, ethical and cultural dimensions necessary for a comprehensive understanding of climate issues. While research has explored barriers to interdisciplinary education more broadly, fewer studies have specifically addressed the barriers to implementing an interdisciplinary approach to climate change from a teacher's perspective of their own agency, nor the enablers of this approach (Borg, Gericke, Höglund & Bergman 2012). Biesta & Tedder's (2006) ecological model sees agency not as something teachers simply have, but as something they achieve through the interaction of their experiences, available resources and institutional structures. Therefore, rather than viewing teachers as automatic "agents of change," it is important to consider the conditions that shape and limit their agency in interdisciplinary teaching and environmental education at large (Saari *et al.*, 2024).

A critical approach to agency is also necessary for assessing interdisciplinarity, which is considered to be an essential feature for driving meaningful climate action (Jones *et al.*, 2010; Lehtonen *et al.*, 2019; Schipper, Dubash & Mulugetta 2021; UNESCO, 2024). The same approach is shared by the Finnish national educational guidelines (Opetushallitus, 2019; Kuusela *et al.*, 2023), which advocate for the integration of CCE elements across all subjects. The national curriculum for secondary schools emphasises the importance of *ethics and environment* as one of the six competencies that permeate secondary education, reflecting a holistic approach to environmental literacy. However, despite the increasing global demand for high-quality climate education, significant gaps remain. A recent UNESCO (2024) report found that 47% of national curriculum frameworks in 100 countries make no reference to climate change; even when present, climate topics are often addressed in a fragmented or superficial manner (Eilam, 2022). Addressing these complexities requires moving beyond policy frameworks to understand how

¹The authors are aware of the interconnection and overlapping between similar fields, such as education for sustainable development, sustainability education, environmental education, among others. Considering the context of upper secondary education, we believe climate change education is the field which aligns better with our research questions, which revolve around climate change as a complex socio-ecological issue. Climate change education is also promoted by UNESCO (see at: <https://www.unesco.org/en/climate-change/education>). Pedagogically speaking, we believe that "climate change education aims at critical thinking about consumerism, human identity as a consumer, and prevailing ways of pursuing happiness pushed by globalisation, capitalism and advertising. Climate change education aims at increasing awareness of interconnectedness, post-material well-being, clarifying the goals of education and life as to meaning and purpose" (Lehtonen *et al.*, 2019). However, this present study will also consider studies conducted in the above-mentioned fields.

teachers themselves experience and implement interdisciplinary CCE in practice. In the Finnish context, these challenges intersect with a curriculum that is, on paper, strongly supportive of interdisciplinary and action-oriented climate education. Beyond the curriculum, recent initiatives such as the Teachers' Climate Change Forum and the Academy of Finland's ClimComp project illustrate efforts to translate this mandate into pedagogical practice (Siponen et al., 2025). These developments align with a broader international emphasis on equipping young people with the competencies needed to act on socio-ecological challenges – as highlighted in the OECD's framing of "agency in the Anthropocene" (White et al., 2023) – making the teachers' role in enabling these competencies a crucial area of investigation.

In this study, we examined the conditions that serve as barriers to and enablers of Finnish upper secondary school teachers' agency to integrate interdisciplinary CCE into their work. By analysing the teacher's perspectives of their agency at a national level and across subjects, this research provides a comprehensive foundation for addressing systemic challenges and fostering a more holistic approach to climate education. The research addresses the following objectives:

1. To examine whether, how and to what extent teachers support interdisciplinarity in CCE.
2. To explore how teachers' access to resources, training and institutional support hinder or enable their implementation of interdisciplinarity in CCE.

Theoretical background

Interdisciplinary climate change education: barriers and enablers

Climate change, recognised as a "wicked problem" (Rittel & Webber, 1973), requires educational strategies that transcend traditional boundaries between disciplines to gain a holistic understanding of real-world problems and to foster agency (Sjöblom et al., 2023). UNESCO's 2024 report underscores the importance of such an approach, particularly at the upper-secondary level. Broadly speaking, interdisciplinarity can be considered to be "the synthesis of two or more disciplines, establishing a new metalevel of discourse" (Klein, 1990). However, this understanding is complicated by the diversity of purposes and degrees of integration within interdisciplinary practices, creating a tension between instrumental and critical interdisciplinarity (Klein, 2017). Instrumental interdisciplinarity focuses on pragmatic problem-solving for specific sectors, while critical interdisciplinarity interrogates the structures of knowledge production itself, challenging traditional boundaries between disciplines and addressing social justice and inclusion.

This tension is particularly relevant in the context of CCE, which has been criticised as climate change "appears in the school curricula in a tokenistic form, commonly fragmented and dispersed among subjects and subsumed as an undefined topic under the undefined notion of *sustainability*" (Eilam, 2022, p. 232). As scholars have argued (Borg et al., 2012, 2014; Hill & Dymont, 2016; Howard-Jones et al., 2021), studying teachers' integration of sustainable development across all subjects is crucial, as research has largely focused on geography and science teachers. The importance of an integrated climate education is mirrored by the Finnish educational system, which embedded the ethical and environmental competence as a cross-curricular theme for secondary education.

In secondary schools, the extent to which interdisciplinarity is implemented remains highly variable, often constrained by subject traditions, institutional frameworks and teacher preparedness. Research on Finnish lower secondary school teachers highlights that teachers' engagement with sustainability education varies significantly depending on their subject discipline (Uitto & Saloranta, 2017), with biology and geography incorporating sustainability concepts more frequently than other fields. A systematic review by Tonnetti and Lentillon-Kaestner (2023) confirms these trends; despite the support for interdisciplinary approaches, their actual

implementation in schools is limited by teachers' identities of their scholarly disciplines, and a lack of institutional support.

Many scholars have studied the barriers teachers have to face in interdisciplinary or climate change teaching (see Czerniak & Johnson, 2014; Parry & Metzger, 2023 in the latter case). However, fewer studies have specifically investigated the barriers to teachers' encounters, and the enablers of them, when implementing an interdisciplinary approach to climate change, particularly from the perspective of teacher agency. Some of the most known barriers are subject compartmentalisation and time constraints, when the workload leaves little room to integrate or change the curriculum (Borg *et al.*, 2012; Taylor *et al.* 2019). Many studies investigate teacher education regarding environmental or sustainability education and highlight other general challenges, such as training, as teachers' lack of knowledge is considered to be a significant hindrance to student learning (Hart & Nolan, 1999; Taylor *et al.*, 2019). Parry and Metzger (2023) mention a UNESCO survey of 58,000 primary and secondary teachers (UNESCO, 2021), highlighting how a quarter of teachers do not feel ready to teach themes related to sustainable development, and more than a third of respondents do not have tools or guidelines for assessing interdisciplinary topics. Other studies consider a particular section of teachers, such as geography: some general challenges were again complex topics with limited time resources and rigid curricula (Corney, 2006), while a specific barrier is the value-alignment between educational objectives and societal values, as well as the challenge to impact state-imposed guidelines (Hammond *et al.*, 2024). Overall, it is clear that despite institutional support for interdisciplinary teaching, the support structures and resources are often missing, making it difficult for teachers to go beyond surface-level integration.

Analytical framework: the importance of teacher agency

To operationalise teachers' agency, we drew on the ecological model of teacher agency proposed by Priestley *et al.* (2015), according to which teachers' decision-making is a complex temporal-relational phenomenon. This model has been applied to CCE (Sihvonen *et al.*, 2023), but with a limited number of teachers, and without a specific focus on interdisciplinarity. In this model, the agency identified by Biesta & Tedder (2006) emerges from the interplay between individual efforts, the resources available and contextual and structural factors. An ecological conceptualisation of agency highlights the importance of enablers and barriers of the school environment, instead of relying only on an innate capacity. Teachers' agency is embedded within the local community (Pyhäältö *et al.*, 2014).

Priestley *et al.* (2015) conceptualise teacher agency as constituted by three key dimensions: iterative, projective and practical-evaluative. The iterative dimension consists of past personal experiences, but it also includes beliefs and values, which influence teachers' willingness and capacity to integrate CCE (Biesta *et al.*, 2015; Howell & Allen, 2019). The projective dimension concerns the short- and long-term objectives, meaning that aspirations can be instrumental (e.g., meeting curriculum requirements) or value-driven (e.g., supporting students' climate literacy). Priestley *et al.*, have warned about the impact of managerialism in education as adding pressure to teachers on what are legitimate and productivity-oriented goals. These two dimensions finally lead into the third practical-evaluative one, which consists of the cultural, structural and material aspects of the daily teaching practice. This includes the availability of resources, time and institutional support for interdisciplinary teaching. In our study, this model guided the design of our survey: we investigated teachers' access to resources and training, their perceived institutional support and their opportunities for participatory practices, since prior research has highlighted that such elements are often inadequate despite being critical for fostering interdisciplinary teaching (Castellazzi *et al.*, 2024; Li *et al.*, 2021; Monroe *et al.*, 2017; Schipper *et al.*, 2021). The key aspect of the approach by Priestley *et al.*, is twofold: i. agency does not depend only on inner

personal characteristics but is also shaped by the availability of resources and ii. agency thrives on, or is hindered by, contextual cultures of thinking, working and doing, as well as broader structural factors.

Materials and methods

Study area, sample and data collection

The data for this study were collected from May to September 2024 in Finland, through an online survey format prepared and launched by Taloustutkimus, a private company. Schools were selected by region, and if a selected school declined, it was replaced by another within the same area (NUTS-2 or NUTS-3). Taloustutkimus, on behalf of the University of Helsinki, requested permission from school principals and facilitated recruitment by contacting principals and vice principals to obtain teachers' contact details and distribute survey invitations. Additional contact information was retrieved from school websites. Teachers were invited to participate primarily during working hours, making schools the main point of contact. Data were collected via Taloustutkimus' own system, which implemented the survey provided by the authors. To protect privacy, the system did not log IP addresses. Personal information was stored on a separate secure register server with an audit trail. Teachers were contacted by email, and responses were stored using a pseudonym. Before secure transfer to the university, all identifiers were removed to ensure full anonymisation. To boost response rates, participants could enter a raffle for three €100 gift cards.

Survey technique

The survey explored aspects of interdisciplinarity in CCE, including perceptions of teaching content, activities, resources and training (full survey in Appendix 1). Design began in January 2024 and was iteratively revised following feedback from the corresponding author's research group. Qualitative questions complemented quantitative data where more detailed insights were needed. Participants received project information, data storage details and provided informed consent before beginning. They were informed of their right to withdraw at any time and could complete the survey in Finnish or English.

The survey consisted of four sections - teaching content, conceptual tools and resources, training and support, demographic information - which included both open- and close-ended questions (Table 1). Following the Priestley et al. (2015) model, each section combined elements of the practical-evaluative agency dimension (cultural, structural, material) to the impact of experiences (iterational dimension) and future preferences and objectives (projective dimension). In this study, eight of the 14 items were used. The survey design was inspired by the survey conducted by University College London (UCL) on the state of climate change and sustainability education in England (Greer et al. 2023), particularly for the choice of elements related to activities and training, and by the national curriculum for Finnish upper secondary schools (Opetushallitus, 2019). The barriers to climate education identified build on those highlighted in previous research (among others, Borg et al., 2012). At the end of the survey, we provided participants with the option to leave their contact details to receive) a report on the survey results and b) future opportunities connected to this study.

Data analysis

In this study, we employed a mixed-methods approach, combining quantitative statistical analyses with the IBM SPSS software and qualitative thematic analyses (Table 2). This methodological approach allowed for a nuanced understanding of both teachers' perspectives and the structural

Table 1. The survey's sections, content summary and question types

Survey section	Content	Question type
Teaching content	<i>Relationship between climate change, biodiversity, and justice; barriers in interdisciplinary CCE</i>	binary, open
Conceptual tools and resources	<i>Perspectives on climate change education; current resources used in teaching and future desires; frequency of climate-change-related participatory activities.</i>	Likert scale, multiple choice
Training and support	<i>Past training received and desires for the future</i>	Likert scale
Demographic information	<i>Gender, age, municipality, subject taught</i>	single-multiple choice

Table 2. Survey's data analysis approach and related methods

Research Focus	Data Type	Analysis Methods
Socio-demographics & Representativity	Quantitative	Descriptive statistics
Teachers' perspectives on interdisciplinary CCE	Quantitative & Qualitative	Descriptive statistics, Mann-Whitney <i>U</i> test, Deductive thematic analysis
Perceived barriers to interdisciplinary CCE	Quantitative & Qualitative	Descriptive statistics, Mann-Whitney <i>U</i> test, Inductive thematic analysis
Enablers: resources, practices, training	Quantitative	Descriptive statistics, Independent samples <i>t</i> -test, Mann-Whitney <i>U</i> test, Logistic regression

factors influencing interdisciplinary CCE implementation (Creswell & Plano Clark, 2018). While we considered and reported occurrences in the thematic analysis, we dispute the logic which says that “more is better”, as a reflective thematic analysis posits for research based on constructions rather than truths (Braun & Clarke, 2021).

The survey collected socio-demographic data on age, gender, subject area and geographical representation. We used descriptive statistics to assess the sample's representativity. To address the first objective, how teachers perceive interdisciplinarity in CCE, we conducted descriptive statistical analyses, followed by a Mann-Whitney *U* test to compare responses between those who apply interdisciplinary approaches and those who do not. We also applied deductive thematic analysis (Braun & Clarke, 2021) to open-ended responses to examine how teachers conceptualise interdisciplinarity. For the second objective, identifying barriers to interdisciplinary CCE, we analysed perceived challenges by using descriptive statistics. A Mann-Whitney *U* test was conducted to compare reported barriers across groups. We then applied inductive thematic analysis (Clark *et al.*, 2021; Creswell, 2018) to explore additional barriers from open-ended responses, using open, axial and thematic coding grounded in participants' language. Regarding enablers of interdisciplinary CCE, we assessed resource availability, training and collaborative practices through descriptive statistics. We conducted an independent samples *t*-test to analyse differences in resource use, and a Mann-Whitney *U* test to compare interdisciplinary activities. Finally, we used logistic regression to predict the likelihood of teachers implementing interdisciplinarity based on their training.

Results

Socio-demographics and representativity

We obtained 243 survey respondents, of which 65.4% identified as female, 30% as male and 4.6% preferred not to say. The age distribution of respondents shows a predominance of middle-aged and older participants, with the majority aged between 50–59 years (34.2%) and 40–49 years (22.8%). Participants aged 60 or above accounted for 19.4%. Younger respondents were less represented, with 20.7% for 30–39 years and those under 30 making up 3%. The sample presents a strong presence of mid- to late- career teachers, consistent with the age distribution, but also includes a mix of both newer and very experienced teachers.

The most taught subjects among respondents were mathematics (43 teachers, 17.7%) and biology and geography (42 teachers, 17.3%), followed by second national language and foreign languages (39 teachers, 16.0%) and history and social studies (34 teachers, 14.0%). In contrast, the least taught subjects were music (eight teachers, 3.3%), physical education (nine teachers, 3.7%) and visual arts (ten teachers, 4.1%). The median number of subjects taught by each teacher was one, with a maximum of five subjects, reflecting a predominance of specialisation.

The NUTS3 (Nomenclature des Unités Territoriales Statistiques) region with the highest number of respondents was the Helsinki Capital region, accounting for 56 respondents (23.6%), followed by the Tampere region, with 48 respondents (20.3%). Tampere alone accounted for 24 respondents (10.1%), making it the single largest contributing municipality in the survey. The capital Helsinki ranked second among municipalities with 19 respondents (8.0%), leading only when considered as part of the Helsinki Capital Region, with Espoo and Vantaa (9 and 6 respondents, respectively). Another important hub of participants was Oulu, located in Northern Ostrobothnia, which contributed 13 respondents (5.5%).

Teachers' perspective on interdisciplinary CCE

Out of 243 respondents, 60.5% of teachers reported to include interdisciplinary content in their teaching related to climate change, biodiversity and/or justice. No significant differences occur in the inclusion of interdisciplinarity among the groups of social and natural sciences, neither for gender, age group, nor geographical region. Those who answered positively were asked to give an example of interdisciplinary content, and most teachers (53%) reported integrating all three aspects of climate change, biodiversity and justice. When only two elements were combined, climate change was most frequently associated with justice (33%, compared to climate change and biodiversity 14%).

Teachers reported various ways of incorporating interdisciplinary approaches, including curriculum connections, collaborative projects and external partnerships. Eight teachers explicitly noted that these three elements are embedded in the biology and geography curriculum. Only one case involved a joint study course combining history and geography (HI1/GE1). Others described colleague collaborations: for example, a course in which physics, chemistry and geography teachers guided students in designing a sustainable village, integrating biological features, industry, energy production, and social sustainability. Interdisciplinary links also emerged in less expected subjects, such as guidance counselling, in which students examined the ethical dimensions of global trade and career choices. Through case-based discussions, they assessed job opportunities and reflected on the social and environmental impacts of consumer demand, such as fast fashion marketing to youth.

The survey results revealed significant differences in how secondary school teachers approach CCE, particularly between those who include interdisciplinarity in their teaching and those who do not (for the complete table, see Appendix 2). Among teachers who incorporate interdisciplinarity, there was a strong consensus that CCE should be a collaborative effort, with significantly higher agreement compared to their non-interdisciplinary colleagues (Mann-

Whitney $U = 5202.00$, $p < 0.001$). These teachers were also more likely to support integrating emotions and well-being into CCE ($U = 5043.50$, $p < 0.001$), reinforcing the importance of addressing climate anxiety and mental health. Furthermore, interdisciplinary teachers strongly advocated for embedding environmental justice within CCE ($U = 5634.50$, $p = 0.003$) and recognised that power and politics cannot be separated from CCE ($U = 5882.50$, $p = 0.016$). On the other hand, non-interdisciplinary teachers were significantly more likely to favour making CCE as a separate subject with a dedicated time slot ($U = 5868.00$, $p = 0.022$), indicating a preference for compartmentalisation rather than integration. They were also more likely to feel that they could not take responsibility for teaching CCE, whereas interdisciplinary teachers expressed greater confidence in their ability to address climate change topics ($U = 4146.00$, $p < 0.001$). Both groups generally agreed on the importance of incorporating local examples of good and bad practices into CCE (70.4%) and shifting the discourse toward a more hopeful and solution-oriented approach (63.4%), though these responses did not differ significantly between the two groups. Overall, the results indicate that interdisciplinary teachers are more committed to embedding CCE into various subjects, recognising its emotional, social and political dimensions.

Perceived barriers to interdisciplinary CCE

The responses reveal several perceived barriers to integrating CCE. Time constraints were prominent: 71.6% of teachers agreed or strongly agreed that they lacked time for external collaborations or alternative activities, and 37.5% reported insufficient time to integrate climate topics. Only 10.3% expressed frustration with these topics, suggesting that emotional resistance is minimal. Most (89.3%) rejected the idea that climate science is weak or confusing, indicating confidence in its scientific basis; similarly, collaboration between colleagues was not widely seen as a barrier (74.1% disagreeing or remaining neutral). Additionally, 29.6% reported a need for more training in climate science, and 32.1% in pedagogy.

To contextualise these results in the light of interdisciplinarity teaching, it is important to highlight that the Mann-Whitney test revealed significant differences between teachers who include interdisciplinary content in their teaching and those who do not (for the complete table, see Appendix 3). Teachers not incorporating interdisciplinarity generally experienced more frustration ($p = 0.002$), tended to view climate change as a complex and confusing topic ($p = 0.002$) and identified significantly more internal time constraints ($p = <0.001$). On the other hand, no significant differences were found between the two groups regarding the need for targeted training, pedagogical methods training, or collaboration with colleagues.

We also coded the barriers noted in the “other” category (Table 3). The most cited barriers were curriculum constraints, time constraints and emotional reactions (such as frustration and anxiety). The three major themes that we identified were structural barriers, meaning how institutional and logistical structures shape teaching practices, epistemological and pedagogical barriers, stemming from knowledge frameworks and pedagogical limitations, and finally political/ideological and emotional barriers, capturing the socio-political and emotional dimensions of climate education.

Curriculum constraints emerged as a dominant structural barrier, with teachers emphasising that existing subject curricula are already densely packed. As a result, there is little room for integrating CCE with the depth it requires. Many teachers expressed frustration that they must prioritise covering foundational content, therefore having limited flexibility to incorporate their subjects with climate perspectives. Related to subject compartmentalisation, some teachers, particularly those in disciplines such as mathematics or music, perceived their subject as being less suitable for integrating climate change content. Others acknowledged the opportunity to incorporate it, but at the expense of other curricular topics they consider more essential: *“In my own subjects (history and social studies), climate issues are sometimes a bit of a pushover. I will not*

Table 3. Qualitative analysis for barriers perceived by teachers

Perceived barriers	Open-ended statement	Occurrence
Structural		38
Curriculum constraints	<i>In high school, the contents of the courses are already completely full, so it is almost impossible to include the contents of that course that are not related to OPS, even if it is otherwise a general goal in the curriculum.</i>	19
Time constraints	<i>There is no time for in-depth processing in high school.</i>	13
Relevance/subject fit	<i>The mathematics curriculum already has more than enough mathematics topics to cover; it doesn't make sense for any outsider to waste time on this</i>	9
Limited resources	<i>A small town does not necessarily have opportunities, e.g. to bring in external lecturers / activity organisers.</i>	8
Content overlap	<i>Fragmentation of information in the curriculum, overlapping subjects</i>	2
Epistemological/ pedagogical		21
Collaboration between teachers	<i>Teachers of different subjects consider the way teachers of other subjects deal with the subject too foreign to them for natural cooperation to arise. E.g., Geography teachers do not value social and/or ethical treatment of the subject.</i>	7
Student-related barriers	<i>The teaching groups are large, young people do not always want to discuss or share their opinions</i>	5
Framing of CC	<i>Textbooks have a very one-sided approach. They do not consider new research on biodiversity. Broilers have been made good, even though they eat soya and are, along with farmed fish, the number one pest of biodiversity.</i>	4
Complexity of the topic	<i>An in-depth treatment is impossible, because only the basics of science are studied in high school.</i>	4
Lack of training	<i>Nobody offers didactic training for teachers. Everything else is available, but training related to the content of the studies cannot be found anywhere.</i>	1
Political/ ideological/ emotional		27
Emotional reactions	<i>The subject is boring. We should come up with some new ways to look at it. Blaming doesn't work.</i>	11
Action-value dissonance	<i>We often discuss with the teachers how, for example, sustainable lifestyles are functionally considered in different subjects. Even more important are actions, what is the operating culture of the school, and do we talk about values as a community.</i>	5
Political influence	<i>Climate hysteria stresses some young people. The purpose of the school is not to incite panic, nor to spread political propaganda.</i>	5
Disinterest	<i>Many of the colleagues do not see the seriousness of the matter, and do not make any changes in their lives related to the subject</i>	3
Denialism	<i>Some of the students' families have negative attitudes related to climate change, which affect the attitudes of the students as well (e.g. they deny the existence of climate change, or think that these things do not need to be taught, because they are unnecessary green talk)</i>	3
		99

give up teaching about the Spartan oligarchy or Joan of Arc at the expense of covering long stretches of environmental destruction in the Middle Ages or the desertification of the Sahara.”

These themes are not rigidly separated. For instance, the lack of collaboration between teachers may be linked to structural barriers such as time constraints or stringent curriculum requirements.

However, epistemological and pedagogical barriers capture the challenges in framing climate change, alone or collaboratively, and teaching it purposefully

“We should talk about the change that is happening now. In addition, the theme is generally viewed too globally in our society. The examination should be closer to our society so that it becomes concrete. In addition, the challenge is how this is forced into everything, and the teacher does not have any creative space to include it appropriately in the teaching, which makes it a must-have for everyone. What is the most common reason for failure to create a clear and important approach to the subject.”

The space for creativity, directly mentioned by two respondents, is particularly interesting for analysis, as it can be linked to the problem of having a packed curriculum with no space for more than the basics, creating irritation and frustration if the continuing requests of fitting climate change in all the subjects persist. As a respondent put it, *“I feel like I’m a puppet on these climate issues, and I’m repeating the material of the mainstream media.”* teachers described feeling constrained by external requirements while navigating a complex topic with uncertain collaboration from students. Layered onto this are political, ideological, and emotional pressures that shape teachers’ sense of agency — how they perceive their ability to promote positive change. Emotions such as anxiety, frustration, boredom, guilt, tiredness and even hysteria, were mentioned, affecting not only teachers but also students and families, often linked to broader political contexts and a sense of disenchantment. Teachers reflected on the challenge of moving from guilt-based content to a future-oriented, hopeful vision — questioning whether such a shift is even possible

“[...] Teaching climate change prevention is generally a bit silly in a small town, in the sense that when everyone drives everywhere all the time (adults and young people) and everyone eats meat, the whole surrounding society works completely opposite to ‘ecologically’. So, society works differently than the teacher says: the contradiction is so incredible that it seems silly to wonder how a sustainable society should work. And this matter is not particularly improved by the current government, and it looked even worse when we had a red-green government, which also did nothing in particular.”

Enablers: resources, practices, training

The analysis is based on current versus desired resource use in CCE, which revealed clear gaps and opportunities. Teachers most often used textbooks, news media, videos, films and talks - reflecting a reliance on traditional and multimedia materials. However, the preferred future use showed notable shifts (Figure 1). Interest in outdoor environments doubled (14.8–29.6%), while university-developed resources rose from 14.0% to 25.9%, and drama-based methods (such as theatre, role-play) from 7.4% to 13.6%. More modest increases were seen for external online resources (15.6–19.8%), debates (12.3–16.0%) and self- or colleague-developed materials (19.5–23.0%). In contrast, some resources declined in preference. Textbook use dropped sharply (76.5–10.7%), followed by news media (63.8–21.0%) and videos/films (56.8–41.2%). Art-based methods saw a slight decline (21.4–18.5%). Strikingly, the preference for using no resources at all rose from 4.9% to 21.8%, suggesting that a growing number of teachers might have felt overwhelmed or disengaged from CCE.

Teachers implementing interdisciplinary content drew significantly more on compound resource use, compared with those relying on the content of the discipline ($t(241) = 7.057, p = < 0.001$). Furthermore, there was a moderate negative correlation ($r = -0.324, p < 0.05$) between teachers’ perceived access to resources and the barriers they face in interdisciplinary climate

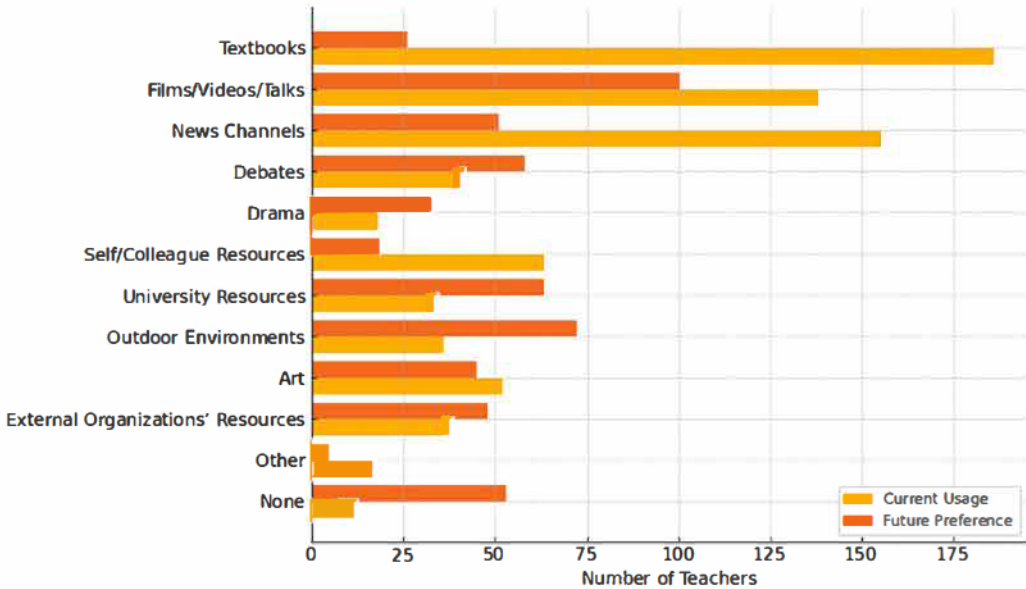


Figure 1. Comparison between current usage and future preference of resources in CCE.

change teaching. This suggests that as teachers perceive greater access to resources, they report encountering fewer barriers. This finding underscores the importance of resource availability in mitigating challenges such as time constraints, difficulties in collaboration and pedagogical gaps.

Teachers commonly drew on participatory climate change activities. Discussions about personal agency, including life histories and actions for change, were relatively common, with 67% engaging in them at least occasionally. School environment projects (47.7%) and student involvement in decision-making (56%) also reflected a willingness to use interactive, student-led approaches. However, collaboration remained limited. Only 25.1% reported engaging in joint planning with colleagues, and arts-based collaborations with colleagues or external partners were rare, with 79.8% reporting little or no involvement. External engagement was similarly underused: 69.2% of teachers rarely or never organised visits to environmental centres, museums, or conservation areas, and 85.2% had little or no participation in citizen science projects.

We found a significant difference in engagement with compound activities between teachers who use interdisciplinarity content and those who do not ($U = 4604.5$, $Z = -4.584$, $p = <0.001$). Surprisingly, teachers who did *not* use interdisciplinary content had a significantly higher mean rank ($M = 147.54$) compared with those who did ($M = 105.32$), indicating that the first group reported engaging in a greater number of activities. This result is in line with the weak positive correlation between barriers and activities: teachers who faced more barriers tended to report engaging in more activities ($r = 0.257$, $p < 0.05$).

Teacher training on climate change revealed important areas for improvement. The most common form of training was self-initiated research with 66.6% engaging at least occasionally and 12% very frequently. Formal exposure during teacher education was limited, as well as employer-provided training, respectively, with 74.4 and 63.2% rarely or never encountered these opportunities. External organisations offered slightly more, with 55% participating occasionally or more in training from teacher associations or environmental groups. Both self-initiated research and external training were linked to a greater likelihood of incorporating interdisciplinarity (respectively $p = < 0.001$ and $p = 0.015$, for the complete logistic regression analysis see appendix 4). These tendencies are confirmed by future support needs: only 30% desired continuous training, while more favoured help in finding teaching materials (47.3%), collaborating with colleagues (44.7%), or

partnering with academic or external actors (47.6%). Time allocation remained crucial – 69.2% believed training should occur during working hours.

Discussion

This study identified several barriers and enablers to the implementation of CCE. While the ecological model of teacher agency emphasised the temporal dimensions of agency, our focus on interdisciplinarity required a shift in emphasis from *when* people enact agency to *how* it is shaped. In our interdisciplinary model of teacher agency, we highlight the continuum between individual and societal levels, where structures and resources actively shape and constrain agency. This expanded framework allows for a more targeted analysis of how teachers' capacity to implement interdisciplinary CCE is facilitated or hindered by institutional conditions, access to materials, professional development opportunities and participatory practices (Figure 2).

Figure 2 illustrates how structures — comprising teachers' personal beliefs, values and conceptual understandings (individual structures) as well as the institutional training and support systems that shape professional practice (social structures) — form the foundation upon which interdisciplinary teaching is built. However, structures alone are insufficient; their actualisation depends on the availability and accessibility of resources. Teaching materials, pedagogical tools and curricular content influence how interdisciplinarity is implemented in practice (individual resources), while collaborative activities, participatory approaches and professional networks create opportunities for interdisciplinary engagement beyond the individual classroom (social resources). By recognising the interdependence of individual and social dimensions, this approach avoids both an overly socialised perspective — limited to institutional analysis — and a hyper-individualised one that isolates practices within disciplines or teacher resources from their wider context. Below we discuss our findings drawing on the four dimensions of the framework, giving prominence to the barriers and enablers they bring forward.

Individual structures: values and experiences

Teachers' conceptualisations of interdisciplinarity play a key role in shaping CCE. The results indicate that well over half of teachers (60.5%) incorporate interdisciplinary elements into their teaching, with no significant differences based on subject area, gender, or location. This percentage, although self-identified, shows a higher proportion compared to previous studies. (Twenty-five per cent of Swedish upper secondary teachers used interdisciplinary work in the (2012) study by Borg *et al.*, with few occurrences being reported by Monroe *et al.*, 2017). This aligns with previous studies suggesting that interdisciplinary engagement is not necessarily discipline-specific, but rather, is shaped by pedagogical orientations (Borg *et al.*, 2012). However, there are differences in how some subjects consider CCE to be a natural part of their curriculum, as shown in previous studies focusing on STEM, geography and biology (Monroe *et al.*, 2017; Cantell *et al.*, 2019; Sund & Gericke, 2020), while others, like history teachers in this study, viewed it as a stretch that takes space away from core content. Teachers who reported implementing interdisciplinary content tended to align conceptually with Klein's critical interdisciplinarity (2017), viewing CCE as a collaborative effort for addressing environmental justice and power dynamics. The impact of justice and power is increasingly recognised by both scholars and practitioners (Chandler *et al.*, 2024; Trott *et al.*, 2023), although research on how to facilitate CCE through conservative or opposite worldviews is still limited (Long *et al.*, 2021).

Social structures: institutional support and training

This study highlights the impact of societal and school structures on the teachers' personal beliefs and teaching choices. Teachers' frustration stems less from the climate content itself, but more from the contradiction between CCE values and determinate trends in society and politics, such as

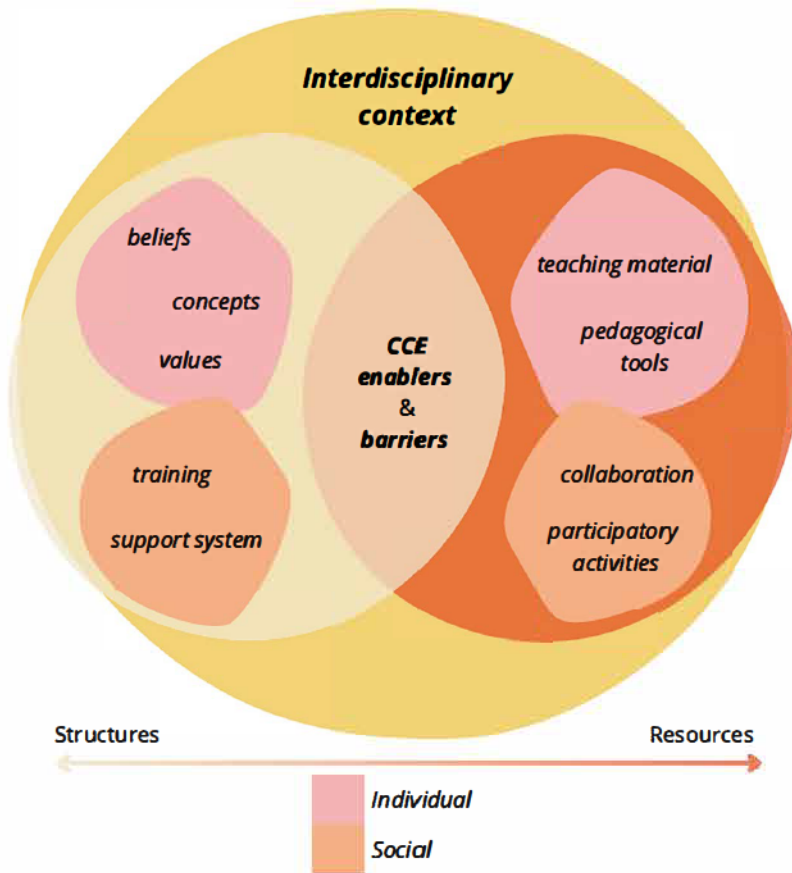


Figure. 2. Interdisciplinary model of teacher agency adapted to evaluate CCE.

greenwashing or denialism. As argued in the ecological model of teacher agency, agency does not emerge solely from an inner motivation on what is “good”, so a critical interdisciplinarity is threatened by external factors that influence our belief system and our emotional reactions. Hammond et al. (2024) already exposed the misalignment between educational objectives and societal values, a barrier that is confirmed in this study through the double barrier of a. feeling a lack of reflection time on grounding values for the school community (recalling Klein’s instrumental interdisciplinarity) and b. a dissonance between the values proposed by CCE and the surrounding society. This dissonance or misalignment provokes emotions in both teachers and students, a dimension that has been increasingly acknowledged in recent research, with educators reporting frustration, sadness, and anxiety in the context of climate education (Clayton et al., 2024; Verlie, Clark, Jarrett & Supriyono 2021). Likewise, students’ emotions are influenced by their communities, especially when family narratives reflect denial or apathy (Bryan, 2020). Teachers engaged in interdisciplinarity recognise this emotional context and actively integrate it into their practice — in line with research showing that acknowledging and supporting students’ emotions enhances the impact of climate education (Ojala, 2015; Verlie et al., 2021).

This tension between individual and societal values aligns with the finding that one in two teachers believe institutions should take action on climate change. However, institutional support has largely focused on training and curriculum guidelines, which have been shown to have a positive impact on student learning (Hart & Nolan, 1999; Taylor et al., 2019), and to address teachers’ lack of preparedness for climate education (UNESCO, 2021). Teachers who received training from external

organisations or engaged in self-directed research were more likely to adopt interdisciplinary approaches. Considering only 30% advocated for continuous training, we can derive that training is often perceived as a burden and not yet integrated enough in the curricular time (as preferred by teachers). Teachers favoured ready-to-use materials, indicating a desire for personalised and effective resources. Connected to these pressures, the freedom offered by the Finnish curriculum - often seen as an enabler for integrative teaching (Haapaniemi *et al.*, 2021) also reveals some drawbacks. This study highlights challenges related to a cross-curricular competence approach: teachers pointed to overlaps between subjects and curriculum overload, leading to frustration with a topic that feels forced into every subject, often without creativity or personalisation.

Individual resources: teaching materials, pedagogical tools

The resources currently most used to support climate change teaching align with previous studies, showing that secondary teachers commonly rely on a mix of traditional and multimedia materials, including videos, news articles and teacher-made material (Greer *et al.*, 2023). A striking difference in this study is the prominence of textbooks as the most frequently used resource, likely reflecting the degree to which climate content is embedded in national curricula. Teachers who engage with a diverse range of resources tend to initiate a virtuous cycle: greater resource variety supports interdisciplinary teaching, which in turn builds confidence in addressing climate change topics. What this study contributes is a clearer view on teachers' interest in future resource use, including interest in outdoor environments, and research-based and drama-based resources. This growing attention to creative pedagogies is confirmed by recent studies highlighting the effectiveness of drama-based workshops in conveying climate concepts and emotions (Wall *et al.*, 2025). As discussed in our analytical framework, resources might function as both enablers and barriers: it is important to recognise the increasing number of teachers unwilling to engage with CCE resources in the future. From a pedagogical point of view, research stresses the importance of constructive hope (Ojala, 2012; Li & Monroe, 2017), meaning to highlight realistic pathways for action, vision that aligns with teachers' preferences for designing CCE: including local examples and making it more hopeful and less focused on disasters. Targeted training offered during curricular time, along with materials developed by researchers, could help teachers present alternative futures and build confidence in applying new methods. Strengthening these elements would enhance the likelihood of successfully integrating interdisciplinary CCE.

Social resources: collaboration and participatory activities

This study echoes findings of studies (Corney, 2006; Borg *et al.*, 2012; Taylor *et al.*, 2019) identifying time and the boundaries between disciplines as the most common challenges to integrating interdisciplinarity. Teachers reported lacking time for external collaborations or alternative activities, and the need for more time to develop the curriculum content. Only one in four of the teachers planned their teaching with colleagues and collaborations with external associations or researchers are even less frequent - interestingly, teachers that do *not* include interdisciplinarity engage in a higher number of different activities. Supposing an "interdisciplinary fatigue", we hypothesise teachers who do not include interdisciplinarity have more time to engage in participatory activities. By interdisciplinary fatigue, we refer to the sense of distress that teachers experience when they are constantly bombarded with new demands, bureaucratic and terminological changes, feeling thrashed around, torn out of their agency and longing for a peaceful and protected working environment (*työrauha*). The survey conducted by the University College London reported similar trends in terms of out-of-the-classroom activities, secondary teachers were encouraging students to take their learning home to families, they largely participated in projects to improve school sustainability and school decision-making (Greer *et al.*, 2023). In both cases, citizen science projects scored quite low (14.8% in this study, 15.2% in UCL's survey).

Ultimately, the expanded framework for teachers' agency offers a holistic approach through which structures and resources influence each other, interacting on the individual-social continuum required by interdisciplinarity. While institutions promote interdisciplinarity and many teachers are receptive, implementation remains uneven, risking "interdisciplinary fatigue." Teachers' needs highlight the value of researcher-teacher collaboration during curricular time, particularly in co-developing pedagogical tools to translate climate change research into accessible, educational formats. Crucially, this process should be guided by the agency model proposed in Figure 2, which positions resources and structures along a continuum between individual and social dimensions. Without this grounding, resources risk becoming burdens rather than enablers of interdisciplinarity and meaningful engagement.

Limitations and ways forward

The basis of the survey was a mixed-method approach that allowed rich data to be obtained, but it inevitably came with some limitations. The response time was longer than predicted in the opening statement, which hindered the extent of open responses. The main limitation of this study is that it relied on teachers' self-perceptions, rather than being an external assessment of their interdisciplinary practices. Alternative approaches could have included analysing teaching materials or course plans to evaluate the actual degree of interdisciplinarity. Future research should investigate the role of academia in CCE, particularly in creating a bridge between schools and research. This includes studying the power structures that limit collaboration and establishing which knowledge promotes the active shaping of preferred futures. To be effective, guidelines and frameworks should be co-created with educators, ensuring they are grounded in a clear understanding of teachers' needs and everyday practices. Current climate change-related research should be translated to inform interdisciplinary climate education: teachers' reliance on self-directed efforts to integrate CCE highlights the need for expanded institutional and external support mechanisms. The same teachers expressed a clear desire for more resources developed by researchers; therefore, we need to ideate up-to-date and targeted resources that avoid curriculum overlaps and enhance collaboration between disciplines.

Conclusions

By adapting the ecological model of teacher agency to interdisciplinary CCE, this study highlights both the commitment of Finnish secondary teachers to interdisciplinarity in CCE and the structural, epistemological and ideological barriers that can undermine it. Teachers broadly support a vision of CCE that is locally grounded, collaborative and inclusive of ethical, well-being and power-related dimensions. Yet curriculum and time constraints, combined with difficult emotional responses, often result in fragmented or superficial integration of climate change themes, contributing to what emerges as interdisciplinary fatigue. Teachers frequently resort to self-directed research and manifested an evident shift in resources preferences, such as outdoor activities, collaboration with researchers and drama-based methods, pointing to a clear opportunity for academia to play a more active role in support and collaboration. Importantly, introducing additional frameworks or collaboration pressures without understanding current practices and challenges may only deepen fatigue. Finland's approach, where environmental and ethical themes are integrated as a cross-curricular competence and reinforced by strong teacher support, illustrates how interdisciplinary CCE can be positioned within national curricula. At the same time, this case study highlights the structural barriers that other education systems will need to address if they aim to make similar approaches not only aspirational but also practically feasible. Future research must therefore examine the power dynamics involved in bridging schools and academia, and work towards co-creating knowledge that is accessible, adaptable and aligned with teachers' lived realities and educational goals in CCE.

Supplementary material. The supplementary material for this article can be found at <https://doi.org/10.1017/ae.2025.10086>.

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